FALL 23

CE IMPACT

LYLES SCHOOL OF CIVIL ENGINEERING

EARTHQUAKE AFTERMATH

Reconnaissance team assessed damage following natural disaster in Turkey

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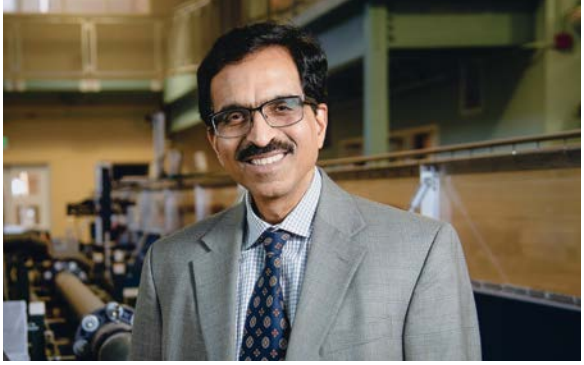
PURDUE UNIVERSITY

Lyles School of Civil Engineering

PHASE CHANGE MATERIALS MAY REDUCE BUILDING'S ENERGY CONSUMPTION | PAGE 4

MESSAGE FROM THE HEAD



It has been just a few weeks since I returned from my six-month sabbatical overseas, yet I feel more at home back on the West Lafayette campus than ever before.

I suppose that is one of the key reasons why one goes on a sabbatical — to gain a newfound perspective. Not only does one get the opportunity to learn from and share insights with colleagues around the world, it also gives one a chance to step back and review how they themselves approach their research, teaching and teamwork. Additionally, with this time for reflection, it allows one to look past what is currently taking place and set one's sights on an even-brighter future.

Thankfully, the Lyles School of Civil Engineering — and Purdue University in general — is filled with like-minded people. That is especially true now as the first semester of the school year has recently begun.

Everywhere I look, I see that eagerness to approach the challenges of today to create a better future. Our students, faculty and staff especially have this mindset — which I suppose is not all that surprising in the study and practice of civil engineering.

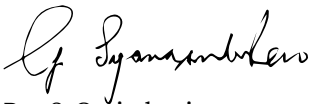
Civil engineering by its very nature is future-focused — as is our education. All the work and research we do is to improve the future for our society. Whether it is preparing the leaders of tomorrow, innovating how we build our habitats or responding to natural disasters, the central theme that drives everything we do is a desire to create a brighter future for everyone.

That is why I — and so many others in this field — are drawn to it. We see the potential in others and the world around us. We know we can make the world better; we know we can improve the lives for the people of today as well as the people of future; and we are consistently pursuing the next giant leaps in research and education.

In this edition, we highlight some of the forward-thinking pursuits taking place today in the Lyles School of Civil Engineering. These stories include our efforts to rebuild communities ravaged by earthquakes, research to improve building materials to be both less costly and more energy efficient and our continued focus to expand our online master's program and make it more accessible.

These are but a few of the incredible endeavors taking place as I write this — and I look forward to sharing even more of our work with you in the future.

Until then, I wish you all the best,



Rao S. Govindaraju
Bowen Engineering Head of Civil Engineering and The Christopher B. and Susan S. Burke Distinguished Professor of Civil Engineering

IN THIS ISSUE:

ON THE COVER

Ayhan Irfanoglu, professor and associate head of the Lyles School of Civil Engineering, led three graduate students on a reconnaissance visit to assess the damage from the massive 7.8 magnitude earthquake that struck Turkey and Syria on February 6, 2023.

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NEWS & EVENTS

CONGRATULATIONS GRADUATES!

Congratulations to the Lyles School of Civil Engineering's class of 2023! In May, we saw more than 150 students earn their undergraduate and graduate degrees. We wish our newest alumni all the best in their future endeavors!

MURPHY AWARD HONOREE

Congratulations to Lyles School of Civil Engineering Professor Marika Santagata. She was recognized this spring with Purdue University's highest teaching honor — the Charles B. Murphy Award. The select few who earn this award are teachers who go above and beyond to provide exceptional educational experiences for their students.

INNOVATION OF THE YEAR

Earlier this spring, Bechtel Corp. presented its Innovation of the Year award to Bowen Laboratory at Purdue University for its contributions to a large-scale government project. The award recognizes proven innovations that have delivered unprecedented results within the company's execution model.

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IMPROVING ROAD SAFETY

TECHNOLOGY TAKES CONTROL OF VEHICLE TO REDUCE DISTRACTED DRIVER EVENTS

Purdue civil engineering researchers are developing technology to improve driving safety by building driver digital twins with a better understanding of driver distraction events.

