LSU

Department of Civil & Environmental Engineering

CEE IN FOCUS

Fall **2022** • VOLUME **22** • NUMBER **1**

FROM THE DEPARTMENT CHAIR

The National Student Steel Bridge Competition is an annual event in which student teams from colleges across the country design, fabricate, and assemble a 1:10 scale steel bridge. In the spring of 2022, the LSU Steel Bridge Team took first place at the regional symposium at Auburn University, sweeping nearly every category. The team has enjoyed consistent success in the last few years, including national finals bids three seasons in a row. It is now preparing for an exciting 2023 season.

During the Fall 2022 semester, Dr. Kofi Christie joined the LSU Department of Civil and Environmental Engineering as a tenure-track assistant professor. He previously held a Presidential Postdoctoral Research Fellow at Princeton University in the Andlinger Center for Energy and the Environment and the Department of Civil and Environmental Engineering. He recently obtained his PhD in Environmental Engineering from Vanderbilt University, and his research is primarily focused on a thermal separation process called membrane distillation (MD), in which a hydrophobic and microporous polymer membrane is used to assist in the separation of pure solvent from a feed stream of dirty water.

Dr. Yen-Fang Su also joined our department in the fall of 2022. He is in the area of structural engineering. He obtained his PhD in Civil Engineering from Purdue University and also had an appointment as a postdoctoral research associate at the University of Cambridge in the United Kingdom. His research focuses on additive manufacturing, the design of innovative structural materials, and novel-sensing technology in civil engineering. The industrial applications of his research have definite and transparent applications to improving efficiencies, safety, and structural integrity of our own buildings and infrastructure and further reducing the environmental impact of the construction industry, as well as significant international commercial applications offering substantial economic benefit to the US.

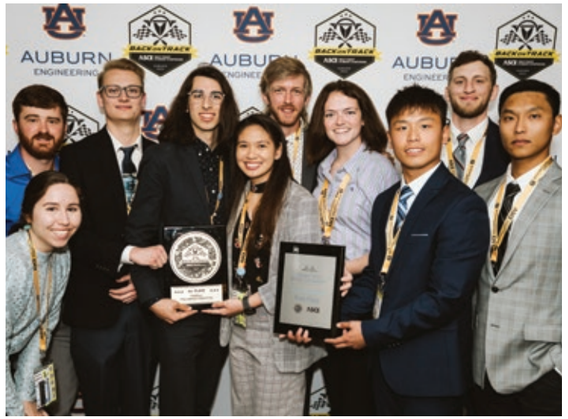
We are highlighting in this newsletter the state and federal grants that some of our faculty recently received. Dr. Sam Snow received from the National Science Foundation a CAREER Award grant that could lead to new water treatment technology. By aiming to design the first smart ultraviolet (UV) LED systems using the new UV colors available with LEDs and their ability to pulse on and off quickly, this technology would offer numerous benefits to people across the world, including cheaper and better treatment of wastewater and new handheld devices that clean drinking water in remote places. LSU Civil and Environmental Engineering Assistant Professors Aaron Bivins and Samuel Snow have a $497,000 grant from the US Environmental Protection Agency to measure the amount of fecal contamination in two Louisiana rivers, find out where the contamination is coming from, and offer solutions on how to prevent it.

Dr. Hany Hassan recently received a grant from the Louisiana Board of Regents. He is an assistant professor in transportation engineering in the LSU Department of Civil and Environmental Engineering and is studying strategies to maximize the benefits of truck platooning on US highways.

Dr. George Z. Voyiadjis, D.Eng.Sc.,
Boyd Professor
Chair and Bingham C. Stewart
Distinguished Professor of Engineering

DEPARTMENT NEWS

STEEL BRIDGE TEAM MAKE IT A TRIFECTA



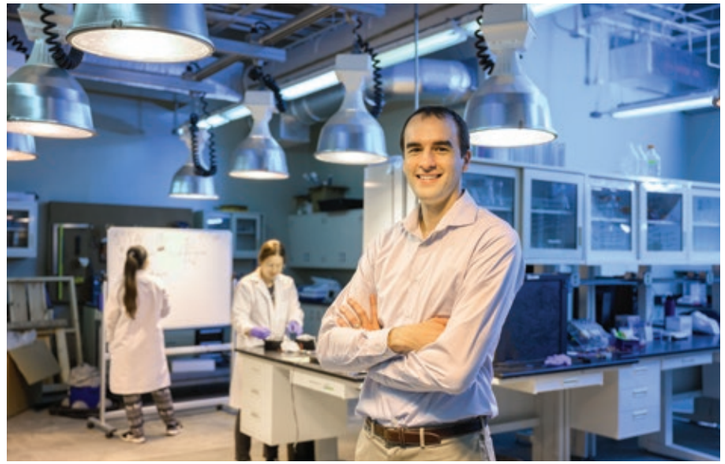
The LSU Steel Bridge Team is back gearing up for what is sure to be an exciting 2023 season but not before celebrating a successful last three years, including national finals bids three seasons in a row.

