FALL 22

CE IMPACT

LYLES SCHOOL OF CIVIL ENGINEERING

The Dirty Truth

DANGEROUS CHEMICALS IN FRESH-SCENTED CLEANING PRODUCTS LINGER IN THE AIR

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PURDUE UNIVERSITY®

Lyles School of Civil Engineering

NEW METHODOLOGY MAY ONE DAY MAP FORESTS AROUND THE WORLD | PAGE 8

MESSAGE FROM THE HEAD

The new school year is upon us and it truly feels like the Purdue University campus that I have known and grown to love.

For the first time since 2019, the opening of the school year was not met with, at best, cautious optimism, but a true sense of joy and excitement. And it could not have been possible without the incredible cooperation demonstrated over the past few years by students, faculty, staff, alumni and friends.

It is interesting how "normalcy" became something to strive for in the last few years — a hard-fought goal that took countless hours of work by tens of thousands of Boilermakers on campus to achieve. Yet, here we are — excited that we are fast approaching pre-pandemic form.

Another word that has often been brought up over the past few years is "resilience." For civil engineers, this word has significant meaning and continues to be an integral part of our design philosophy. Our students, faculty and staff have and continued to demonstrate that same resilience. We adjusted, held strong and shared in each other's successes.

This cooperation also allowed us in the Lyles School of Civil Engineering to continue what we do best: educate the civil engineers of tomorrow and lead the world in cutting-edge research.

In this edition of IMPACT, we share several examples of our innovative research. Stories include a study on indoor air quality; collecting data from satellites and unmanned aerial vehicles to map urban and rural environments; the development of polymers that can reduce the volume of tailings; and research into improving both quality and environmental impact of concrete.

The work and research conducted here at the Lyles School of Civil Engineering continues on with the goal of improving the world around us. Because while normalcy is always appreciated, we will continue to strive for excellence.

All the best,

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

IN THIS ISSUE:

ON THE COVER

A recent study published in the journal Science Advances *found that prolonged exposure to the chemicals used to create fresh-scented cleaning products may be hazardous.*

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NEWS & EVENTS

COMMENCEMENT

Congratulations to the nearly 200 graduate and undergraduate students who earned their civil engineering degrees in May! We wish you the very best and look forward to your return visits to campus.

RANKINGS

The Lyles School of Civil Engineering remains a top 10 civil engineering undergraduate program in the United States.

U.S. News & World Report has released its national rankings of graduate programs for 2022 with Purdue Civil Engineering ranked No. 7 in the nation. The rankings are computed from the responses to a survey sent to deans, heads and selected senior faculty.

Overall, Purdue University's College of Engineering graduate program was ranked No. 4 in the nation.

GET CONNECTED!

The Lyles School of Civil Engineering has several ways for you to stay up-to-date with our activities and accomplishments. One of the best ways is to subscribe to our social media channels.

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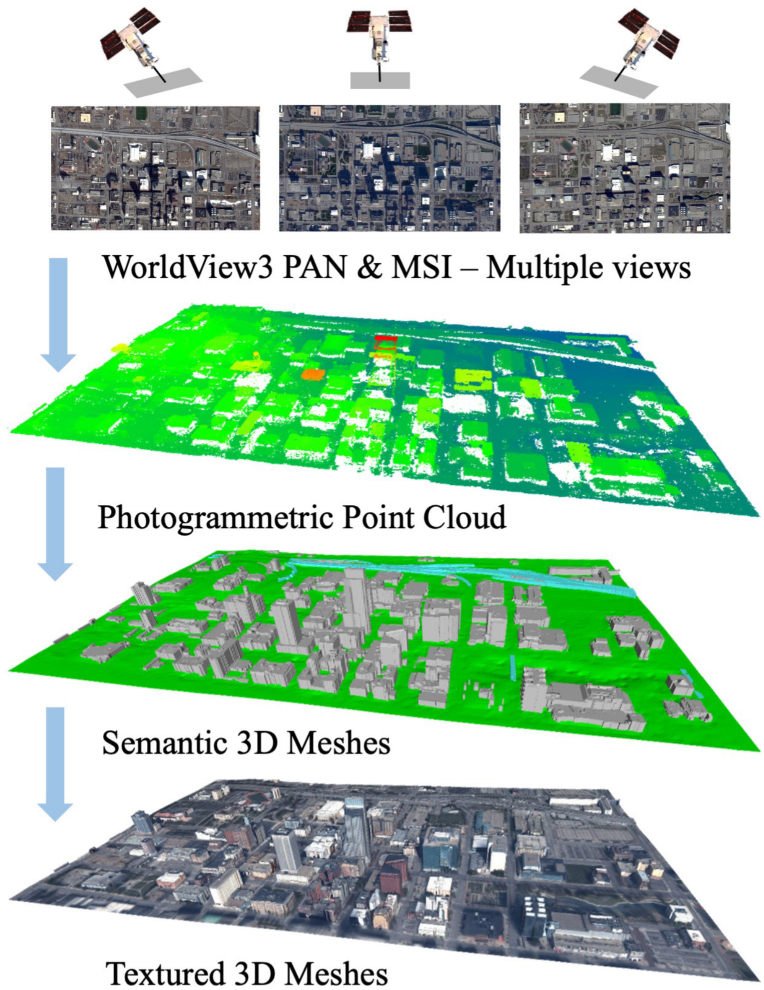
ENGINEERING 3D CITY MODELS

DATA WILL INFORM URBAN PLANNING, DISASTER MITIGATION



Workflow illustration of 3D city models created from satellite images (Downtown Omaha, Nebraska)

Purdue researchers are using images taken from space to recreate picture-perfect 3-D models of cities.