According to the National Highway Traffic Safety Administration (NHTSA), there were 38,824 people killed in motor vehicle crashes on U.S. roadways in 2020. Among these cases, 3,142 were a result of at least one of the drivers being distracted.

In an effort to improve driver safety, a research team led by Ziran Wang, assistant professor of civil engineering, has developed a semi-supervised approach to use computer vision technologies to detect when a driver is distracted. When distracted driving is detected, the system issues an audio alert or haptic alert (vibration on steering wheel or driver seat) to the driver. If there is no action from the driver, the second step is to provide control command. If the vehicle is in manual mode, then the vehicle takes over the control from the driver, changing into automated mode to ensure safe driving for a short duration. If the vehicle is already in automated driving mode, then it will automatically slow down and find a safe place to park.

"As technology advances, so do opportunities for driver distractions," Wang said. "From texting while driving to chatting with passengers, all of these factors lead to an increase of risk to everyone on the road."

Yunsheng Ma, a civil engineering PhD student and graduate researcher, said this research is about saving lives.

"Just one single distracted driver can result in injury and death of many others on the highway," Ma said. "This technology isn't just to protect the driver from distractions — it is to protect all the other drivers, passengers and pedestrians around them as well."

However, Wang said, a driver can also "over-trust" such automated systems. When the automated driving features are engaged, the driver is allowed to take their hands off the steering wheel and feet off the pedals, but they need to stay alert and get ready to take over the driving task when the system requests. Due to human nature, the attention from the driver on road conditions can diminish when they are not in charge of driving, and distracted behavior can decrease the driver's capability of taking over, which in turn leads to traffic accidents.

"As a key element of intelligent vehicles, advanced driver-assistance systems have been designed to support human drivers either by providing warnings to reduce risk exposure or by assisting the vehicle actuation to relieve drivers' burden on some of the driving tasks," Wang said. "When functioning, these systems can help the driver safely navigate the vehicle through tricky traffic scenarios when they are distracted by some other tasks."

Wang said the research is still in the early prototype phase on their lab's automated vehicle platform, but the team has been presenting its research progress at top AI conferences, including the 2023 Conference on Neural Information Processing Systems (NeurIPS) and 2023 Conference on Computer Vision and Pattern Recognition (CVPR).

PhD students Yunsheng Ma (left) and Juanwu "David" Lu test automated driving features on their automated vehicle platform.

COOL TECHNOLOGY

INCORPORATION OF PHASE CHANGE MATERIALS MAY REDUCE BUILDING'S ENERGY CONSUMPTION

Heating and cooling homes carries a hefty economic and environmental price tag — but Purdue civil engineers are working to change that.

The U.S. Energy Information Administration reported in 2015 that more than half of all home energy in the United States is used for heating and cooling, and it also represents more than 14% of the nation's overall energy use. To address this issue, Mirian Velay-Lizancos, assistant professor of civil engineering, and her research team have developed a scalable, automatable process that improves upon the traditional method to incorporate phase change materials (PCMs) into construction materials.

A PCM converts changes in thermal energy into phase changes by transitioning from a solid into a liquid, or vice versa. PCMs provide useful cooling or heating by absorbing or releasing energy during those transitions. However, Velay-Lizancos said, PCMs — as they are now — have too many drawbacks to be used in home construction.

"Currently, PCMs are incorporated into other materials via microencapsulation or macroencapsulation," Velay-Lizancos said. "These methods limit the use of PCMs. Microencapsulation has a negative effect on the strength and durability of construction materials. Macroencapsulation limits the shape and production method of construction materials."

Velay-Lizancos' newly-patented method uses liquid immersion and a vacuum to incorporate PCMs after construction materials have already been formed. The method requires only a vacuum system, something Velay-Lizancos said is both easier and more accessible for manufacturers to work with.

"This increases the strength, enhances the durability and increases the thermal inertia of the construction materials," Velay-Lizancos said. "This new method also distributes PCMs so they are concentrated in the surface layer of the construction materials. More of the PCMs are in contact with external surfaces of the building envelope, which makes the PCMs more effective."

