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CCEE NEWS

DEPARTMENT OF CIVIL, CONSTRUCTION, AND ENVIRONMENTAL ENGINEERING
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Recent findings by CCEE researchers offer encouraging news for renewable energy. Read more on **page 02**.

Dr. Morton Barlaz

LETTER FROM THE DEPARTMENT HEAD

Dear Friends,

As I write this letter in August, we are settled into Fitts-Woolard Hall, and I am thrilled to see students in our new classrooms. A grand opening celebration will be held on October 29 as part of Red and White Week (**redwhiteweek.ncsu.edu**), and there is a virtual tour of the new CCEE spaces available on our website (**www.ccee.ncsu.edu**).

I am pleased to welcome new members of our department. **Dr. Katherine Anarde** is starting as an assistant professor in coastal engineering; read more about her on **page 09**. **Taylor Wanbaugh** joined CCEE in August as our communications director. Taylor earned a bachelor's degree in journalism from the University of Missouri and was most recently the managing editor for *Business North Carolina* magazine. Previously, she was a staff writer for the *National Society of Professional Engineers*.

At the same time, it is with a deep sense of gratitude that I wish a fond farewell to several staff members. **Lindsay Smith** has been appointed as senior director of development for the NC State Engineering Foundation; we appreciate her efforts on behalf of our department. **Toni Pascucci** and **Jake Rhoads** are both retiring. Toni has supported our undergraduate students via advising and mentorship, while Jake has supported our faculty members and students in the machine shop; read more about them on **page 08**. **Julie Williams Dixon** has served as the department's communications officer and editor of our newsletter since 2016. This will be her last newsletter as she makes time to pursue photography and film projects and spend more time with family. Our communications activities have grown exponentially under Julie's leadership, and we appreciate her gradual transition and continued support.

This newsletter features stories on some of the cutting-edge research led by our faculty, highlighting our contributions to the well-being of society. **Dr. Murthy Guddati** has developed algorithms to use sound waves to detect the depth of bridge pile foundations, oil reservoirs, asphalt pavement health and hardened arteries. **Dr. Abhinav Gupta** is leading the Center for Nuclear Energy Facilities and Structures and working with utilities all over the world. **Drs. Joe DeCarolis** and **Jeremiah Johnson** describe their recent work on the integration of solar energy and energy storage. **Dr. Andrew Grieshop** is working on the impacts of changes in indoor cookstove technology on air quality. Finally, **Dr. Richard Kim** describes his work to change how we specify the installation of asphalt roadways, while **Drs. Shane Underwood** and **Cassie Castorena** consider the impact of a warmer climate on asphalt performance and durability.

Thank you as always for your financial support. I am grateful for the confidence that you have placed in the department. Your support provides help with field trips and special projects for undergraduates, allows graduate students to make presentations at national conferences, and helps us recruit and retain the best students and faculty in the world. Your support continues to be very helpful as we settle into Fitts-Woolard Hall. We need your support as we strive for excellence in all that we do. Please contribute regularly to the department. I always enjoy meeting and speaking with people interested in the department. Please let me know if you are in the area and would like to tour our facilities. Thank you.

Morton A. Barlaz
Distinguished University Professor and CCEE Department Head

CCEE AT NC STATE SUSTAINABLE INFRASTRUCTURE FOR SOCIETY

$23 million in research expenditures
234 ongoing research projects
15 winners of CAREER and other NSF young faculty awards
53 faculty members
289 graduate students
799 undergraduate students

Wind turbine, battery storage and a solar photovoltaic array. Photo credit: istockphoto.com.

How to satisfy changing energy demands: **the symbiotic relationship between solar photovoltaics and battery storage**

As the effects of climate change continue to threaten communities, recent findings by CCEE researchers offer encouraging news for renewable energy. New research by **DRS. JEREMIAH JOHNSON**, **JOE DECAROLIS**, Anderson Rodrigo de Queiroz (NC Central University) and graduate student **DANIEL SODANO** finds that when a power system combines energy storage with solar power generation, the reliability benefits are greater than the sum of its parts.

Electric utilities are tasked with ensuring that electricity supply can reliably meet consumer demands at all times, particularly during high-demand periods — hot summer afternoons and cold winter mornings — when the grid is stressed. The reliability benefits of specific energy technologies are a critical factor that affect utility plans for future capacity deployment. Solar photovoltaics and battery storage each present their own reliability challenges: solar only generates when the sun is shining, and batteries are energy-limited, meaning they can only provide a finite amount of energy before needing a recharge.

For this study, the researchers looked at the power system in North and South Carolina to assess issues related to renewable energy and reliability. With data on power demand and the mix of power-generation sources, the researchers built a computational model to assess how much power a system could expect from different sources during periods of peak energy demand. The models allowed researchers to vary the size of solar arrays and the amount of energy storage in the system to determine how those changes might affect the overall reliability benefits during periods of peak demand.

The research findings indicate that solar and storage have a symbiotic relationship. For example, when a system combines solar and energy storage, that combination can be relied upon to provide as much as 40 percent more power during peak demand than if the output from each source is added together.

Why is that? Electricity demand rises, peaks and then falls over the course of a day. Solar generation follows the same pattern as electricity demand as the sun rises and falls during the day and can thus be used to meet a portion of the peak daily demand. Energy-limited storage can more effectively satisfy the remaining peak demand left by solar.

"Our work suggests that solar power can offer greater benefits to reliability than sustainable energy skeptics suggest. Investing in both solar power and energy storage systems can unlock reliability value that neither technology would provide on its own."