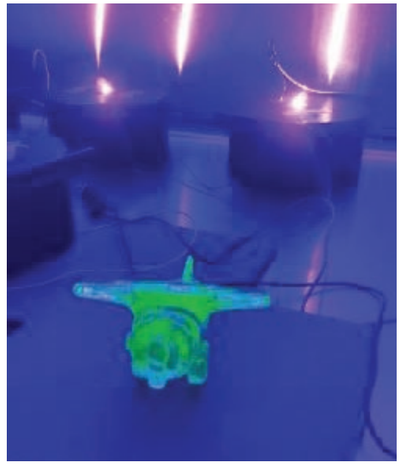
The National Student Steel Bridge Competition is an annual event in which student teams from colleges across the country design, fabricate, and assemble a 1:10 scale steel bridge. In the spring of 2022, the LSU Steel Bridge Team took first place at the regional symposium at Auburn University, sweeping nearly every category. The team then advanced to the national finals for the third year in a row and traveled to Virginia Tech at the end of May. The Steel Tigers took 10th place overall out of several hundred entries and won second place in the video entry competition. Though the team is extremely competitive, being a part of Steel Bridge is more than the awards and trophies. It is an educational, enriching, resume-building experience with a close-knit team that feels like family.

The Steel Bridge competition team helps students develop important skills that they may not have the opportunity to in a typical class. In the shop, everyone learns to safely operate the powerful tools used in the fabrication and modification of the bridge. On the build team, communication is key. Builders need to be loud and assertive, something that doesn't come naturally to all students. During the design phase, everyone's voice is heard, and all are invited to present ideas, including those who don't have deep knowledge of steel design. Students learn to think creatively and learn real-world applications to the formulas in their textbooks.

Another exciting part of the Steel Bridge experience is the travel. Competing in the regional and national competitions is the culmination of the team's dedication and hard work throughout the year. Traveling together is a very rewarding experience for students and strengthens the team's chemistry greatly. For the 2023 season, the regional competition will be held at the University of South Alabama in Mobile, and the national finals will be at the University of California-San Diego.

SNOW'S CAREER AWARD COULD LEAD TO NEW WATER TREATMENT TECHNOLOGY





For the last few decades, LEDs, or light-emitting diodes, have been in common use in light bulbs and electronics. And more recently, researchers have made LEDs that can shine high-energy ultraviolet, or UV, rays, providing a new tool for water treatment technologies.

LSU Civil and Environmental Engineering Assistant Professor Samuel Snow takes this a step further by aiming to design the first smart UV LED systems using the new UV colors available with LEDs and their ability to pulse on and off quickly. This technology would offer numerous benefits to people across the world, from cheaper and better treatment of wastewater to new handheld devices that clean drinking water in remote places.

It's all part of Snow's project, "Accelerating Sustainable Water Treatment Using Smart Ultraviolet Light Emitting Diodes," which just received a National Science Foundation CAREER Award in the amount of $534,860.

"Most people will never notice when water treatment technologies improve, because it will only be a small change on water utility bills at the end of the day," Snow said. "In effect, the technologies will make it cheaper to clean our drinking and wastewater before use or discharge. The advances do, however, provide opportunities for some new handheld technologies.

"There are already some personal-scale water treatment devices available for hikers and disaster relief which use UV technology. Our work should help us design better tools of this sort which make use of the LED advancements."

How exactly would it do that? First, the new colors of light in the UV range will allow for more control of which types of chemical oxidants are produced using UV-driven advanced oxidation processes. Snow's project seeks to find out what water and/or wastewater conditions will benefit the most from these new oxidant choices.

Second, the ability to pulse on and off LEDs instantly is promising, because other fields, including the food safety industry, found efficiency gains when applying pulsed irradiation for disinfection.

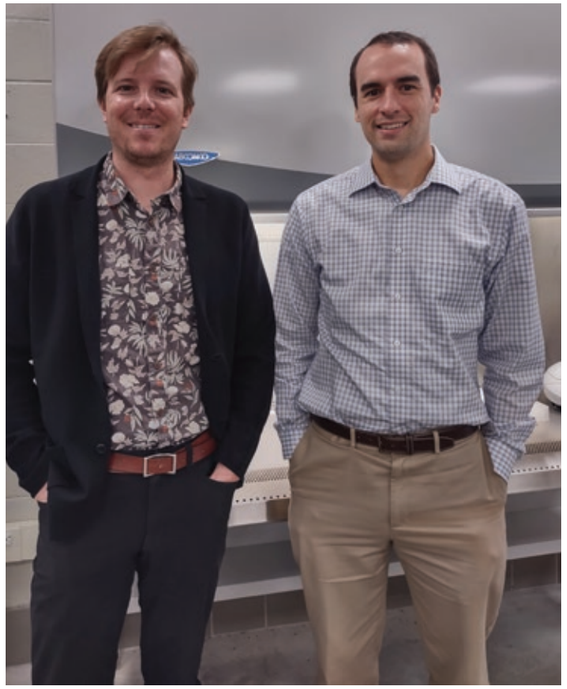
"We want to explore why these efficiency gains exist and whether they are important in water treatment," Snow said. "We also think that by applying pulses of light, we can use high-intensity pulses while keeping the LED cool enough to maintain better efficiency and long lifetimes.

"We believe we are some of the first…to look specifically at the pulsed application of UV LEDs in these research aims."

Snow added that this research will engage local middle and high school students in scientific learning activities and send college students to developing countries to test new devices during study abroad trips while training graduate students to perform cutting-edge experiments.

CEE FACULTY MEASURE, WORK TO ADDRESS CONTAMINATION IN LOUISIANA RIVERS

Even though temperatures will soar into the 90s this summer, Louisianans may want to think twice before jumping into a few local rivers to cool off. LSU Civil and Environmental Engineering Assistant Professors Aaron Bivins and Samuel Snow have a $497,000 grant from the US Environmental Protection Agency to measure the amount of fecal contamination in two Louisiana rivers, find out where the contamination is coming from, and offer solutions on how to prevent it.