Through the collection of spaceborne, airborne and terrestrial images, Lyles School of Civil Engineering faculty and students have developed the capability to produce large-scale city models using 3D point clouds. These models are geometrically accurate, topologically consistent, physically genuine and computationally portable.

"These 3D models provide an incredible amount of information on a city that we can review on a computer unlike ever before," said Jie Shan, Professor of Civil Engineering with a courtesy appointment in the Department of Earth, Atmospheric and Planetary Sciences. "They provide necessary information for situational awareness, 3D navigation, disaster mitigation, energy management and sustainable development."

The models will also serve as crucial foundation data for digital twin development and smart city management. The final products can be visualized and utilized in a variety of design software packages, social media and meta reality across different platforms.

Researcher and civil engineering PhD student Zhixin Li said both urban development and disaster response would benefit from this work. It will greatly aid city planners and emergency responders.

"The highly-detailed and accurate data that this program can provide will help anyone working for the city," Li said. "When it comes to development, improvement or disaster response, the more detailed and accurate information you have, the better you can do your job."

Shan added, "What we have already been able to accomplish and visualize has been incredible. Besides major projects like development and city safety, this program could also be used for simple improvements and urban planning such as locating the best places to install solar panels."

Collaborating in this research are Kitware Inc., Raytheon, Columbia University and Rutgers University under the support of the Intelligence Advanced Research Projects Activity (IARPA).

CONCRETE IMPROVEMENTS

RESEARCHERS INNOVATE APPLICATIONS TO IMPROVE DURABILITY AND LOWER CARBON EMISSIONS IN VITAL BUILDING MATERIAL

In both its makeup and durability, Purdue University is researching how to improve concrete.

"Concrete is used in just about every part of development," James H. and Carol H. Cure Professor in Civil Engineering Jan Olek said. "That is why we should always look for ways to improve upon such a vital component."

For one research project, Olek's team has been evaluating different mechanical and durability properties of concretes in which 25 percent of the weight of cement has been replaced with nontraditional supplementary cementitious materials (SCMs), such as natural pozzolans, volcanic ashes, fluidized bed combustion ashes (waste material from the coal-fired power plants) and ground bottom ashes (also waste material from power plants).

These nontraditional materials could potentially serve as an alternative to fly ash or slag, other waste products traditionally used as cement replacements — and, Olek said, improve the overall properties of concrete.

"Our most recent findings show that the engineering characteristics of concretes with nontraditional SCMs are either comparable to or better than concretes made with traditional SCMs," Olek said.

Civil engineering PhD student researcher Alberto Castillo said another potential added benefit is the smaller environmental impact.

"Large amounts of carbon dioxide (CO_2) accompany the production of standard concrete," Castillo said. "With these nontraditional SCMs, carbon emissions are lower. More research is needed but the results, so far, have been promising."

IMPROVING DURABILITY

Olek's other research team is looking into adding nanoparticles to concrete to improve its durability. The team is using an automated air void analysis apparatus to perform a faster and more accurate determination of the characteristics inherent in air void systems.

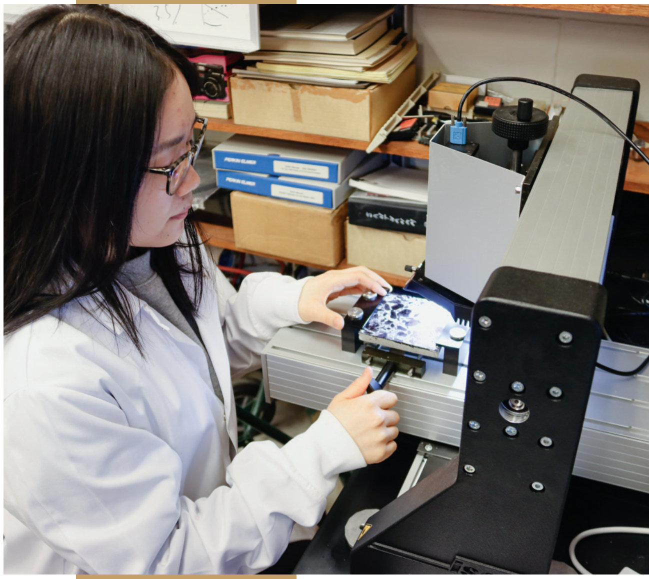
Achieving properly dispersed system of entrained air voids in hardened concrete is critical with respect to ensuring its resistance to freezing and thawing cycles.