DR. JEREMIAH JOHNSON

This research was conducted with support from the North Carolina Policy Collaboratory. ▪

How do you clean the kitchen?

Study in India tests various approaches to fight indoor air pollution

A woman in rural Karnataka, South India, cooks over a traditional stove under a chimney. Top right is an unused liquefied petroleum gas (propane) tank and stove. Households frequently use multiple cooking devices to meet their needs. Photo credit: Karthik Sethuraman

Indoor air pollution is a leading cause of heart and lung disease globally. It is responsible for more than 2 million early deaths per year among the nearly 3 billion people in developing countries who rely on basic stoves, which often amount to indoor campfires.

DR. ANDREW GRIESHOP co-led a recently completed study funded by the Environmental Protection Agency (EPA) to examine the effects of various options to replace the use of dirty indoor cookstoves in rural India. Researchers found large improvements in air quality when households adopted and used gas stoves and chimney ventilation.

The study focused on households in Karnataka in the south and Himachal Pradesh in the foothills of the Himalayas. Field researchers performed in-home testing over the course of four years to give a realistic assessment of several cooking fuels and technologies. The team includes collaborators from the Stockholm Environment Institute, University of British Columbia, University of Washington, University of Georgia and two Indian nongovernmental organizations.

The study offered rural households free or discounted cookstove options, including improved wood versions, some with chimneys, and propane gas and electric cookstove models. Measurements were completed before and after the new stoves were installed to determine how the new stoves influenced indoor air quality, fuel use, air pollutant emissions and various household characteristics. Grieshop's team conducted the air pollution measurements, which involved nearly 300 emission tests and thousands of days of air quality monitoring.

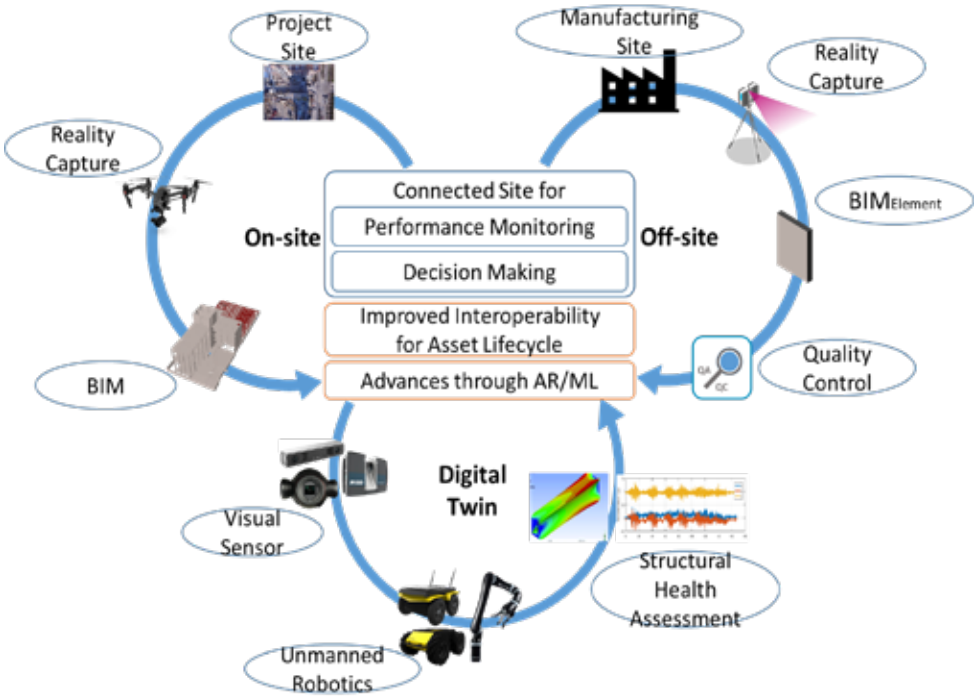
Somewhat surprisingly, households overwhelmingly selected the gas stove even though they typically gathered firewood and were not accustomed to paying for fuel. Those who used gas stoves exclusively had cleaner indoor air, with particulate matter levels reduced by 90 percent on average. However, use of the gas stove was inconsistent, and cooks often used multiple fuel sources and stoves. The study also found that effective use of a chimney reduced indoor air pollution by more than half.

Data obtained in this study was used to evaluate a model distributed by the World Health Organization for setting air quality standards. Findings indicated that the model tended to greatly overestimate pollution levels, and the team identified ways in which the model could be improved. Alumnus **ROSHAN WATHORE** (MSCE 2015) played a key role in the field work, and recent CCEE graduate **DR. MAKSIM ISLAM** (Ph.D. 2021) led the analysis of the air quality data. ▪

"While field work like this is challenging, it is the only way to get a 'real-world' picture of a problem and a realistic view on possible solutions. Our study will contribute to understanding and better decision-making as organizations around the world work to address this enormous problem."

DR. ANDY GRIESHOP

How to balance nuclear safety and cost: **CCEE researchers lead in technological solutions for nuclear energy**



Digital engineering solutions for reducing the cost and enhancing safety.

"We are involved in diverse projects that range from the use of digital engineering and virtual reality for reducing the cost of nuclear construction, to the use of artificial intelligence and machine learning for enhancing safety through risk-informed decision-making."

DR. ABHINAV GUPTA

The U.S. Department of Energy has identified nuclear energy as a key resource to meet both the nation's electricity demands and environmental goals. Nuclear energy provides more than half of our emission-free electricity but faces significant challenges in developing safeguards against potential accidents and the excessively high cost of building new plants.