The Yellow Water and Natalbany rivers, which run between Baton Rouge and Hammond, have always been on the state's Impaired Waters list for fecal coliforms, and neither river has ever met the standard for secondary contact recreation, such as swimming. This prompted Bivins and Snow to request the grant from the EPA. As part of their project, Bivins and Snow will take samples from eight sites along both rivers and measure the markers to figure out where the fecal material is coming from.

"The LDEQ (Louisiana Department of Environmental Quality) has some ideas about where it might be coming from, but I'll be able to say if it's human, pigs, deer or cows," Bivins said. "By taking different measurements, we'll be able to tell community leaders if half of the contamination is coming from human sewage and other percentages from animals.

"Traditionally, what we've done to measure water quality is measure E. coli or other bacteria, but the thing about E. coli is every warm-blooded mammal sheds the bacteria in their feces, so if you find it, it doesn't tell you where to go to fix the problem. The advantage of source-tracking markers is to identify the exact source of the contamination."

According to Bivins and Snow, many people who live near the Yellow Water and Natalbany Rivers use aerated treatment units for the waste at their homes, which means poorly treated sewage could be running into the rivers, with the possibility that much of it is discharged by non-point sources. Snow is using UV-LED technology in his lab to see if the water coming out of these wastewater systems can be disinfected.

"Septic tanks are normally used by those without a line to a sewer treatment plant, but these communities don't have the option for a septic tank because the ground on their property may have a high water table or non-percolating ground," Snow said.

Snow proposes creating a much smaller version of a disinfection unit by using UV-LEDs to break down the waste.

"DEQ regulates the big treatment plants but has no jurisdiction over private homes," he said. "Louisiana Department of Health gets that task. Legally, homeowners are doing the right thing by dumping waste into their front yard or ditch. Our concept is to create a smaller, affordable, effective disinfection step that could handle a situation where the wastewater treatment system has not been maintained very well."

Bivins and Snow are working with Pontchartrain Conservancy, based in New Orleans, whose reports show that there are as many as 500 permitted discharges into the rivers in and around Hammond. During previous studies, Pontchartrain Conservancy went to these waterbodies looking for discharges and found at least 80 more sources that were not permitted.

"Pontchartrain Conservancy will lead the community engagement work, and whatever we find gets fed back into the decision-making process and back into the community," Bivins said. "One of the things that's unique about this project is our engagement with local stakeholders and decision makers. We're actually getting to work with Pontchartrain Conservancy and Tangipahoa Parish to answer questions that are most relevant to their needs. To be able to interface with the community in a way that's practical and helpful is very rewarding."

While Pontchartrain Conservancy has had several successful projects to improve water quality in Louisiana watersheds, it is excited to work with new, innovative approaches coming out of world-class research led by LSU.

"Onsite wastewater systems have long been problematic for Louisiana's waterways and have been a contributing cause to the degradation in using these resources for recreation," Pontchartrain Conservancy Executive Director and LSU College of Engineering Alumna Kristi Trail said. "What is incredibly exciting is the prospect that this research will have to identify sources and reduce the contribution of pathogens at the source."

"It's going to be great for everyone, not only in the US, but also in developing countries where a small-scale treatment system could actually be a big improvement," Snow said. "It's pretty rare for academics to have this opportunity, so we're both very excited about this project."

Bivins and Snow plan to meet with city officials one-on-one while the DEQ is currently working to improve the water quality in these watersheds.

LSU EXPERTS WEIGH-IN ON RECORD LOW MISSISSIPPI RIVER LEVELS

LSU students in Kory Konsoer's Geography Field Methods course visit the historically low Mississippi River, and the unearthed ferry.

In the month of October, the Mississippi River has seen record low levels from Illinois to Louisiana. In Baton Rouge, the level is revealing a more than 100-year-old sunken ferry and the underbelly of the USS Kidd.

"While this is the time of the year when the river levels are usually low, we typically do not see anything this extreme. At least five or six locations along the river, including Mississippi, Arkansas and Missouri are seeing historically low-water levels," said Clint Willson, the director of the LSU Center for River Studies and the Mike N. Dooley, PE Professor of Civil & Environmental Engineering. "The reason for this is that a large percentage of the Mississippi River watershed, which covers approximately 42 percent of the contiguous United States, is either in a drought or is experiencing extremely dry conditions. Typically, in the fall, at least one or two of the major Mississippi River tributaries would be in 'normal' flow conditions and the river would not be this low."

Willson, and Kory Konsoer, LSU Department of Geography & Anthropology associate professor and Coastal Studies Institute Fellow, shares more insight on what the low-level means for the state and nation.

WHAT DOES THIS MEAN FOR THE ECONOMY OF THE COUNTRY?

Konsoer: An environmental impact, that could have economic consequences, is that the extremely low water levels are also allowing for saltwater intrusion from the Gulf of Mexico up the Mississippi River. Plaquemines Parish and New Orleans do use water from the river for municipal drinking water, so this saltwater wedge that is extending upstream is a cause for concern. The U.S. Army Corps of Engineers, or USACE, is constructing a sill on the river bed near Myrtle Grove, La. to block the wedge from moving upstream.