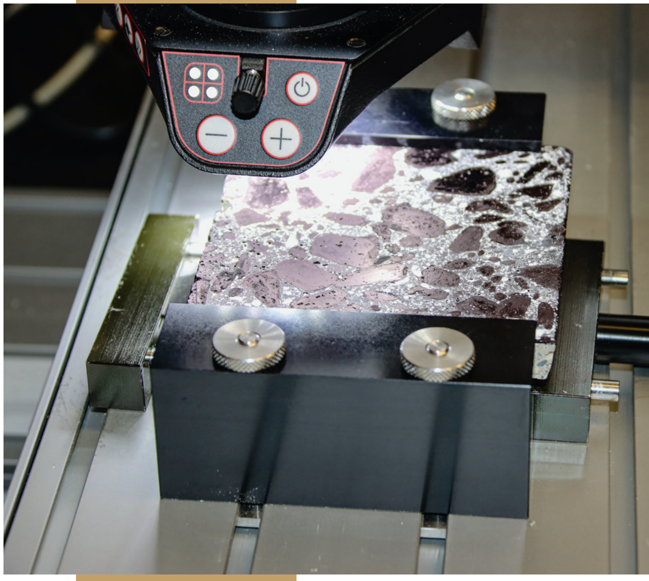
"Traditionally, researchers would have to measure air voids manually, with the individual air voids being counted by a trained operator," Olek said. "This process is not only time consuming, but the results are also strongly influenced by the skill level and the experience of the operator."

Civil engineering PhD student researcher Dan Huang said the use of the automated air void analysis apparatus allows for a remarkable improvement in quality of the results as it can detect very small voids that are not visible to the human eye.

"Unlike manual air void counting, this apparatus can detect small air voids using a high resolution camera," Huang said. "The results can be linked to the durability of such samples and help predict the service life of the concrete."

A research report is expected to come out in 2023, Olek said.





AN AI ALGORITHM FOR BETTER ROADS

SENSOR PACKAGE WOULD ALERT CIVIC OFFICIALS BEFORE POTHOLES BECOME A PROBLEM

Purdue researchers created a system that could dramatically improve how cities keep track of road conditions.

Lyles School of Civil Engineering Associate Professor Mohammad Jahanshahi and his research team have developed an inexpensive sensor package that can be attached to several vehicles, including volunteer vehicles, Uber/Lyft fleet, USPS and garbage trucks, etc.. These devices will scan the roads for damage as the vehicles drive over them and then can upload that information to a database for alerts and tracking.

“By and large, pothole detection and reporting comes entirely from people encountering the road hazards themselves and reporting them,” Jahanshahi said. “As a result, the potholes are almost always only reported on once they have already become a problem. With this device and reporting program, cities and counties will be able to respond to a developing pothole before it becomes an issue.”

Jahanshahi said that in addition to identifying and reporting on potholes, the device and the AI algorithm his team developed can also provide color-coded details such as size, depth, and growth of damaged areas.

Civil engineering PhD student Yu-Ting Huang developed the autonomous AI for the device.

“One of the biggest reasons why roads across the United States are damaged is due to lack of inspection,” Huang said. “If we can improve both the accuracy and frequency of inspection, we should see a dramatic increase in road quality throughout the country.”

The other bonus to this system, Huang said, is the opportunistic data collection and processing through crowdsourcing and internet-of-things that this system provides to improve road conditions in future smart cities.

“With manual inspections as they are now, it is both time-consuming and dangerous for people to keep track of road damage,” she said. “With this system, consistent, detailed reports can be made while ensuring a greater degree of safety for everyone who uses and inspects these roads.”

Jahanshahi said his team is currently working with the city of West Lafayette to test out implementation. From there, he said, they aim to gather more data and further improve their hardware and software.

“This is a pretty exciting point in our work,” Jahanshahi said. “We’re going from testing on a small scale to something much larger — which could potentially lead to seeing a dramatic improvement to this country’s infrastructure.” This work received the second place award in the best student paper competition by the ASCE Structural Health Monitoring and Control Committee at the ASCE Engineering Mechanics Institute (EMI) Conference 2022.

REDEFINING FLOOD ZONES

IMPROVEMENTS IN FLOOD MODELING WILL MORE ACCURATELY ASSESS DEGREE OF RISK

Flood risk determination in the United States needs far greater attention to the details, Purdue University researchers say.

Venkatesh Merwade, Professor of Civil Engineering with courtesy appointment in Agricultural and Biological Engineering, leads a research team that aims to improve flood modeling and prediction for the United States. The team seeks to accomplish this by finding ways to create better and more accurate information on flood prediction and risk, and by proposing methods for improving prediction by federal agencies.