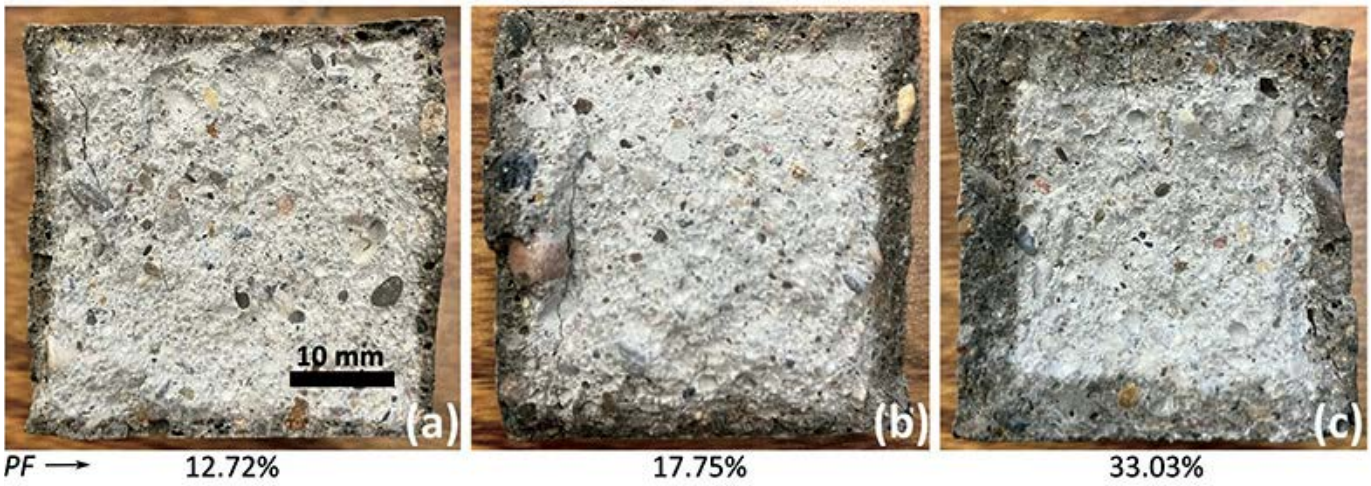
Marina Garcia Lopez-Arias, a civil engineering PhD student and graduate researcher, said the porous nature of construction materials such as bricks, drywall and concrete make these materials the best choices for incorporating PCMs.

"We've observed these types of materials can more easily incorporate PCMs while also not suffering a loss to their integrity," Lopez-Arias. "They are the ideal materials and what we have focused on."

An experimental campaign was conducted on cement mortars with three water-to-cement ratios and, therefore, different initial porosity levels. PCMs were incorporated into the mortars for three different vacuum periods: 15 minutes, one hour and four hours. Velay-Lizancos' team observed an increase on the thermal inertia of 24% and a more than 22% increase in the compressive strength, with just 7% of the volume of the element filled with PCM.

Velay-Lizancos said the team's next step is to apply their work to an at-scale setup with cameras and sensors.

"This will allow us to visualize with cameras and sensors the thermal performance of the building envelope," Velay-Lizancos said. "Clients will have the hard data and also be able to visualize the advantages of this technology."



Darker areas show how far phase change materials, or PCMs, have penetrated the pores of construction materials that spent 15 minutes, one hour and four hours in a process developed by Mirian Velay-Lizancos, assistant professor of civil engineering, and her research team. The process improves upon the traditional method to incorporate PCMs into construction materials, which could reduce a building's energy consumption, leading to a reduction in carbon dioxide emissions and operational costs.

DEVASTATING DAMAGE

STRUCTURAL ENGINEERING TEAM RECOUNTS RECONNAISSANCE VISIT TO TURKEY FOLLOWING MASSIVE EARTHQUAKES

Fatih Canakci was only 3 years old in August 1999 when a catastrophic earthquake of magnitude 7.6 struck the Kocaeli Province of Turkey, causing monumental damage and more than 17,000 deaths.

Although Canakci, now a graduate student in civil engineering, doesn't remember much from the devastating event that impacted his family and homeland, its lingering influence motivated him to become a civil engineer and analyze the design of structures in earthquake-prone areas.

In March, Canakci was one of three graduate students, along with Lissette Iturburu and Oscar Forero, who accompanied Ayhan Irfanoglu, professor and associate head of the Lyles School of Civil Engineering, on a reconnaissance visit to assess the massive damage from back-to-back 7.8 and 7.5 magnitude earthquakes that struck Turkey and Syria on February 6, 2023. The group joined teams of engineers — many of whom were Purdue civil engineering alumni — supported by the American Concrete Institute.