NC State's Center for Nuclear Energy Facilities and Structures (CNEFS), directed by CCEE's **DR. ABHINAV GUPTA**, is an industry-sponsored research organization focused on the development of safe and economically competitive nuclear energy. The center has an international reach with industry partners from around the globe. The faculty, post-docs and graduate students involved in CNEFS are engaged in cutting-edge interdisciplinary research that has evolved from traditional mechanics-based solutions to modern artificial intelligence and augmented reality-based solutions.

Center researchers are partners in major industry initiatives such as Idaho National Laboratory's Versatile Test Reactor, TerraPower's Natrium Reactor, the European Commission's METIS project and South Korea's efforts in enhancing the seismic safety of its plants. With support from the Advanced Research Projects Agency-Energy, CNEFS faculty members have led a university-industry-national lab consortia for the development of a nearly autonomous monitoring and control (NAMAC) system as well as the development of a construction performance modeling and simulation (CPMS) platform.

In recent work, researchers have developed "as-built" digital twins of nuclear facilities by capturing video images and laser scans using drones to create 3D models. These digital twins provide a virtual representation and allow engineers to perform quality inspections, as well as enhance the capability to monitor and assess structural health of equipment, piping and buildings in a nuclear facility.

CNEFS is supported by the largest nuclear utilities in the Americas, Europe and Asia including Dominion Energy and Duke Energy in the U.S., Électricité de France S.A. in France and Korea Hydro & Nuclear Power Co. in South Korea. Plants owned by these and other utilities have benefited from innovative solutions developed at CNEFS in multiple areas of protection against natural hazards (earthquakes, flooding and tornadoes), advanced simulations, licensing, construction and operations and maintenance. Some of these solutions have also been used by non-nuclear energy infrastructure companies such as ABB for the safety of electrical substations in California and FDH Infrastructure Services for assessing the structural health of concrete dams. ▪

NEW RESEARCH PROJECTS

Since January 2021, CCEE has launched numerous new research projects with funding from federal and state agencies, foundations and industry sponsors. This support will enable CCEE faculty members, their research teams and their collaborators to address problems facing infrastructure and the environment in North Carolina and around the world.

FEDERAL GRANTS

DR. ALI HAJBABAIE, with collaborators Drs. Julie Swann and Leila Hajibabai from the Edward P. Fitts Department of Industrial and Systems Engineering, received funding from the National Science Foundation to collect data on COVID-19 vaccine allocation, distribution and shipment, administration, and inventory to quantify vaccination-performance measures such as lead times, gender and race / ethnicity, and vaccine spoilage. The collection and archiving of time-sensitive data on U.S. vaccination efforts will assist researchers in enabling a more efficient response to future pandemics or natural or man-made disasters.

DR. DETLEF KNAPPE received funding from the Department of Defense's Strategic Environmental Research and Development Agency to identify approaches to thermally reactivate spent granular activated carbon used to remediate sites contaminated with per- and polyfluoroalkyl substances (PFAS). Strategies will be developed that effectively mineralize adsorbed PFAS, prevent the release of products of incomplete combustion and hydrogen fluoride into the air, and prevent the leaching of products of incomplete combustion and fluoride from reactivated granular activated carbon. Identifying effective and safe reactivation conditions will support the reuse of granular-activated carbon for environmental cleanup.

The management of liquid and solid wastes that contain PFAS represents an ongoing challenge with large data gaps and many technologies still under development. **DRS. MORTON BARLAZ**, **JAMES LEVIS** and **DETLEF KNAPPE** received support from the U.S. Environmental Protection Agency to further develop a systems-analysis tool to estimate the release of PFAS from various treatment and disposal systems that receive PFAS-contaminated wastes. In ongoing research, they are updating the usability and functionality of the graphical user interface (GUI) and analyzing several management scenarios to illustrate tool functionality.

DR. CASEY DIETRICH, with support from the National Oceanographic Partnership Program, will collaborate with researchers from eight institutions across the U.S. to improve forecasts of waves, storm surge, erosion and infrastructure damages during coastal storms. The project will develop models for erosion along beach transects spanning the entire U.S. coastline and link them into a larger forecasting framework for predictions during upcoming hurricane seasons.

DR. JOHN BAUGH, with collaborators Drs. G. Gopalakrishnan and A. Bhaskara (University of Utah's School of Computing) and researchers from computer-systems design company Nvidia, received a grant from the National Science Foundation to study correctness and efficiency aspects of deep learning approaches used in artificial intelligence. Progress in machine learning is ultimately constrained by what can be programmed efficiently as large sparse parallel computations. Through this three-year project, they will develop verification techniques to avoid errors as neural networks are optimized for computational efficiency.

The National Science Foundation is supporting **DR. KEVIN HAN** and collaborators Drs. Collin Lynch (Department of Computer Science) and Cesar Delgado (College of Education), to investigate how graduate students in critical engineering fields learn to put academic knowledge into practice while working in diverse, interdisciplinary teams. Their objective is to prepare students to transfer their classroom experiences to professional practice by improving students' ability to work in multidisciplinary teams and deal with diverse opinions, ideas and backgrounds.

With funding from the National Academies of Sciences, Engineering, and Medicine, **DR. KEVIN HAN**, in collaboration with Dr. Yelda Turkan (Oregon State University), will investigate how state departments of transportation are using unmanned aircraft systems for highway construction. They are also identifying potential obstacles, such as legal implications, technical expertise, safety and training, in utilizing drones for construction-related applications.