Flood Insurance Rate Maps (FIRMs) managed by Federal Emergency Management Agency (FEMA) have been providing ongoing flood information to most of the communities in the U.S. over the past half century, Merwade said. However, the uncertainty associated with the modeling of FIRMs may adversely affect the reliability of flood predictions.

"Currently, the flood maps we use come from FEMA and many people buy flood insurance based on these maps," Merwade said. "Areas are either inside the flood zone lines or they are out — and that determines whether or not one is required to buy flood insurance. These static maps have a lot of uncertainty to them. "

Civil engineering PhD student researcher Tao Huang is working on gaining a better understanding of flooding risk and implications to society.

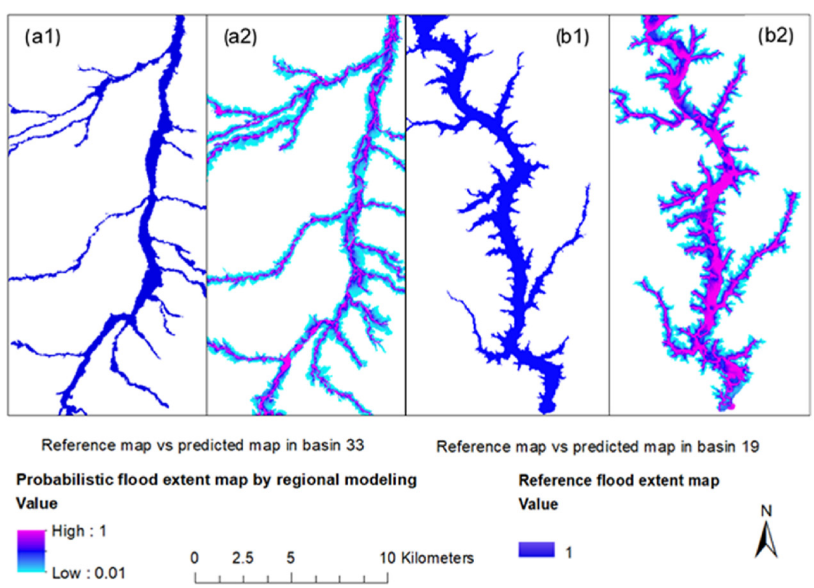
"Risk is assessed by the probability of inundation," Huang said. "It does not account for where people live. Right now, areas with no human population are being perceived as facing the same flooding consequences as cities with large populations."

Merwade said a systematic understanding of the uncertainty in the modeling process of FIRMs is necessary. To resolve this uncertainty, Merwade's research team has opted to the use Bayesian model averaging — a statistical approach that can combine estimations from multiple models and produce reliable probabilistic predictions.

"We cannot continue to base flood zones on lines on a map and a simple 'it is either in or out' approach," Merwade said. "Your risk from floods increases and decreases greatly depending on how close you live to flood-prone areas. We need to account for the probabilities and determine the degrees of risk. Flood risk cannot be something as simplistic as whether or not you live on one side of a map line."

Merwade said he expects to produce his findings in 2023.

> "WE CANNOT CONTINUE TO BASE FLOOD ZONES ON LINES ON A MAP AND A SIMPLE 'IT IS EITHER IN OR OUT' APPROACH."
>
> ***—Venkatesh Merwade***
> *Professor, Lyles School of Civil Engineering*



Jinglin Jiang and Brandon Boor

HAZARDS LURK
IN FRESH-SCENTED CLEANING PRODUCTS

Mopping produces pollutants similar to vehicle emissions

The fresh-scented products used to clean our homes and offices come with risks to our respiratory health. The chemicals used to create scents such as lemon and pine pollute indoor air with nano-sized particles in similar ways that motor emissions affect the air we breathe outdoors, according to a new study published in the journal *Science Advances*.

"It's not only the direct emissions released from these various cleaning products, but also the different chemical reactions that can occur in the air," said Brandon Boor, associate professor of civil engineering and an author on the study. "These are very reactive molecules that contribute to outdoor air pollution and smog. We wanted to investigate whether the same chemical transformations were occurring inside buildings and if so, what concentrations of secondary pollutants are produced."

The chemical compounds limonene and alpha-pinene are added to many common household products such as cleaning and personal care products, air fresheners, candles and aromatherapy products to create a pleasant scent. They're also found in nature — limonene in citrus peels and alpha-pinene in pine trees. It's when the chemicals are released and mixed with ozone that they react and become dangerous.

The experiment, conducted in partnership with researchers at Indiana University, took place within a contained room that replicated a typical indoor office environment. Cleaning products were used to mop the floor and wipe down tables and other surfaces. The researchers then measured the volatile organic compounds present in the air for 90 minutes after cleaning.

"People in the United States spend more than 90% of their time indoors, especially during a pandemic," said Jinglin Jiang (MS'18), a PhD student in civil engineering who ran the data analysis on the study. "By creating a well-controlled indoor environmental system, we can calculate the emission rate for these indoor pollutants and extrapolate to different indoor environments."