"We landed in Gaziantep and traveled 40 miles west to reach the disaster zone where we were shocked by what we saw," Canakci said. "Most of the buildings were heavily damaged. Some had collapsed, many of them residential structures. Understanding that more than 50,000 people died in the earthquake reinforces our critical mission as structural engineers which is to learn how structures respond to strong ground motion and determine how to build structures to withstand high levels of seismic excitation."

Irfanoglu, who traveled to Turkey in 1999 on his own as a graduate student to observe structural damage from the Kocaeli earthquake, wanted the earthquake engineering graduate students on this trip to survey the wreckage first-hand and learn how to quickly assess the structural integrity of a building.

"When you see it with your own eyes, it's not like a photograph," Irfanoglu said. "You're in the middle of it. There are some areas where the buildings are completely gone, and it requires imagination to reconstruct what happened. There's an overwhelming sense of loss. Seeing the devastation up close makes it evident that our work directly impacts people's lives."

For Iturburu, a native of Ecuador — another earthquake-prone region, the experience helped focus her research direction by expanding her view on the seismic vulnerability of buildings in different communities.

"Witnessing the real-world implications of structural failures and the devastating impact on communities has solidified my commitment to pursue a career focused on resilience," Iturburu said.

Irfanoglu credits the late Mete Sozen, the Karl H. Kettelhut Distinguished Professor of Civil Engineering, and his work on the earthquake-resistant design of reinforced concrete structures for establishing Purdue as a leading institution for earthquake engineering. Sozen developed a simple seismic vulnerability ranking method, making safe building practices easier to adopt.

A scholarship established in Sozen's name to support students in earthquake engineering provided some of the funding for the graduate students to go on the reconnaissance trip. Part of the team's work included assessing structures using the index Sozen developed to determine whether it could be applied to taller buildings.

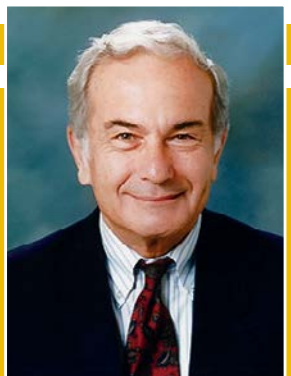
"Professor Sozen dedicated his life to developing the Hassan Index," Forero said. "During this research trip, we were able to gather valuable data for the largest dataset on this index, which is a testament to Professor Sozen's enduring legacy. It's exciting to be part of the next generation of engineers who will ensure that Professor Sozen's work and contributions continue to make a significant impact in the field of earthquake engineering."

In 2003, Irfanoglu joined Sozen and a team from Purdue — led by Professor Julio Ramirez — on a research trip to eastern Turkey following a 6.4 magnitude earthquake. It would turn out to be Sozen's final earthquake reconnaissance trip. The things Irfanoglu learned from Sozen during that week changed his perspective as an engineer.

"I hope to convey the same knowledge to my students that Sozen instilled in me," Irfanoglu said. "Once you get to that level of understanding, you can work faster and visualize how damage develops. Sozen espoused a belief to keep things simple so that in the face of uncertainty we can make the right decisions without sacrificing lives or property."

For years after he witnessed the aftermath of the '99 earthquakes, Irfanoglu would close his eyes and walk the streets again and again in his mind. Now, scenes from the '23 earthquakes occupy his thoughts.

"Sadly, there will be more disasters like this around the world," Irfanoglu said. "We know the solutions and they are neither complicated nor that costly. We hope that by speaking up and sharing our observations, designers and builders will do the right thing and construct robust buildings.'"



THE PROFESSOR METE A. SOZEN FUND

To support the Professor Mete A. Sozen Fund for students interested in earthquake engineering, contact Eric Putman, chief development officer, at 765-494-2236 or eaputman@purdueforlife.org.

PREDICTING FLOODS AND DROUGHTS

NEW METHODS INCORPORATE IMPACT OF LAND USE AND CLIMATE CHANGE

Professor Venkatesh Merwade and PhD student Jibin Joseph review streamflow data.

When predicting floods and droughts, researchers examine a river's history. However, due to climate change and direct human intervention, history is swiftly becoming an inaccurate predictor, experts say.

Venkatesh Merwade, professor of civil engineering, and Sanjiv Kumar (MSCE '08, PhD CE '11), an assistant professor in Auburn University's College of Forestry, Wildlife and Environment, are leading a research team that is analyzing long-term river discharge data for the entire contiguous United States to learn how past, present and future changes in climate and land use are impacting river flows. The need, Merwade said, is especially great because the methods experts have been using for decades are becoming less and less viable.