HOW DOES IT IMPACT INDUSTRY, INCLUDING TOURISM?

Willson: While the low river levels have forced some river cruises to be cancelled, the major economic impact is due to the restrictions on the barge traffic – a critical part of keeping products and commerce moving throughout the Mississippi River and its tributaries. Below Baton Rouge, the USACE maintains the navigation channel depth at a minimum of 50 feet. However, the navigation channel, above Baton Rouge, is maintained to a depth of at least nine feet. The nine-foot depth allows fully loaded barges, often connected to another 10 or more barges, to move up and down the river reliably and safely. However, the historically low river levels are restricting how much can be put on the barges and/or how many can be towed at the same time. This is having a tremendous impact on the nation's agricultural community since over 60 percent of our agricultural exports are transported down the river on barges. During normal conditions, these barges transport the exports to Louisiana-based ports, where they are loaded onto ocean-going vessels and then transported around the world. The inability to load barges and their reduced capacity is resulting in a backlog of grain and other products. While the major impact of this is on the agricultural community, the ripple effect will be felt by ports in the lowermost Mississippi that transfer the products to larger ships and countries around the world who rely on these exports.

CAN YOU DESCRIBE WHAT WE'RE SEEING NOW COMPARED TO THE USUALLY ROARING RIVER?

Willson: According to the United States Geological Survey data, since the beginning of October, the Mississippi River's discharge at Baton Rouge has been below 200,000 cubic feet per second, or cfs, and now is around 150,000 cfs. During years when the USACE has to open the Bonnet Carré spillway, located just up the river from New Orleans, the Mississippi River discharge is about 10 times higher, i.e., 1,500,000 cfs.

In terms of river levels, during the month of October, the Mississippi River in Baton Rouge is between 4 and 5 feet high. For reference, the flood stage of the river is 35 feet and the record high level is 47.3 feet.

WHAT DO THE SHORT- AND LONG-TERM WEATHER FORECASTS MEAN IN TERMS OF GETTING THE RIVER BACK TO IDEAL WATER LEVEL CONDITIONS?

Konsoer: Another cause for concern is that climatologists are predicting another La Niña year this winter from Dec. 2022 – Feb. 2023. This has the potential for drier than average winter months in many parts of the Mississippi watershed, setting up a situation where the water is not replenished for the high water season and water levels stay lower than average in the spring.

WHAT CAN BE DONE TO FIX THIS?

Willson: There isn't a lot that can be done, other than expedited dredging to deepen the navigation channel for these abnormally low river levels. The USACE typically has to dredge the navigation channel to keep the authorized depths, but the severity of the current conditions means that they are having to dredge more locations and/or to larger depths. That said, there are some efforts to get more water into the main river, such as the Tennessee Valley Authority's releasing more water from two of its dams to help supplement water levels on the Mississippi River. However, that is not a sustainable, long-term solution.

One thing to keep in mind is that little or none of the rain that falls in the greater Baton Rouge area goes to the Mississippi River. The stormwater runoff goes generally southeast towards the Amite River and then into Lake Maurepas and Lake Pontchartrain.

LSU's Scholarship First agenda places coastal research as among the top five of the university's strategic priorities. It also aligns science and engineering with arts and humanities toward better outcomes in each focus area, a key aspect of the evolving LSU 2030 Strategic Plan.

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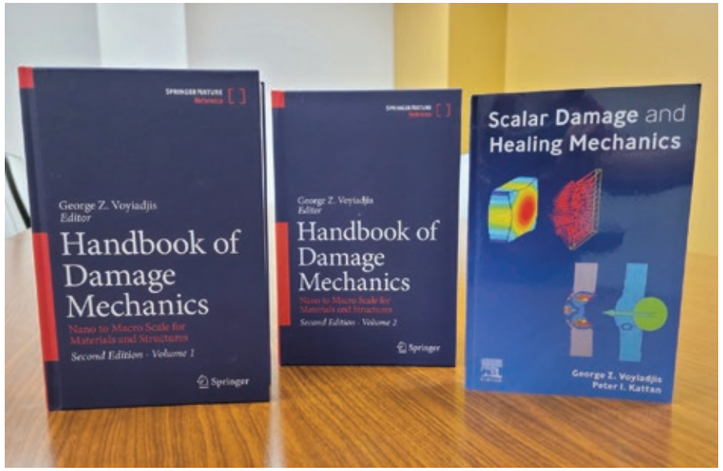
VOYIADJIS HAS PAIR OF BOOKS PUBLISHED



LSU Civil and Environmental Engineering Chair and Boyd Professor George Voyiadjis recently enjoyed the publication of a second edition of his books, Handbook on Damage Mechanics Volumes 1 and 2, by Springer Publishing and Scalar Damage and Healing Mechanics by Elevier Science.

In the seven years since the first edition of his handbook hit shelves, many advances have been made in the field.

1. Voyiadjis, G. Z., editor, Handbook of Damage Mechanics: Nano to Macro Scale for Materials and Structures, Second Edition 1375p., Springer Wien, New York, ISBN 978-3-030-60243-7 (print and electronic bundle), 2022. https://doi.org/10.1007/978-3-030-60242-0

"A need arises now for a second edition of the handbook," Voyiadjis said. "Damage characterization and mechanics is a broad and highly interdisciplinary field that has been continuously evolving in the last half century. A very select group of internationally recognized authors from both academia and industry and from three continents were selected to write 47 chapters on this topic and its various branches. There is currently one dedicated journal to this topic, as well as a handful of books and thousands of research papers."