The researchers found that mopping and cleaning under normal conditions indoors creates high concentrations of radicals in the air, initiating a chain of complex chemical reactions that ultimately form small nano-sized particles called ultra-fine aerosols. This process of new particle formation has been widely studied in outdoor environments, but less so indoors. Data from this study suggests the average person would breathe in about 1 billion to 10 billion nanoparticles each minute. That level of pollution is equivalent to emissions produced by vehicle traffic in a large city.

These ultra-fine aerosols have the potential to penetrate deep into our respiratory system and then be transported throughout the body, possibly causing cardiovascular health issues. Although outdoor air quality is regulated because of its impact on public health, indoor air quality remains largely unregulated.

"There are two ways to minimize the harmful effects when using these cleaning products," Jiang said. "Creating a better control strategy for the indoor ventilation system to dilute the pollutants and wearing personal protective equipment, such as N95 face masks."

Renovating ventilation and filtration systems is costly and unlikely to occur on a widespread basis without governmental enforcement, much like the Clean Air Act curbing outside emissions when it was passed in 1963. Individuals who work as custodians or house cleaners face the highest risks due to prolonged exposure to aerosols at high concentrations. Futher, they may not have a choice in the type of products they use. When you do have a choice, Boor suggests avoiding use of limonene and alpha-pinene products as much as possible.

"We need to consider the long-term, cumulative effects of repeated exposure to chemicals and aerosols produced by scented household products," he said. "The mindset is that when you smell these pleasant aromas, you think 'the house is clean.' But clean air should have no scent."

WE NEED TO CONSIDER THE LONG-TERM, CUMULATIVE EFFECTS OF REPEATED EXPOSURE TO CHEMICALS AND AEROSOLS PRODUCED BY SCENTED HOUSEHOLD PRODUCTS.

TREE SEGMENTATION

New methodology may one day map forests around the world

What if we could map every tree on the planet? It's a question that drives the work of Joshua Carpenter (MS'20), a PhD student and researcher in the Geospatial Data Science Lab supervised by Jinha Jung, Assistant Professor of Civil Engineering. Just as the field of precision agriculture uses high technology sensor and analysis tools to measure the growth and health of fields of crops, Carpenter is developing methodologies that could one day be similarly applied to forests around the globe.

"In the field of geomatics, we believe if you want to understand something, you have to be able to put it on a map," Carpenter said. "While our discipline is rooted in traditional surveying, technology such as GPS satellites, imaging satellites, UAVs and LiDAR allow for many more applications beyond construction. I'm interested in applications to trees because it's an area that's hardly studied and trees are highly important to civilization."

Trees are important in developing products, supplying lumber and fuel. They're also important for the ecosystem and the environment, providing habitats and nutrients for animals, birds and insects. Understanding the health of individual trees would allow for better management of invasive pests such as the emerald ash borer or the deadly blight that has nearly eradicated the American chestnut. Mapping trees can also provide critical information used to mitigate forest fires and protect natural resources.

Mapping every tree on the planet is a gargantuan task, one that Carpenter hopes might be achieved within his lifetime. Right now, he's focused on mapping 500 acres of Martell Forest, a University-owned outdoor lab managed by the Department of Forestry and located about seven miles west of campus.

Using an unmanned aerial vehicle (UAV) to fly over the forest and take high resolution images enables Carpenter to map items down to the centimeter. But it's not a scalable solution. Covering larger areas requires the use of satellite data, but the resolution of images obtained by satellite is much lower and doesn't accurately depict tiny features. Several trees might be represented within a single pixel. The challenge is finding a method to map small things from low resolution data.