"Flood control and prediction had been viewed as being stationary but we are finding that is no longer the case," Merwade said. "The current methods are not accounting for land use and climate change and these two factors have become more impactful than a river's history when predicting floods and droughts."

To gain greater insight into the changing river flows, Merwade's team is studying and assessing the trends and stationarity in annual peak streamflow. The team is using 3,907 U.S. Geological Survey streamflow gauging sites and annual maximum runoff from Community Earth System Model version 1 Large Ensemble (CESM1-LE) datasets. These datasets feature 40 realizations of the historical and future climate and 18 realizations of preindustrial climate by using different tests to examine stationarity and nonstationarity on a continental scale.

Jibin Joseph, a civil engineering PhD student and graduate researcher, said the team's goal is to track river data from 1850 to develop predictions up to 2100.

"Our goal is to use what we learned from historical data along with current climate and land use information to better predict the future," Joseph said. "This requires an immense amount of data collection, processing and computation, but we believe this will lead to a more accurate flood prediction."

Merwade's team found that the annual peak streamflows at 33.6% of sites show a significant trend (both increasing and decreasing) over the contiguous United States. Further, the team's research into watershed-scale data also indicates "that direct human intervention dominates the non-stationary response" with regard to peak-flow changes.

"The more we continue our study, the more apparent it becomes that direct human intervention is showing a more dominant large-scale impact on rivers in the U.S. than other factors, including land use and climate change," Merwade said. "We also found that direct human intervention is not captured in climate models and our study will improve the climate model for better prediction of the future. While we are still in the process of collecting and analyzing data, we are confident that our research will contribute to the development of a more accurate flood prediction model for the future."

Merwade said his team expects to publish its findings by the end of 2023.

ROBOT INSPECTOR

AI-POWERED AGENT DETECTS DAMAGE IN SURROUNDING ENVIRONMENT

The age of robotic inspectors is fast-approaching — and Purdue engineers are working to provide them with the knowledge to do so.

Along with his research team, Mohammad Jahanshahi, associate professor of civil engineering, is developing an artificial intelligence-powered robotic agent capable of accurately and robustly detecting damages in its environment. While still in the early stages of development, Jahanshahi said the team has already seen promising results.

"We're at a very exciting time in our research," Jahanshahi said. "What we're working on and developing is completely new but we can already see incredible progress with how our robotic agent is able to learn."

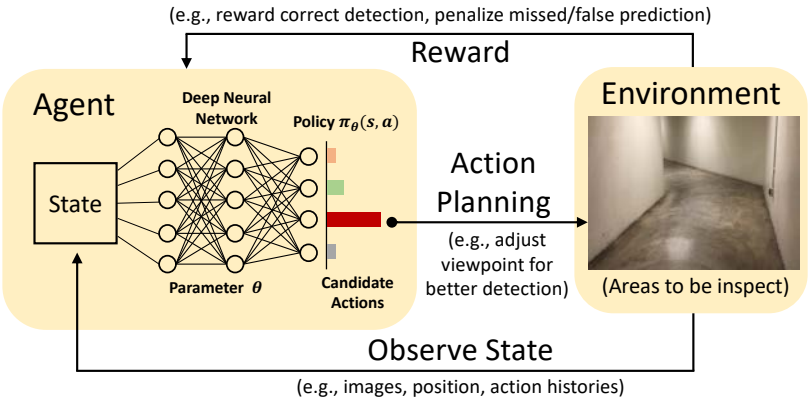
What sets this robotic agent apart from most AI-based visual detection algorithms, Jahanshahi said, is its ability to actively explore its surroundings using color images. By picking the most informative viewpoints while exploring, the agent can reduce uncertainty and improve its detection results through iterative learning.

"A robotic inspector like this would be perfect for nuclear reactor inspections," Jahanshahi said. "Instead of manually operating a camera and searching for cracks or other damage, the AI-powered robotic agent could more thoroughly and precisely detect, catalogue, and report what it finds — and in a shorter amount of time."

As of now, Jahanshahi's research team reported that active perception exhibits a notable enhancement in crack inspection performance, yielding an increase of up to 40 percent when compared to its raster scanning counterpart given a similar inspection time. Additionally, the proposed method can conduct accurate inspections in about the half the time as other AI-based inspectors.

Wen Tang, a civil engineering PhD student and graduate researcher, said that while considerable progress has been achieved by utilizing state-of-the-art computer vision approaches for damage detection, these approaches are still far away from being used for autonomous robotic inspection systems due to the uncertainties in data collection and data interpretation.