Topics covered include the fundaments of continuum damage mechanics, composite damage mechanics, rock damage mechanics, micromechanical damage and healing for concrete, damage and failure of ductile metals, damage in brittle materials, damage for disordered materials, and damage in crystalline metals and alloys.

"One of the major features of the Handbook of Damage Mechanics is coverage of the latest research in the new topic of healing mechanics of materials," Voyiadjis said. "The second edition includes four chapters on this emerging subject. The fundamentals of continuum damage mechanics are presented in nine selected chapters in a section of their own. The handbook integrated knowledge from the theoretical, numerical, and experimental areas of damage mechanics. This book mainly targets graduate students of damage mechanics, researchers in academia and industry who are active or intend to become active in this field, and practicing engineers and scientists who work in this topic and would like to solve problems utilizing the tools offered by damage mechanics."

2. Voyiadjis, G. Z., and Kattan, P., Scalar Damage and Healing Mechanics, 541 p., Elsevier Science, USA, ISBN-13: 978-0128233399, ISBN-10: 0128233397, 2022.

Voyiadjis' other recently published work, Scalar Damage and Healing Mechanics, is the result of a recent upsurge and interest in the subject of damage mechanics, especially using a scalar damage variable. A high percentage of research papers published on damage mechanics employ a simplistic scalar approach. The reason for this is its simplicity and ease of implementation numerically in order to solve practical problems.

"Self-healing smart materials have emerged into the research arena and have been deployed in industrial and biomedical applications, in which the modeling techniques and predicting schemes are crucial for designers to optimize these smart materials," Voyiadjis said. "In practice, plastic deformation is coupled with damage and healing in these systems, which necessitates a coupled formulation for characterization. Another reason for writing this book is to introduce new concepts in damage mechanics. These new concepts either have appeared only recently in the literature or have never been published before."

Some selected chapters deal with basic issues of the damage variable and its decomposition. Chapters 16 and 17 cover the new concept of an undamageable material. Other emerging concepts in damage mechanics like the use of damage mechanics templates, self-regenerating materials, and other issues are not presented here but are left for a forthcoming edition of this book. There are more than 100 exercises at the end of each chapter for students to practice.

Voyiadjis is an expert in multi-scale modeling of size effects in materials with different methods of atomistic simulation and continuum-enhanced models, including gradient plasticity and gradient damage. His research activities of particular interest encompass macro- and micro-mechanical constitutive modeling, experimental procedures for quantification of crack densities, thermal effects, interfaces, failure, fracture, impact, and deflect nucleation and evolution in crystalline metals.

Voyiadjis is a Foreign Member of the Academia Europaea (Physics & Engineering Sciences), the European Academy of Sciences, and the European Academy of Sciences and Arts (Technical and Environmental Sciences). He is also a Foreign Member of both the Polish Academy of Sciences Division IV (Technical Sciences), and the National Academy of Engineering of Korea. He is the recipient of the 2022 American Society of Mechanical Engineers Nadai Medal, the 2008 Nathan M. Newmark Medal of the American Society of Civil Engineers, and the 2012 Khan International Medal for outstanding life-long contribution to the field of plasticity. He was also the recipient of the Damage Mechanics Medal for his significant contribution to continuum damage mechanics in 2015.

In 1980, Voyiadjis began his career at LSU as an assistant professor after working at the California Institute of Technology, where he earned his master's in civil engineering, and Columbia University, where he earned his PhD in engineering mechanics.

FACULTY NEWS

CEE FACULTY WELCOME DR. YEN-FANG SU

Dr. Yen-Fang Su joined the LSU Department of Civil and Environmental Engineering as a new faculty member this fall 2022. Previously, he was a postdoctoral researcher in the Department of Engineering at the University of Cambridge in the United Kingdom. Dr. Su earned his PhD at Lyles School of Civil Engineering at Purdue University–West Lafayette and before that, he worked as a structural engineer for several years. Dr. Su has conducted multidisciplinary structural engineering, materials science, and artificial intelligence-related research during his academic journey.

Previous Work

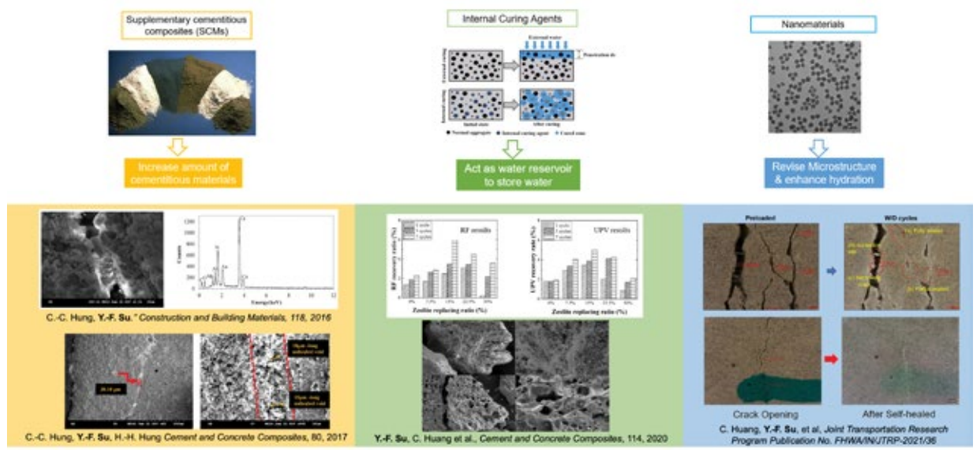
- **ADVANCED NON-DESTRUCTIVE TESTING METHOD FOR CONCRETE PROPERTIES EVALUATION**