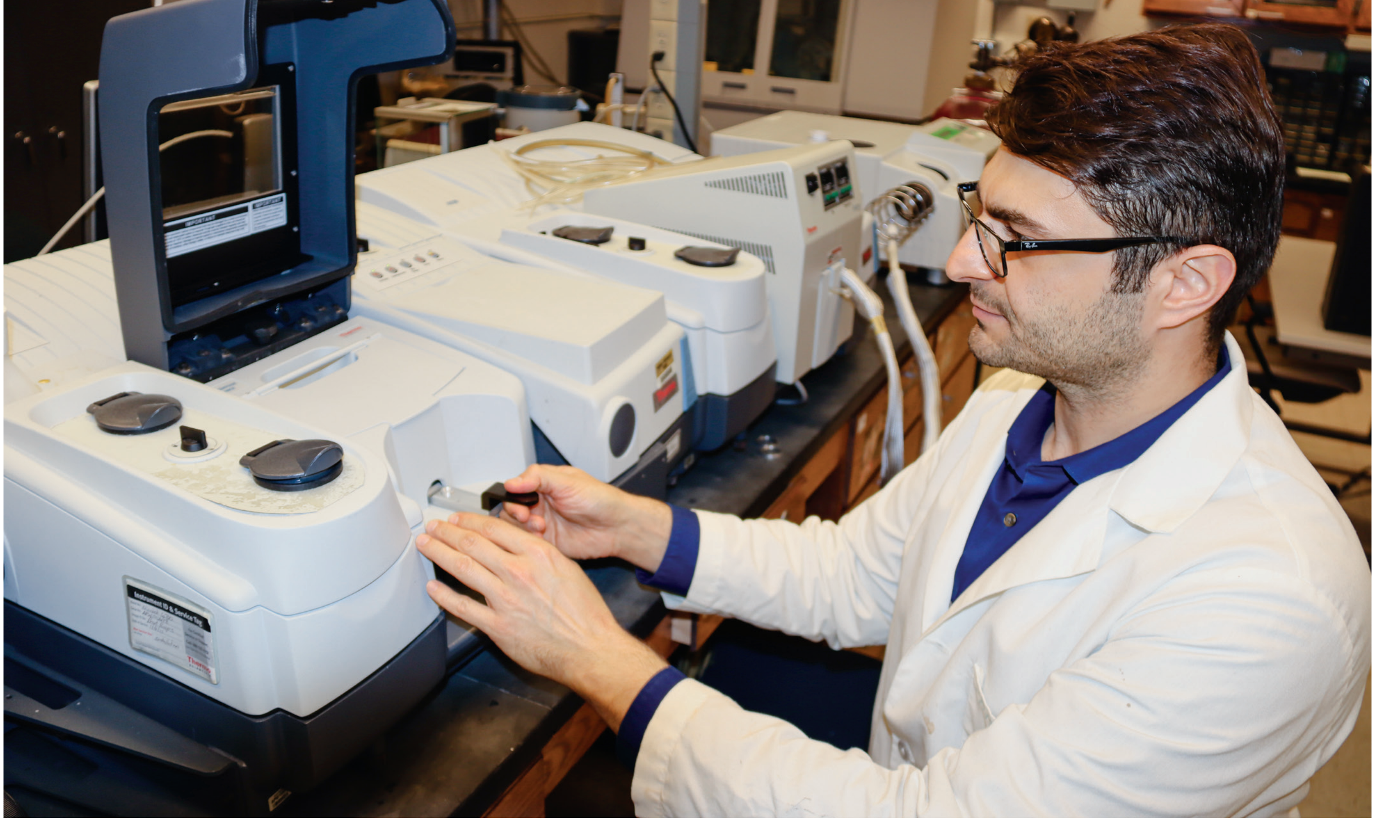
"What we're trying to do at Martell is build a data set that will serve as a ground validation," Carpenter said. "We have high resolution data. We also have low resolution data. We're trying to bridge the gap between the two."

On this project, Carpenter and Jung are partnering with Songlin Fei, professor of forestry and natural resources and director of the Integrated Digital Forestry Initiative which leverages digital technology and multidisciplinary expertise to measure, monitor and manage urban and rural forests to maximize social, economic and ecological benefits.

The team plotted 100 points scattered throughout Martell and then used a laser scanner to create a point cloud of the trees within 100 feet of each point. That generates a super high resolution data set to describe the trees within that small cluster in the middle of the forest. Then, a UAV was flown over the forest a few times during the season to take pictures of the trees. The data obtained from the UAV covers the entirety of the forest in high resolution, although not as high resolution as what can be obtained with the laser scanner.

Analyzed together, the data sets create validation data that can be used to study how each tree expresses itself in even larger data sets such as those obtained by satellites. Carpenter then developed a series of algorithms that identify individual tree trunks within a point cloud. By mimicking the method that certain trees grow, the algorithm can interpret data in the point cloud to map the rest of the tree, segmenting out individual trees.

"This technology is going to be very useful," Carpenter said. "It's a major step towards automating how we monitor the health of the world's forests and manage disease and wildfires. We'll be able to identify which species are thriving and which are dying across different climates. I'm still an engineer even though I'm working on forests. So it's the thrill of finding a solution to a problem that excites me."



A MULTIDISCIPLINARY EFFORT

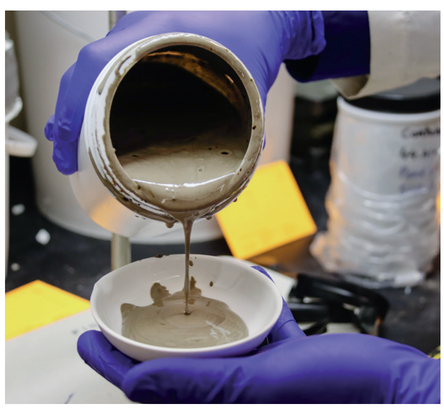
GEOTECHNICAL ENGINEERING AND SOIL CHEMISTRY RESEARCHERS PURSUE LONG-TERM SOLUTION FOR OIL SAND TAILINGS

A multidisciplinary effort between Purdue University's Lyles School of Civil Engineering and the Departments of Agronomy and Earth, Atmospheric, and Planetary Sciences aims to contribute to the design of practical engineering solutions for the safe long-term management of Canada's oil sands tailings ponds.