"We've had to develop a new way to teach and encourage the AI to learn," Tang said. "We have been employing positive and negative reinforcements as it learns to properly identify damages.



Professor Mohammad Jahanshahi and PhD student Wen Tang review recently collected data from their robotic agent.

We've created a scoring system as well, so that the AI has something to work toward for further encouragement."

For now, Jahanshahi said, more research and finetuning is required before his team can move forward in their work — but the team is optimistic for the future.

"What we've already been able to accomplish has been wonderful," Jahanshahi said. "Every day the AI gets better. I look forward to where we'll be by the end of 2023."

AT THE FOREFRONT OF CYBERSECURITY

PURDUE'S FIRST NATIONAL UNIVERSITY TRANSPORTATION CENTER TO ASSESS VULNERABILITIES ASSOCIATED WITH TRANSPORTATION SYSTEMS

As the United States transitions further toward smart and connected cities, the need for increased cybersecurity and resiliency research grows as well.

In February 2023, the U.S. Department of Transportation (USDOT) awarded $435 million in grant awards for 34 University Transportation Centers (UTC) that will help the next generation of transportation professionals make roads, bridges, rail, shipping and airspace safer, more innovative, and more efficient. The UTCs will advance transportation expertise and technology in the varied disciplines that comprise the field of transportation through education, research and technology transfer activities.

Purdue University was selected as a major partner in a national UTC with Satish Ukkusuri, the Reilly Professor of Civil Engineering, leading the team. The $4 million-per-year grant issued to this consortium, with Clemson University as the lead institution, has tasked researchers to focus on cybersecurity — specifically, the vulnerabilities of cybersecurity associated with transportation cyber-physical-social systems (TCPSS).

TCPSS uses computations and communication embedded in and interacting with physical processes to add new capabilities to transportation systems. The UTC will work on identifying challenges and threats across transportation modes, geographies and applications; and pioneering advanced cybersecurity and resiliency strategies and solutions for multimodal transportation.

"Our goal is to be at the forefront of cybersecurity," Ukkusuri said. "As the world develops and integrates autonomous vehicles and smart cities, the cyberthreats we face increase significantly. And these threats will only continue to grow and evolve over time."

Eunhan Ka and Zengxiang Lei, both civil engineering PhD students, will be part of the research team. Both said the need for a nationwide program in transportation cybersecurity is absolutely necessary to protect and prepare the U.S. to defend future threats.

"We see emerging technology coming out almost every day — and with that, it's clear that we need to explore our vulnerabilities," Lei said. "We have to understand where exactly — in both our hardware and software — the risks are."

Graduate students Zengxiang Lei, Eunhan Ka and Omar Hamim test cybersecurity algorithms in the Urban Mobility Networks and Intelligence Lab.

"It's definitely time for an effort like this," Ka added. "New developments and breakthroughs are coming faster and faster and we're going to leave ourselves vulnerable if we don't start working now."

By the end of 2023, Ukkusuri said, a central office will be established as the project expands. This interdisciplinary research project at Purdue will include faculty from computer science, industrial engineering and electrical and computer engineering.

"We want to explore and tackle this issue from all angles," Ukkusuri said. "Understanding the extent of connection within the infrastructure enables us to be both better protected against cybersecurity threats and more resilient in our recovery."

Other members in the Clemson-Purdue UTC consortium include Benedict College, Florida International University, Morgan State University (Maryland), South Carolina State University, University of Alabama at Tuscaloosa, University of California at Santa Cruz and University of Texas at Dallas.

CAPTURING CITY SPRAWL

ACCURATE 3D URBAN MAPPING ESSENTIAL TO INFORM MINDFUL DESIGN, EXPANSION

As cities continue to rise, expand and become more complex, current urban mapping systems become less reliable, Purdue University researchers said.

At present, more than 50% of the entire world's population lives in cities. And, according to the United Nations Department of Economic and Social Affairs, that number will increase to nearly 70% by 2050.

These ever-expanding cities need more accurate mapping for both emergency and disaster response planning, and to lessen their environmental impact.

"As cities evolve and grow, so must our methods to accurately map them," said Jinha Jung, associate professor of civil engineering. "The world's major cities are only going to become more sprawling and complex every year and emergency and disaster response teams will only have more difficulty in their responsiveness without accurate, detailed mapping."

As it is now, "current two-dimensional mapping is not a sustainable way to support building cities," said Hunsoo Song, a civil engineering PhD student and graduate researcher. "Most 2D maps provide only coarse resolution information and lack 3D data, resulting in significant differences from actual 3D environments."