Su's previous work has focused on developing a reliable instantaneous AI-guided piezoelectric sensing system to monitor in-situ concrete properties, including early-age strength gain and long-term structural health monitoring (SHM) for concrete structures. In his study, novel piezoelectric sensors coupled with the electromechanical impedance (EMI) method were utilized to address the problem. The software, coupled with a physics-informed statistic model and advanced machine-learning algorithms, was developed to optimize sensing performance. He also conducted large-scale slab experiments to validate feasibility and implemented this technology on interstate highways I-70, I-74, and I-465 in concrete paving and patching jobs. The projects have supported the Department of Transportation (DOT) in decision making to determine the optimal traffic opening time and long-term health monitoring. It was highlighted as an ASCE 2021 GameChanger Project. Owing to this project's high potential and significant interests, it was expanded to a large-scale transportation pool-fund research program with multiple states and federal agencies' participation.

The AI-guided real-time concrete sensing system.

- **MULTIFUNCTIONAL HIGH-PERFORMANCE CEMENTITIOUS COMPOSITES AND STRUCTURES**

Dr. Su has led several projects funded by the DOT and a collaborative project with a private material company in the concrete industry to study advanced multifunctional high-performance fiber-reinforced cementitious composites and nanomaterials in Accelerated Bridge Construction (ABC). In particular, the applications are for the bridge deck expansion joint or link slab to replace the conventional concrete. The study explores the feasibility of using advanced cementitious composites to: 1) accommodate tensile stress induced by thermal or flexural movement in structures and 2) heal the shrinkage cracks within one season cycle to eliminate potential issues of reinforcement corrosion and increase the durability of concrete. Moreover, he has conducted in-depth studies on the autogenous healing behavior of cementitious composites incorporated with supplementary cementitious materials, internal curing agents, and nanomaterials to improve the mechanical performance and sustainability of large-scale structural members such as beams and retrofitting jackets. In addition, he has also investigated the potential of leveraging the additive manufacturing method for cementitious composites with controlled rheological properties.



High ductility self-healing cementitious composites.

Current Work

Dr. Su joined the £5.9 million Resilient Materials for Life (RM4L) program funded by the Engineering and Physical Sciences Research Council (EPSRC) in the United Kingdom to develop biomimetic cementitious materials that adapt to their environment and develop immunity, self-diagnose damage, and self-heal when required for the structure. He's working on multiple research projects, including combining the data-driven approach and computational modelling to optimize self-healing and self-sensing materials and structure, leveraging additive manufacturing methods for smart-sensing materials, and digitizing structural systems using the IoT sensor array.

Future Work

Building upon his previous multidisciplinary research experience in structure and materials, Dr. Su plans to focus on 3D concrete printing for structural application, artificial intelligence, sustainable composite materials and structural systems, and advanced robotic-based structural health monitoring. His research aims to provide insights that can help solve practical engineering problems and understand the underlying mechanisms of concrete materials and structures under various conditions. The goal is to accelerate the development of next-generation sustainable, intelligent, and resilient structural systems against natural hazards such as hurricanes and earthquakes.

DR. KOFI CHRISTIE JOINS CEE FACULTY

During the Fall 2022 semester, Dr. Kofi Christie joined the LSU Department of Civil and Environmental Engineering as a tenure-track assistant professor. Before joining LSU, Dr. Christie was a Presidential Postdoctoral Research Fellow at Princeton University in the Andlinger Center for Energy and the Environment and the Department of Civil and Environmental Engineering.

His research focuses on the advancement of water treatment and desalination technologies to enable more efficient resource recovery and improve our understanding of fundamental nanoscale phenomena. Fresh water only accounts for roughly 2.5% of Earth's water resources, and the rapid growth of global populations expected over the coming decades has urged the improvement of processes that can make nontraditional water sources (i.e., brackish water, seawater, produced and extracted water, industrial wastewater) a sustainable alternative. Membrane technologies are expected to play a major role in this water supply augmentation.

Dr. Christie is primarily focused on a thermal separation process called membrane distillation (MD), in which a hydrophobic and microporous polymer membrane is used to assist in the separation of pure solvent from a feed stream of dirty water. Differing from processes like reverse osmosis or nanofiltration, which are driven by hydraulic pressure, the driving force for MD is a vapor pressure gradient across the polymer membrane, which is typically driven by imposing a temperature difference or by pulling negative vacuum pressure on the permeate side of the membrane.

MEMBRANE FOULING

Membrane-based separation is a long-standing area of interest for the selective collection of valuable resources (i.e., pure water, minerals, or chemicals). However, membranes are subject to fouling that typically results in a decrease in the rate of pure water production. A unique challenge to MD is the wetting of membrane pores when the feedwater contains a considerable level of amphiphilic molecules or low-surface-tension, water miscible contaminants. Fortunately, these problems can be satisfactorily addressed either by extensive pre-treatment of the feedwater and/or by using novel membranes with special wettability. What remains to be an important challenge is membrane scaling, which is particularly problematic if MD is to be used in its most promising application of recovering water from hypersaline wastewater. By elucidating the key differences between common scaling pathways (Figure 1), we can design and fabricate better membranes to maximize water recovery.