INDUSTRY, NONPROFIT AND FOUNDATION GRANTS

DR. MO GABR, in collaboration with colleagues from the University of Surrey, England, and the University of Wollongong, Australia, received a grant from the University Global Partnership Network Research Collaboration Fund to explore the integration of various marine renewable energy harvest components into a collaborative system on a shared platform. These include marine hydrokinetic energy devices, offshore wind turbines, geothermal energy harvesting foundations and possibly solar arrays, as well as energy-storage technology from green hydrogen production. The project aims to develop various deployable configurations and demonstrate preliminary feasibility and proof of concept.

NEW RESEARCH PROJECTS
continued

DR. GIORGIO T. PROESTOS received funding from the Concrete Reinforcing Steel Institute Foundation to investigate the performance of deep concrete beams reinforced with high-strength steel headed bars. The research will involve conducting several large-scale deep beam experiments in the Constructed Facilities Lab and developing nonlinear models to investigate the safety and resilience of the beams.

DR. JAMES LEVIS is working with MANN+HUMMEL to conduct a life-cycle assessment of the Filter Cube III. The product is designed to remove nitrogen oxides (NOx) and particulate matter (PM) from ambient air to improve air quality. The purpose of this project is to quantify the environmental emissions and impacts from the manufacturing, operation, disposal and recovery of the Filter Cube III to better understand and improve its sustainability.

DR. ANDREW GRIESHOP received funding from the Clean Cooking Alliance to conduct a global analysis of the impacts of the widespread transition to liquefied petroleum gas (LPG — or propane) for household cooking in low- and middle-income countries where use of solid fuels such as wood and charcoal currently dominate. The study will analyze how shifts could affect climate, human health and environmental change and will include in-depth analysis for four target countries: Haiti, Kenya, Nigeria and Rwanda. This study is in collaboration with researchers from the Stockholm Environment Institute in Sweden and the University of Liverpool in the UK.

DR. DETLEF KNAPPE received funding from CDM Smith to study the occurrence of PFAS in wastewater-treatment plants. This multi-institutional project is supported by The Water Research Foundation and seeks to determine the identity and quantity of PFAS in U.S. wastewater-treatment plants. Members of the Knappe group will focus on the occurrence of volatile PFAS that transfer from wastewater to air during treatment. Understanding the fate of volatile PFAS during wastewater treatment is important from a standpoint of human exposure and long-range PFAS transport.

DR. GREGORY LUCIER will collaborate with **DRS. GIORGIO T. PROESTOS** and **RUDOLF "RUDI" SERACINO** on a project sponsored by the Precast / Prestressed Concrete Institute (PCI). The project aims to refine the design methodology for prestressed dapped end beams. A dapped end is common in precast concrete structures such as office buildings and parking garages because the cut-out at each end of the beam allows for a more efficient floor-to-floor height. The research will include analytical modeling and extensive large-scale experimental testing to study the effects of including dapped ends in very deep beams and lightweight concrete beams. Both deep beams and lightweight concrete beams are becoming more common in modern structures that have requirements for long clear spans and heavy loads from amenities such as green roofs.

STATE GRANTS

DRS. JOE DECAROLIS and **MO GABR** will collaborate with Dr. Anderson Rodrigo de Queiroz (NC Central University) to study the risk of hurricane damage to a diversified offshore renewable energy portfolio. With funding from the North Carolina Renewable Ocean Energy Program, the project will develop fragility curves to link environmental conditions to the risk of failure of the anchoring and mooring lines associated with supporting marine hydrokinetics devices. Such a failure would disrupt energy generation.

DR. MO GABR will collaborate with Dr. Wesley Williams (UNC Charlotte) on an interdisciplinary project sponsored by the North Carolina Renewable Ocean Energy Program. The research seeks to develop a prototype Retrievable Polymeric Anchor (ROPA) for anchoring multidirectional marine hydrokinetic devices. The project includes performing proof of concept analyses and building and testing a small-scale prototype ROPA, with a focus on installation and retrieval mechanisms.

DRS. MO GABR and **ROY BORDEN**, with support from the North Carolina Renewable Ocean Energy Program, will investigate the response of monopiles supporting offshore renewable ocean energy devices off the coast of North Carolina. As larger offshore wind turbines are introduced into the market (with some now having 15GW capacity), the research seeks to address the lack of technical guidance on the use of significantly larger and less flexible monopiles to support hybrid offshore renewable ocean energy devices.

DR. MERVYN KOWALSKY, with support from the Alaska Department of Transportation, will investigate the impact of low temperatures on high-strength steel. Alaska has extreme climates and the highest seismic hazards within the U.S. Over the last several years, high-strength steel reinforcement has become increasingly common. However, there have been concerns over the potential for brittle behavior that may be worsened due to low temperatures. Using material and structure level seismic tests, the impact of low temperatures on high-strength steel will be explored.

DR. EDWARD JASELSKIS received funding from the North Carolina Department of Transportation (NCDOT) to enhance its risk-assessment

program, which serves multiple modes of transportation and various project delivery methods. The research involves a further understanding of current programs in other state agencies, identifying best practices and implementing them as part of the new integrated project delivery process.

DR. SHANE UNDERWOOD received funding from the Arizona Department of Transportation to investigate how climate change is expected to impact its asphalt concrete pavements. General circulation models have predicted a wide range of changes over the next several decades. Underwood is working with the Arizona DOT to develop long-term climate model data in connection with future heat and precipitation through the end of the century. The project will further the DOT's climate research in pavement material selection and freeze / thaw impacts.