Tailings ponds are engineered dam and dyke facilities used to store fluid fine tailings. These tailings are high water content waste byproducts of oil sands mining. Currently, there are more than 1 billion cubic meters of fluid fine tailings in northern Alberta. And with each passing year, the volume of these ponds only continues to grow.

"Right now, the volume of tailings could just about canvas all of Chicago," said Cliff Johnston, professor of soil chemistry. "These tailings are like a milkshake made of around 30 percent clay and 70 percent water with organic materials in it. You can literally see these ponds from space."

One of the most effective paths to improving the situation involves treat-



ing these tailings with water-soluble polymers to accelerate their dewatering for final integration into reclaimed landscape. "Despite the wide application of this methodology, the mechanisms that control the effectiveness of the treatment are not completely understood, and many questions remain regarding the long-term properties of the unique geomaterial created as a result of the treatment" said Marika Santagata, associate professor of civil engineering.

Mohammadhasan Sasar, a geotechnical engineering PhD student, explained that this is due to "the complex and variable nature of the tailings, and the many factors that come into play, including water chemistry, type and amount of polymer added and amount of mixing energy applied in the field."

Sasar has been working with Santagata and Johnston on understanding the interplay that exists between the chemistry of the polymer treated tailings and their short-term and long-term structure and engineering properties. The complex nature of the research required an incredible amount of cooperation between departments.

"Without the interdisciplinary efforts between our group in civil engineering and the soil chemistry laboratory in the Department of Agronomy, this would have been far too complex of an issue to tackle," Santagata said. "Study of polymer-clay-organic interactions, and characterization of these ultra-soft geomaterials required expertise in multiple disciplines."

The research team is now working to share their results with the professional community.

IMPROVING INVENTORY ESTIMATES

LIDAR SCANS ACCURATELY MEASURE INDIANA'S SALT STOCKPILES

Through the implementation of Light Detection and Ranging (LiDAR), Purdue University researchers seek to greatly improve the stockpile volume estimation in salt barn facilities.

Since early 2021, the research team lead by Ayman Habib, the Thomas A. Page Professor of Civil Engineering, and Darcy Bullock, the Lyles Family Professor of Civil Engineering, has conducted more than 90 scans at 30 unique facilities throughout Indiana. The salt, which costs $100 per ton, is used to de-ice Indiana's roadways — amounting to around $100 million spent annually.

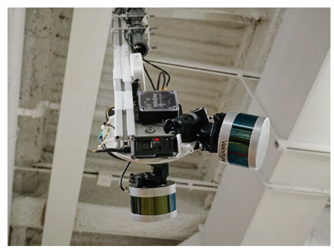
"The need of these salt storage sites is great to ensure clean and safe travel in the state — especially in winter," said Habib. "Winters can be unpredictable and states like Indiana always need to be prepared to deploy salt trucks — which means they need to also be sure that they have enough salt in their storage facilities."

Until their research began, INDOT relied on its inspectors to keep track of their salt inventory through visual monitoring. This could result in a significant variance between different inspectors.

"The inspectors are experts at tracking volume, but it still ultimately comes down to their experience and a bit of guesswork," civil engineering PhD student Justin Mahlberg said. "A discrepancy between two inspectors of different experience levels could result in possibly as much as a 50-ton difference."

With that in mind, the research team set up LiDAR sensors and took inventory at 30 unique storage sites. Through repeated scans, researchers were able to create a point cloud that accurately estimated the volume of salt within a 1% to 3% margin of error.

"This new system allows for the state to not only keep a far more accurate inventory, but it could result in future savings due to the accurate data," civil engineering PhD student Raja Manish said.



Habib said the next step in research is to install permanent LiDAR cameras in the storage facilities to ensure consistent, accurate measurements.

"We've already installed cameras in a few of the facilities that scan the area, but many of the tests were done with a tripod-mounted camera," Habib said. "We're excited to see this work move along so well with such strong results. This is a tremendous boon for both INDOT and Indiana's millions of drivers."

Date	03/30/2022
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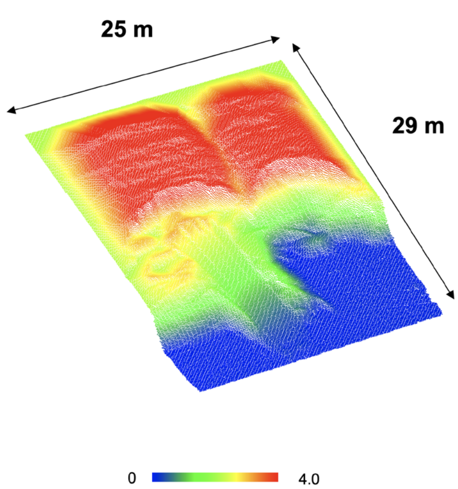


Occlusion percentage: 27.77%

Image of Data Collection from GoPro Camera

BUILDING A BETTER WORLD

A FRIENDSHIP FORMED AT PURDUE INSPIRED ALUMNUS DRAKE KROHN TO SUPPORT SPECIAL OLYMPICS

Purdue Civil Engineering is often the first choice for its students. For alumnus Drake Krohn, it was his only choice.