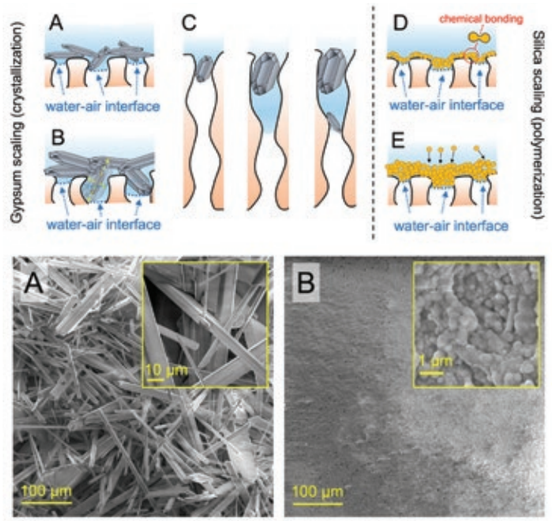


Figure 1 – Schematic illustration of the scalant growth process on porous membrane substrates during separation of high-salinity feed solutions saturated with gypsum (left) or silica (right).

DESIGN AND FABRICATION OF POLYMERIC MATERIALS

Recently, superhydrophobic MD membranes have been explored as an effective material design strategy for fouling mitigation from nontraditional water sources. The two major requirements for fabricating a superhydrophobic membrane, or, more generally, a superhydrophobic surface, are that: (1) the material has low surface energy and (2) the surface has a high degree of roughness. By using techniques such as intercalating micron-sized clusters of silica nanoparticles (SiNPs) within a matrix of polymeric nanofibers, superior fouling resistance can be obtained (Figure 2).

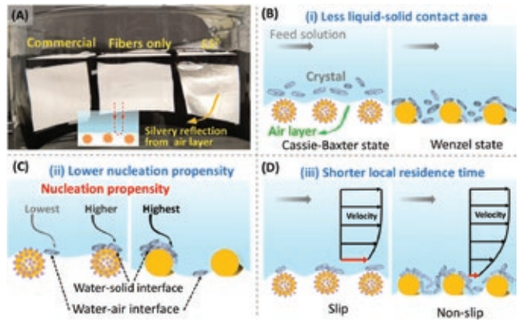


Figure 2 – (A) Photos of the submerged commercial PVDF membrane (left), electrospun PVDF-HFP fibrous membrane (center), and r-SH membrane fabricated using ES2 (right). The r-SH membrane has a silvery reflective surface due to the presence of a surface-bound air layer. Graphical illustration of (B) reduced liquid–solid interfacial area, (C) lower overall surface energy and nucleation propensity, and (D) reduced local residence time, with a superhydrophobic membrane (left) as compared with a hydrophobic membrane (right).

Another type of material that can enable low-energy water production is thermoresponsive polymers (Figure 3). Due to their unique phase behavior, production flexibility, and

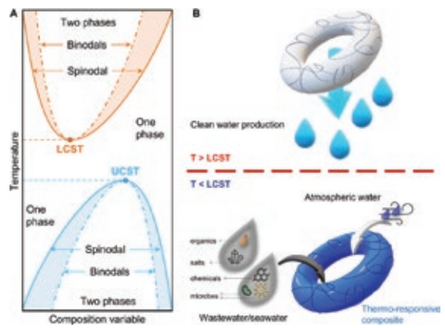


Figure 3 – (A) Phase diagram for a thermoresponsive polymer with either a LCST or an UCST cloud point. B) Schematic showing a section of membrane comprised of thermoresponsive composites used in water treatment and collection

biocompatibility, these materials may allow for sustainable routes to fresh water in current and new technologies. The design and application of poly(N-isopropylacrylamide)-(PNIPAm-) based thermoresponsive microgels and hydrogels can extend our technological capabilities for water treatment.

ENERGY EFFICIENCY ANALYSIS

Module-scale analysis of membrane separation can help to bridge the gap between molecular-scale and large volume (101-102 million gal day-1) analyses. By modeling the mass and heat transfer across an MD membrane in various configurations of waste heat utilization and latent heat recovery (Figure 4), we can identify the presence of critical conditions to determine whether the implementation of various process interventions for energy efficiency can offer large enough benefits to justify their widespread use. This analysis can extend the energy efficiency conversation to capture broader nuance and better serve the water treatment needs of key industries.

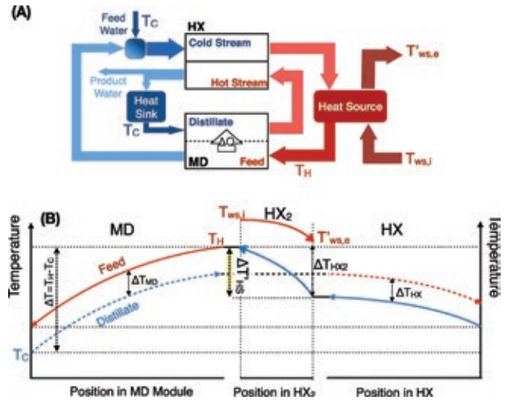


Figure 4 – (A) Schematic and (B) temperature profiles for a countercurrent direct-contact membrane distillation (DCMD) system with recycled feed and distillate streams and a heat exchanger to recover heat from the distillate stream and another heat exchanger to harness heat from a waste-heat source.