DRS. SHANE UNDERWOOD and **CASSIE CASTORENA** received funding from the NCDOT to study how pavement surface texture and friction affect roadway safety. Increases in overall vehicle collisions and collision rates during wet conditions are a major safety concern for state highway agencies. The researchers will develop friction and texture performance models on recent overlays. These models will be used to help define performance thresholds and identify asphalt mixtures that may reflect inferior performance and pose safety hazards.

DRS. CASSIE CASTORENA, **SHANE UNDERWOOD** and **RICHARD KIM** received funding from the NCDOT to improve procedures for designing surface asphalt mixtures containing recycled materials, including reclaimed asphalt pavement and recycled asphalt shingles. Recycled asphalt is generally brittle and may not fully mobilize and blend with new materials. Consequently, high recycled content mixtures may be prone to cracking if appropriate measures are not taken during the mixture design process. The project will investigate modifications to existing procedures to improve pavement performance.

DRS. GIORGIO T. PROESTOS, **RUDI SERACINO** and **GREGORY LUCIER** received funding from the NCDOT to conduct research on how concrete bridge girders perform after nearly 60 years of use and degradation. Evaluation of the Bonner Bridge girders recovered during bridge demolition in North Carolina's Dare County will include full-scale load testing of multiple 61-foot-by-45-inch-deep prestressed concrete beams at the Constructed Facilities Lab. The research also includes developing modeling techniques that can be used to evaluate aging concrete infrastructure.

DRS. SHANE UNDERWOOD and **BRINA MONTOYA** received funding from the NCDOT to assess the effectiveness of its post-hurricane design and repair strategies. The resilience of transportation infrastructure in North Carolina has gained increased attention following the more than $450 million in damage caused by recent hurricanes. The researchers will make comparative performance assessments of structures repaired in recent hurricanes and produce a set of guidelines and recommendations for design, repair and reconstruction that may improve the resilience of roadway design in the state.

DR. RICHARD KIM received funding from the NCDOT to evaluate the effects of construction variability on pavement performance using lab tests and mechanistic models. Plant-produced asphalt mixtures from a full-depth asphalt pavement on Carr Road in Durham, NC, will be used in this study. This research will enhance the NCDOT's understanding of the effects of construction variability and whether its current acceptance limits and pay factors are appropriate. This research is expected to improve quality assurance procedures at the NCDOT.

DR. RICHARD KIM received funding from the NCDOT to evaluate the field performance of various geosynthetic interlayer products, including their resistance to reflective cracking and debonding failure in asphalt overlays. The roadway for this field study is NC 96 in Youngsville, NC. This research will produce construction guidelines and project selection guidelines for the different geosynthetic interlayer products.

DR. GIORGIO T. PROESTOS received funding from the NCDOT to conduct research on new strut-and-tie design and evaluation procedures of reinforced concrete bridge bent caps. The research will involve developing new design methods and evaluating their performance using nonlinear finite element and kinematic models. The research also involves conducting a series of large-scale reinforced concrete deep beam experiments monitored with full field of view digital image correlation (DIC) equipment.

DRS. MOE POUR-GHAZ, **MO GABR** and **GREGORY LUCIER** received funding from the NCDOT to develop new life prediction models and software for estimating the service life of culvert pipes by accounting for material degradation processes and structural requirements. This project accounts for exposure conditions, structural requirements, repair and rehabilitation strategies, as well as mitigation methods to increase the service life of culverts exposed to aggressive elements.

OTHER

In a student-led proposal funded by the NC Water Resources Research Institute, Ph.D. student **NANCY LEE ALEXANDER** will work with **DRS. DETLEF KNAPPE** and Erin Baker (Department of Chemistry) to study the environmental behavior of pesticides. The researchers will use novel mass spectrometry approaches to determine how pesticides degrade in aquatic environments and assess the possible impact of pesticides and their degradation products on private well water. Community engagement is an important component of this research; findings will be shared with individual private well users through letters and digital media as well as with the larger community through community meetings. ▪

Two long-time staff members retiring this fall

Toni Pascucci poses with Mr. and Ms. Wuf.

TONI PASCUCCI retires after 16 years as undergraduate student services assistant.

For thousands of our alumni, one of the faces seen most often during their undergraduate career was Toni Pascucci. If you needed to add or drop a class, check for scholarship or internship opportunities or identify your advisor, then you went to see Mrs. Pascucci. She was the 'face' of student services. She will be greatly missed by faculty, staff and students! We asked her to reminisce. ▪

We moved to North Carolina in 1995 from New Jersey, and I worked as a teacher assistant where my two boys attended school at first. Since my husband and boys were huge Wolfpack fans, I decided that I wanted to work at NC State. I told myself that was the ONLY job I wanted and would just keep applying until I got one. It took about eight months but luckily, I did!

What made my job so special was getting to know all the students, not only by advising them but also being there as a friend, someone who they could feel comfortable with just stopping by to say hello. My job is different every day — helping students, helping faculty, planning events, awarding scholarships, planning class schedules and working with companies who have job / internship opportunities for our students. It's the kind of job that is very rewarding and appreciated. There's not a day that goes by that I don't get a thank you from a student or faculty member for something I helped them with.

Of course, technology has changed a lot since I started working here in 2005. Now we all rely so much on our computers, Google calendars and smart phones, but there were many years where sticky notes and reminders written on my desk calendar were how I kept track of things. And yes, I still use a Rolodex.