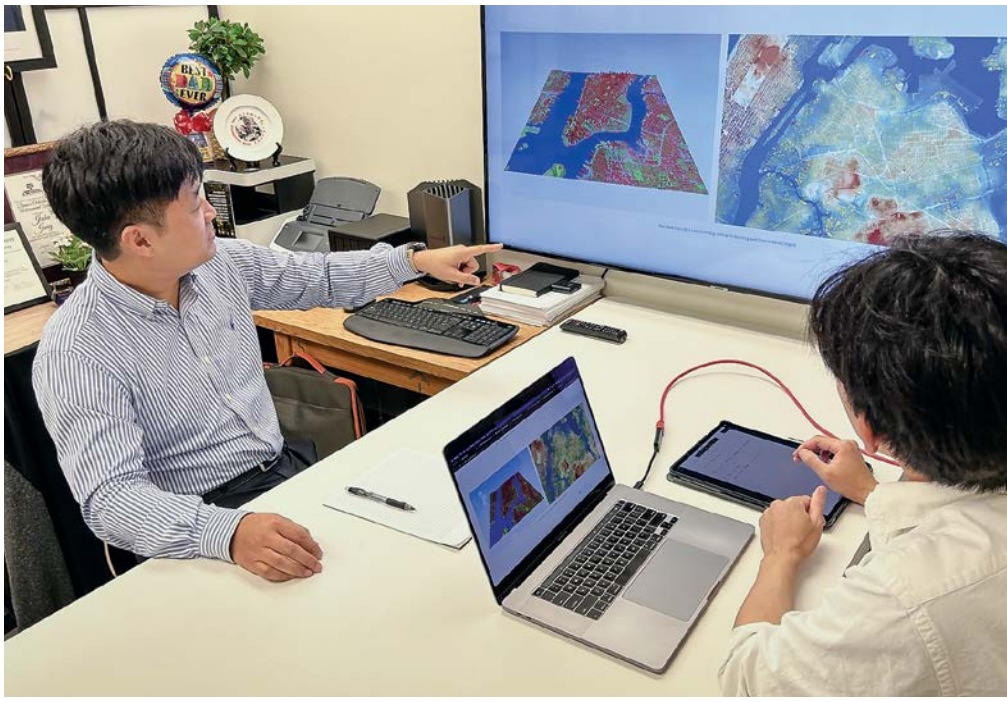
These discrepancies, Song said, become particularly evident as cities grow denser and taller, increasing the need for 3D maps to precisely represent these urban environments. To address this problem, Jung's research team is developing a 3D urban mapping system that would greatly increase the detail and accuracy of city layouts and significantly improve city planning. Members of the research team are collecting the image data from organizations such as the U.S. Geological Survey's 3D Elevation Program and the U.S. Department of Agriculture's National Agriculture Imagery Program.

"The rising demand for highly accurate representations of the 3D world in applications such as Digital Twins (a virtual model of a physical object) coupled with the growing discrepancy between 2D and 3D realities, underscores the need for a transition towards more comprehensive and scalable 3D mapping solutions," Song said.

The issue of growing "urban heat islands" is also another chief concern Song said, where cities replace natural land cover with dense concentrations of pavement, buildings and other surfaces that absorb and retain heat. This effect, the U.S. Environmental Protection Agency states, increases energy costs, air pollution levels and heat-related illness and mortality.

"It is difficult to determine how to address the problem of hotspots, but we do know that mindful city design and increased landscaping help to alleviate it," Song said. "To do a better job of reducing climate hotspots, we need more-detailed 3D maps so we can thoughtfully design our growing cities."

Jung said the team expects to release a full report on its findings in 2024.



Professor Jinha Jung and PhD student Hunsoo Song input data to further enhance their 3D city model.

A FORCE IN THE INDUSTRY

LEGACY BOILERMAKER CENTERS CORE VALUES AS CEO OF FAMILY BUSINESS

Growing up in a family rooted in meaningful culture, family business and civil engineering, Clayton Force (BSCE'02, MSCE'03) thought no better place to start his civil engineering journey than at Purdue University.

Born and raised in Columbus, Indiana, with two parents who are Purdue alumni, Force said he has been a part of Boilermaker traditions and values from the get-go.

"Purdue was a natural fit for me" Force said. "I had been on campus for events ever since I was a kid and knew from a young age that I wanted to study engineering there."

Force was first introduced to the construction industry and civil engineering through his father, who earned his bachelor's and master's degrees in civil engineering from Purdue. Throughout his summers in high school and while studying engineering at Purdue, Force gained hands-on field experience working as a construction laborer.