A southern Indiana native, Krohn — like many aspiring engineering students — grew up with a strong interest in math, science and building things. And when it was time to choose a university, he had one — and only one — place in mind.

"Looking back on it, it definitely wasn't the wisest decision to make and I wouldn't recommend anyone do it, either," Krohn said. "But Purdue was the only university I applied to. It's where I knew I wanted to go to study engineering. It's funny because I've always seen myself as a very rational person, but, for me, it just made sense to do this."

Krohn's determination served him well as a student in the Lyles School of Civil Engineering. With a focus on transportation engineering, he earned his bachelor's degree in 2015 and his master's in 2017 while researching with Darcy Bullock, the Lyles Family Professor of Civil Engineering.

"My experience at Purdue and my time working with Professor Bullock were some of the best years I've ever had," Krohn said. "Civil engineers — and especially those in transportation — have such a huge impact on the world and its future. Ensuring safe travel and creating new ways for people to travel are absolutely vital for our future."

Krohn now works as a project engineer in the Chicago office for Jacobs, an international engineering company. There, he is part of the airfield expansion team for the Chicago O'Hare International Airport. The team is currently working to create additional terminals following the construction of new runways.

In addition to his work, Krohn's interest in aiding and improving the community extends beyond his career. Since his time at Purdue, Krohn has actively volunteered with the Special Olympics and works closely with the Special Olympics of Illinois.

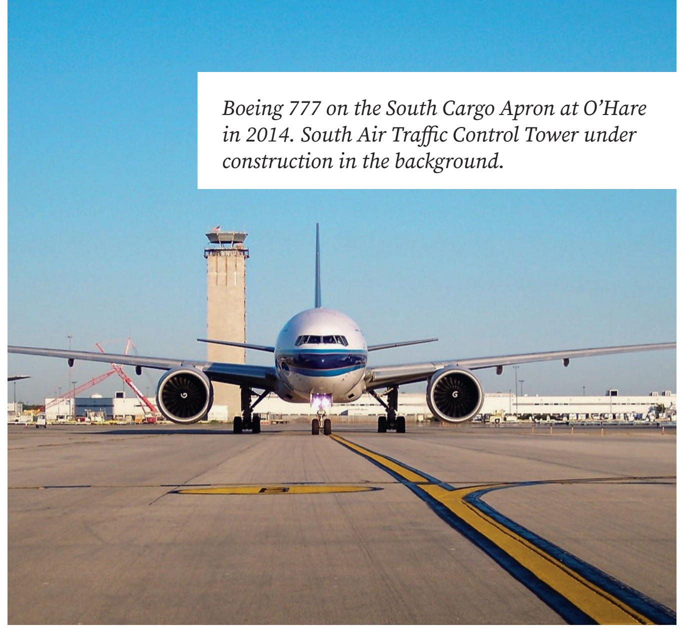
He got involved in special needs programs like the Special Olympics and Best Buddies due to a friendship he made his sophomore year at Purdue.

"By random chance, I happened to eat lunch right around the same time as Ryan, an employee of the University's dining services who has special needs," Krohn said. "We ended up having lunch together every day and became friends. From there, I learned more about special needs programs and I realized it was something I wanted to be a part of."

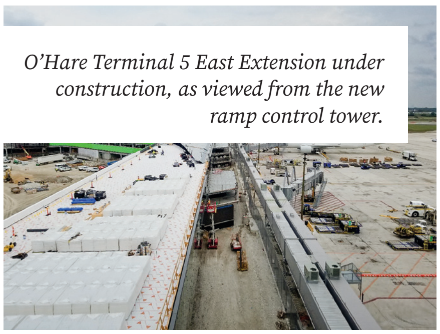
Krohn said it just "made sense" to volunteer. Because — like his interest in civil engineering — it all stems from a desire to make the world a better place.

"It's a wonderful program that gives people with special needs the opportunity to shine," Krohn said. "I've always had an interest in being part of something bigger than just myself. I guess that's why civil engineering always appealed to me."

Parking lot construction at DuPage Airport, with Gulfstream G200 in the background.



Boeing 777 on the South Cargo Apron at O'Hare in 2014. South Air Traffic Control Tower under construction in the background.



O'Hare Terminal 5 East Extension under construction, as viewed from the new ramp control tower.

O'Hare Terminal 5 East Extension Interior under construction.

Drake with Harry and Mitchell, Special Olympics Athletes, at the 2019 O'Hare Plane Pull, a fundraiser for Special Olympics Illinois.

Drake and Ryan at Wiley Dining Court on Purdue's campus. The two met at Wiley when Drake was an undergraduate. Ryan has worked at Wiley since 2012

Drake at Purdue Aviation, where he obtained his private pilot's license as an undergraduate.

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