I feel fortunate to be one of those people who worked for 16 years at a job that I loved! There was never a day that I didn't feel like going into work, and that is still true. It was hard getting used to working from home during the pandemic, I missed the interaction with people and felt very isolated like I'm sure most people did. I was so lucky to work with great faculty and staff. I made so many great friends over the years that I hope to stay in contact with. I can't say enough about the managers I had while working here, Dr. Barlaz, Dr. Parish, Dr. Nau, Dr. Leming, Dr. Aziz, Dr. Seracino — the best of the best!

I'll never forget my years at NC State. I was always so proud to say I worked there and especially proud to say I worked for the Department of Civil, Construction, and Environmental Engineering. Retiring is one of the hardest decisions I've had to make, but with two sons and grandchildren that live in Raleigh and parents in their 90's that live in New Jersey, I thought it was time to concentrate on them.

Thank you Dr. Barlaz, and Dr. Parish for hiring me and giving me the opportunity to be part of this university that gave me 16 years of wonderful memories. I will truly miss everyone!!!

Fondly, Toni Pascucci

Jakes Rhoads assisting Aaron Stroud in preparing for the ASCE Steel Bridge competition in 2016.

JAKE RHOADS retires after 14 years as director of CCEE machine shop.

Jake Rhoads has been with the department since 2007 and has assisted hundreds of students as they sought solutions for creating customized equipment to conduct their lab or field research. He will retire this fall after 14 years at NC State. Jake brought decades of experience from the factory floor to the university setting, including sheet metal fabrication, welding, millwright and maintenance skills, to mention a few. He speaks fondly of his time at large manufacturing facilities, where at

one point he was a group leader in a shop with more than 50 tradesmen, but says that finishing out his career in an environment with a focus on helping students has been fulfilling.

Rhoads has fabricated mini-bioreactors for graduate students conducting environmental research. He's welded bridge column specimens for use in seismic engineering research. And of course, any of our alumni who participated on the Steel Bridge Team know that Jake Rhoads was instrumental in assisting the students with fabricating parts for their bridge.

"One of the most interesting projects I helped with was the development of the Flexcrevator," Rhoads continues. He worked with alumnus **TATE RODGERS** (BSENE 2011, MSENE 2013) from the very beginning on this technology. The Flexcrevator is now trademarked, licensed and manufactured for use in developing countries to empty pit latrines, providing great improvements in human sanitation. "I was involved in the earliest fabrications. We did a lot of trial and error, and there were many generations of that product before it was finalized," Rhoads says with pride.

Rhoads has been invaluable for the department, finding unique solutions for numerous challenges. For example, he was closely involved with the design and fabrication of the base for a driving simulator that is now housed on the first floor of Fitts-Woolard Hall. He was also essential in assisting with many aspects of our move.

"This job grew over the years, and it's been a pleasure. It's been rewarding. You can see the young minds coming in, and hopefully I've given them some perspective, and they've picked up some things that they can carry with them. The students always came first in my mind," said Rhoads.

Jake Rhoads is ready to relax some, though he did say that his wife Tracie "just last week gave me my to-do list." Can you blame her? If you ask him to do something, it gets done right. ▪

Anarde brings expertise in measuring and modeling coastal hazards

DR. KATHERINE ANARDE joined the CCEE faculty in August as an assistant professor in the Environmental, Water Resources and Coastal Engineering group. Anarde's research combines observational and numerical approaches to investigate how acute and chronic hazards influence the habitability of coastlines. Her research on acute coastal hazards has focused on tropical cyclone impacts to sandy coastlines, with projects spanning measurement of ocean waves and landscape change during hurricane impact, generation of meteorological tsunami ("meteotsunami") waves by spiral rainbands and infrastructure vulnerability. Presently, Anarde is investigating the chronic effects of sea level rise on coastal communities, focusing on the frequency and impacts of "sunny day" floods. Anarde also studies how coastal management practices (e.g., beach nourishment) feedback to alter natural processes in ways that reduce the habitability of the coast. Her research is largely interdisciplinary and involves collaboration with economists, geomorphologists, structural engineers and social scientists, as well as coastal stakeholders.

Anarde received a B.A. in geology from the University of Colorado at Boulder in 2011. She then worked as an Environmental Consultant at ENVIRON International Corporation before returning for a Ph.D. in civil and environmental engineering at Rice University. Prior to joining the NC State faculty, she was a postdoctoral

researcher in the Coastal Environmental Change Lab at the University of North Carolina at Chapel Hill. Anarde is currently the project manager for the Collaboratory for Coastal Adaptation over Space and Time (C-CoAST), an NSF Research Coordination Network.

Anarde will be teaching CE 487, Introduction to Coastal and Ocean Engineering, next spring, and CE 583, Coastal Processes, in Fall 2023. She also plans to offer a course on field measurements in the coastal zone, which will introduce the theory behind instrumentation used to measure currents, waves, topographic change and sediment transport. As part of this course, students will have hands-on experiences using instrumentation, analyze data, learn to identify common pitfalls in obtaining quality field data, and design a field campaign.

Anarde is originally from Colorado and is excited to live in a state that has both mountains and the ocean. ▪

How can we improve the performance and adoption of new asphalt pavement technologies?

The asphalt pavement network is the United States' largest investment in its civil infrastructure. With a broad network of asphalt-paved roads spanning the U.S., even small improvements in asphalt pavement quality can yield significant savings in maintenance and rehabilitation.

Asphalt concrete is a complex engineering material because its behavior varies due to a number of factors including age, temperature and rate of loading. Asphalt pavement, which is the layered roadway structure with asphalt concrete on top, is subject to traffic loading and environmental conditions that affect performance over time. Furthermore, the introduction of new materials and recycling techniques has made prediction of the long-term performance of asphalt pavement even more difficult. More than 20 years ago, the Federal Highway Administration (FHWA) began implementing models developed by CCEE's **DR. RICHARD KIM** to drive performance-related specifications (PRS).