"I always had an interest in learning how things worked," Force said. "And having that early exposure to construction helped encourage my curiosity."

While at Purdue, Force kept busy at the Lyles School of Civil Engineering. During his time as a student, Force was a member of the Purdue chapter of ASCE and Sigma Chi Fraternity.

"Through the Lyles School of Civil Engineering and the Sigma Chi Fraternity, I was able to form strong connections with others who shared similar interests and career goals," Force said.

Force earned his bachelor's degree in civil engineering with an emphasis in structural engineering, and his master's degree with an emphasis in construction a year later. His graduate experience, Force said, provided him "with a broad perspective of civil engineering applications and a business perspective on the industry, which have been very beneficial."

Following graduation, Force moved to downtown Chicago where he worked as a project engineer and project manager in the construction industry.

"It was a great experience to have right out of college," Force said. "It provided me with a lot of industry and project experience and personal connections that I use regularly to this day."

After eight years of industry experience in Chicago, Force had the opportunity to move to Columbus to work for the family business.

Force Construction Company Inc., based in Columbus, Indiana, was established by Force's grandfather, Don, in 1946. For 77 years, Force Construction has been providing clients with quality construction projects and is dedicated to the family-values based culture of their company.

Force began his career at the company as project engineering manager, and took a role in various project management and business development responsibilities.

"It's a humbling experience to come to work and see the business my family and my coworkers have built and the culture that they have created," Force said.

In 2017, Force was promoted to vice president. Force said that he hopes his "Purdue experience has helped bring a broader perspective and application of civil engineering to the company."

Force Construction has a strong emphasis on core values that have contributed to the culture and longevity of the business, Force said, and he believes those values are critically important to the success of the company.

"Since coming to the company, it truly feels like I have expanded my family," Force said. "With the company being employee-owned with a family-values based culture, you can't help but feel a close connection to everyone here."

Force and his wife and Purdue classmate, Angela, reside in Columbus with their three children. He was elected president of the company in 2019 by its board of directors and assumed the role of CEO in 2021 after his father retired.

Force also serves on a number of boards in his community — as well as the Lyles School of Civil Engineering Alumni Advisory Board — and he regularly returns to Purdue as a guest lecturer. Force shares his industry and personal experiences with students with the hope of spreading the myriad opportunities and possibilities that a Purdue civil engineering degree can create for them.

"The value of a Purdue engineering degree speaks to so many things," Force said. "I try to share with Purdue students that regardless of the civil engineering discipline or career path they may choose, a Purdue engineering degree is forever a testament to their critical thinking and time management skills, demonstrates a propensity towards math and science and provides them exposure to and success in competitive environments."

ONLINE MASTER'S DEGREE

The online master's degree offered through the Lyles School of Civil Engineering allows students to tailor their degree by matching their engineering interests with career goals. The program features interdisciplinary tracks in sustainable water, infrastructure resiliency and sustainability and smart mobility. With courses taught by the same world-renowned faculty who instruct on-campus students, it is no wonder our 30-credit Master of Science degree is consistently ranked the No. 2 online master's in civil engineering in the country by *U.S. News & World Report*.

MEET A RECENT GRADUATE

John Joseph Wardlaw

Current position/employer:
Quality, Safety, Environment Coordinator at Tropical Bottling Company and Brouwerij Nacional Balashi Aruba

What interested you in an online program?
Purdue University is a world-renowned university and offers an online program. I would have loved to have attended in person, however, with a full-time job and living on the beautiful Caribbean island of Aruba, that was not possible. I am grateful that Purdue offers an online program because it allowed me to experience a first-class master's education with the feeling of being part of the Boilermaker community without physically being on campus.

What made Purdue the right fit for you?
I had the option to attend other globally well-known programs, however when looking at the options of both core and elective courses I felt an immediate pull toward Purdue as it allowed me to select the courses that interested me most.

How will this degree transform your life?
The process of earning the degree has already transformed my life by the knowledge and learning experiences gained over the past two years. My Purdue degree gave me the key to open many doors and possibilities for my future career.

What's your next giant leap?
To find the appropriate job that will allow me to use the knowledge gained while earning this degree to assist in making civil engineering more efficient, effective and sustainable.

What advice would you give someone considering the online civil engineering master's program at Purdue?
To ensure that your family and work support your efforts because indeed you will need that support as you put in many hours of study for each course.

PURDUE UNIVERSITY | Lyles School of Civil Engineering

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