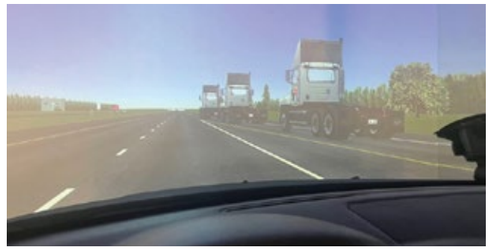
COASTAL RESEARCH – DR. NAVID JAFARI WITH PRESIDENT WILLIAM TATE IV

On October 17, LSU President William Tate IV, Professor Robert Twilley (vice president of the LSU Office of Research and Economic Development), and LA State Representative Jerome Zeringue visited Wax Lake Delta in the Atchafalaya Basin to see firsthand the ongoing coastal and geotechnical engineering research in the CEE department. During their visit, Associate Professor Navid Jafari and PhD student Mohamed Hassan discussed their work on quantifying the capacity of natural infrastructure, such as wetlands mangroves, to provide coastal defense services against hurricanes and rising sea levels. Dr. Jafari and Mohamed are specifically focused on understanding how the geomechanical properties of roots and sediment that anchor the vegetation to land spatially and temporally vary across the coast. For example, they want to know how vegetation root strength changes from salt to fresh marshes, during summer to winter seasons, and with and without hydrologic connection to sediment-laden rivers. Wax Lake Delta and the broader Louisiana coast are a unique landscape to study natural infrastructure through the lens of geotechnical engineering because it is actively experiencing the effects of climate change. It is a canary in the coal mine for the rest of the coast.

The field demonstration involved showing technological advancements to interrogate wetland soils. This includes translating the cone penetrometer test (CPT) used in subsurface geotechnical investigations to measure wetland root and sediment strengths. They showed that salt marsh root strength decreases with the duration of flooding from tides. Dr. Jafari also showed recent novel research using X-ray computed tomography scans to explore the amount of topology of live roots that contribute to root strengths measure by the CPT.

The societal implications of the Louisiana coast are immense. For example, coastal wetlands are valuable ecosystems. They improve water quality, provide wildlife habitat and biodiversity, sequester carbon, and very importantly protect coastal communities from hurricanes by dampening waves, distancing the urban centers from open water, and reducing storm surge heights. Yet, hurricanes are one of the most common natural drivers of coastal wetland loss. For coastal Louisiana, the combined impacts of Hurricanes Katrina and Rita (2005) and later Hurricanes Gustav and Ike (2008) converted nearly the area of New York City into open water. As a result, understanding and predicting wetland loss due to hurricanes is paramount to US security because of the significant consequences with respect to coastal populations. This, in turn, can help inform the scientific community and public on how the wetlands are eroded, what controls the root strengths, why they occur in certain hurricanes but not others, and what are their potential for long-term recovery.

STUDYING PLATOONING STRATEGIES FOR AUTONOMOUS TRUCKS AT LSU



So many things have changed during the COVID-19 pandemic, one being transportation. During the past two years, the need for truck drivers and supplies has ramped up, leading one LSU professor to research improvements to the supply chain while making traffic safety a priority using autonomous vehicles.

Thanks to a $183,000 grant from the Louisiana Board of Regents, Dr. Hany Hassan, an assistant professor in transportation engineering in the LSU Department of Civil and Environmental Engineering, is studying strategies to maximize the benefits of truck platooning on US highways. Truck platooning is when trucks travel together with short headway distances and connected by a computer system, which communicates with the trucks to align speed, acceleration, and braking. Drivers steer, watch the system, and intervene when needed "We are expecting this technology to help the freight movement," Hassan said. "The main benefit of this project is trying to identify what will be the best platoon size—five or six trucks—and see if the trucks should stay in one lane or use two. Identifying the optimum platoon size and configuration is important for the freight sector to maximize its benefits on highways. This will be conducted while taking into consideration driving behaviors of other traditional vehicles that will share the road with autonomous truck platooning."

According to the US Department of Transportation Federal Highway Administration, platooning reduces air drag, improves fuel economy, and also has the potential to increase vehicle capacity on the highways, particularly along freight corridors. The benefits of truck platooning deployment and operations include improving fuel savings and reducing greenhouse gas emissions; improving throughput, mobility, and road efficiency; and reducing operating costs for the commercial freight industry.

Hassan says that while this new mode of traffic technology is incredibly beneficial, it also comes with its challenges.

"Imagine you are driving and there is a long platooning truck beside you," he said. "You need to take the next exit. How do you get over? This is one of the scenarios we are going to test."

Hassan and his PhD student Mohamed Mohamed will put truck platooning to the test in three ways. First, they will use a microsimulation tool called VISSIM that can create any road environment and simulate any type of vehicle that will move on the road network. The software will give measurements to evaluate the impact of platooning. Secondly, they will use the driving simulator lab in LSU's Patrick F. Taylor Hall, which will allow them to test driver behavior. An example of the studied driving simulator scenarios are shown in Figure 1.

"Drivers in the driving simulation lab will be told which trucks are platooning based on their color," Hassan said. "We want to see if drivers will speed up to pass the platoon or even go between the trucks. We want to know if platooning trucks will cause more accidents or reduce the number of accidents especially at complex traffic segments like merging and diverging areas."

Finally, this research aims to explore drivers' opinions, preferences, and acceptance of different truck platooning configurations by conducting national survey.

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