In the asphalt multiscale testing lab, Ph.D. student Kazuo Kuchiishi calibrates the load cell of the Asphalt Mixture Performance Tester (AMPT). This instrument is used to measure the stiffness, cracking resistance and deformation resistance of asphalt mixtures. Kuchiishi is conducting research to improve the test method used to measure the dynamic modulus of asphalt mixtures.

Since then, a group of CCEE researchers in the Transportation Materials group including **DRS. SHANE UNDERWOOD**, **CASSIE CASTORENA** and Kim have continued to improve the model's accuracy and efficiency. Their work, alongside CCEE's **DR. MURTHY GUDDATI**, who has expertise in computational mechanics, led to FlexPAVE™. This article looks at the past, present and future of quality assurance specifications for asphalt pavements.

Predicting asphalt pavement performance

Historically, a varying and complex array of factors has prohibited asphalt engineers from adopting mechanistic principles that are essential to the reliable prediction of the performance of asphalt pavement. Consequently, empiricism prevailed in the asphalt pavement community, and the nation's pavement infrastructure suffered as a result. The letter grade given by the American Society of Civil Engineers (ASCE) in their infrastructure report card for the condition of the nation's pavement network has been hovering around "D" for the last decade.

The critical questions are:

- How can we improve the performance of asphalt pavements?
- How can we motivate contractors to innovate and build better pavements?
- How can the paving industry adapt to fast-changing material technologies, such as warm-mix asphalt, reclaimed asphalt pavement and reclaimed asphalt shingles?

The FHWA believes that performance-related specifications are the answer to these questions and has worked closely with CCEE's asphalt materials group on their development and implementation.

- **#1** recycled product in the world
- **2.6 million** miles of paved roads in the U.S.
- Approximately **18 billion** tons of asphalt on U.S. roads
- **350 million** tons of asphalt produced every year

What are performance-related specifications (PRS)?

PRS describe the asphalt characteristics (binder content, in-place density, etc.) that have been shown to correlate with fundamental engineering properties that predict performance. Because PRS provide the basis for rational acceptance and pay adjustment decisions, the models used to predict pavement performance must be accurate, scientifically sound, proven against field performance, and usable by highway agencies and contractors. In the late 1990s, the FHWA identified models that Kim had developed as the main engine for the PRS and as the next-generation models for the performance prediction of asphalt pavements. Kim's models integrate several mechanistic principles that have been used in modeling solid propellants (solid fuels used for rocket engines) and allow the efficient laboratory characterization of the fatigue cracking and rutting performance of asphalt concrete and asphalt pavements under widely varying traffic and environmental conditions.

FlexPAVE™

Since the FHWA's decision to use these NC State models for next-generation pavement analysis, Underwood, Castorena and Kim have worked on a series of projects to improve the models' accuracy, standardize the material characterization methods, and verify and calibrate the models using field performance data. These efforts have resulted in three national standards for asphalt mixture testing by the American Association of State Highway Officials (AASHTO) and several TechBriefs by the FHWA. In addition, Guddati has developed a numerically efficient, three-dimensional finite element program, named FlexPAVE™ by the FHWA that incorporates Kim's material models. FlexPAVE™, which is available in the public domain, has been verified using field data for more than 60 different asphalt mixtures and pavements.

More than 140 researchers all over the world are currently using FlexPAVE™ for their pavement-performance analysis. The NC State research team works with several state highway agencies to train agency personnel to use the relevant laboratory test methods, material-analysis programs, and FlexPAVE™. The PRS have been implemented in asphalt-paving projects by seven state agencies in the U.S. and by the Ontario Ministry of Transportation in Canada as shadow specifications to determine incentives and disincentives for the work done by contractors. Shadow specifications are applied to actual paving projects to evaluate their effectiveness but do not have the legal power of conventional quality assurance specifications. Brazilian researchers are working with the NC State research team to develop Brazil's mechanistic-empirical pavement design method using FlexPAVE™. The NC State research team is also working with researchers in Università Politecnica delle Marche in Italy to evaluate the performance of an asphalt mixture with an innovative binder in Italy's motorway.

"I started using the AMPT test methods and FlexMAT / FlexPAVE software thanks to a collaboration with Professor Kim focused on a research project funded by an Italian Highway Administration. I do believe the approach developed at NC State is the most powerful tool available for road pavement design because it combines scientific rigor and engineering pragmatism from laboratory characterization to structural analysis."

PROFESSOR FRANCESCO CANESTRARI

Università Politecnica delle Marche, Ancona, Italy

Climate change impacts on pavement infrastructure

Underwood and Castorena, along with graduate research assistant **NARGES MATINI,** are also demonstrating the utility of the tools for examining how climate change may impact pavement infrastructure. Their analysis has shown that asphalt pavements subjected to regular flooding and / or heat waves will degrade more quickly and may have higher long-term maintenance and repair costs.

"FlexPAVE is a critical part of this analysis because it so closely integrates real-world climate records into the analysis," Underwood says. "We have been able to leverage this capability to look at a wide range of climate stressors on pavements including heat waves and flooding."

The developed PRS will allow for more accurate predictions of pavement performance, leading to the development of sustainable asphalt materials and pavements. They will result in significant improvements in the quality of the nation's highways, motivating contractors to be innovative and cost-effective in their materials and construction practices. It's a win-win for all stakeholders. ▪

In this staged scene, researchers are creating the environment and instrumentation that eventually will be used during pilot testing on humans.

Seeing through sound: from infrastructure health to human health

To put it in simple language, DR. MURTHY GUDDATI's research uses sound waves to look into structures, whether it's an aging bridge or a human brain. His research team has developed technologies that range in complexity from tapping on bridge piles with a hammer and measuring the waves that return to using shear-wave elastography and mathematical algorithms to assess blood clots during brain surgery. For more than a decade, Guddati has been working in the area of mathematical manipulations rooted in wave propagation theory. He collaborates with experts that include not only structural and mechanical engineers from various universities but also researchers from mathematics and biomedical engineering.

AN ANCIENT TECHNIQUE?

Have you ever knocked on a watermelon at the farmer's market to see how it sounds before you buy it? Maybe you've tapped on the walls of your house to locate the studs? Perhaps some of you are familiar with the practice of dragging a metal chain on a bridge deck and using the sound to determine internal damage?

"This practice of 'seeing through sound' is an ancient technique. What's new is making the technique so precise that we can make consequential decisions based on what we see. To do this, we develop mathematical algorithms based on physical understanding, and then we test them using computer modeling, then experimentation, and finally field testing."

DR. MURTHY GUDDATI

PILE TESTING

One of the technologies Guddati and his research team developed arose from the need for engineers to estimate the depth of bridge pile foundations. Often with aging bridges, the original pile depths are unknown due to missing records. Scour (soil erosion caused by flooding) can cause the embedded depth of the pile to be reduced to the point that the bridge becomes unstable, possibly leading to collapse.

Guddati says this application is one of the simplest mathematically, but is the most mature as a usable technology. It works by tapping on the side of the pile with a hammer and measuring the acceleration of the returning waves (oscillations) at two locations. By measuring the

waves that return, the depth from which they are reflecting back can be calculated. This technology was first tested by computer simulations, then in conjunction with structural engineers working at the Constructed Facilities Lab, and finally in the field with research funding from the North Carolina and Alaska Departments of Transportation. Guddati says that EDAR (Effective Dispersion Analysis of Reflections) technology can be extended to characterize pile integrity, but further testing is necessary.

Dr. Murthy Guddati

DETECTING OIL RESERVOIRS OR CRACKS IN SOLIDS

Separate from EDAR, Guddati and his team developed sophisticated numerical algorithms to image the subsurface with high-frequency waves. The basic idea is to excite the surface by sending waves that will propagate through the earth or structure. The features encountered by the waves cause reflections. When they come back to the surface, the algorithms can be used to convert the reflected waves to an image of the subsurface containing, for example, petroleum reservoirs or cracks. These techniques can naturally be used to detect discrete cracks or delamination in aging infrastructure.

PROFILING SOIL LAYERS

Local soil properties affect how a structure experiences an earthquake, which propagates up from bed rock to the surface through the soil layers. Engineers have typically used the borehole technique to measure soil properties, but this process is invasive and expensive. Instead, Guddati's team uses guided wave inversion to estimate the material properties of the soil strata. The technique is based on the fact that the layering affects the propagation and dispersion of (medium-frequency) elastic waves along the ground. Thus, the observed wave dispersion on the ground surface can be used to back-calculate the soil profiles. Key to the success of the developed techniques are advanced mathematical algorithms Guddati's team developed. The generalizability of these algorithms also paved the way to several other applications.

CHARACTERIZING PAVEMENT DAMAGE

"Given the successes of our findings on soil characterization, we thought 'OK there is another big layered system in our nation which is pavements,'" Guddati says. His research team is working with the NCDOT to test its methods on assessing the health of pavement, and findings show that using guided wave inversions is more reliable than the traditional testing method of a falling weight deflectometer and other dynamic testing techniques. Implications for policymakers are substantial as this would add to their ability to plan for roadway maintenance.

Moving to medicine

SHEAR-WAVE ELASTOGRAPHY TO ASSESS VASCULAR HEALTH

The next frontier for the techniques developed by Guddati's team is health care — more specifically medical diagnostics. The first endeavor is aimed at helping diagnose cardiovascular disease.

"I realized this technology can be used for different systems, and medicine is something that I was always interested in, so I began partnering with the Mayo Clinic to develop better biomedical ultrasound techniques," Guddati says.

In 2017, Guddati began a collaboration that includes researchers at the Mayo Clinic and Duke University. The aim of this research is to develop inexpensive, non-invasive ultrasound techniques that can be implemented on existing ultrasound scanners with minor modifications.

"The technique that we are working on uses ultrasound, but not in the traditional way," Guddati explains. "We are not using it to just see something, but to apply force on an arterial wall, which generates waves that propagate along the arterial wall. The way in which these waves propagate is affected by the stiffness of the artery."

Stiffening of the arteries is one of the early indicators of cardiovascular disease. The team began this work with computer

modeling, moved to phantom experiments using rubber tubes to simulate arteries, and is now testing the techniques on human subjects.

The technology being developed for this medical application uses shear-wave elastography, and Guddati believes that it has numerous other potential uses in health care diagnostics. His research team is moving forward with three different applications. The first involves characterizing stiffness and dissipation properties of the liver, which has implications for detection of cirrhosis. The second involves estimating red blood cell content in blood clots in the brain, which is critical for determining the protocol for emergency surgery. The third seeks to characterize tumors for potential malignancy without the invasiveness of a biopsy. The concept is based on the fact that cancerous tumors are stiffer than benign tumors. As in the other research, the technique will include exciting the tumor with soundwaves, examining the scattered waves that return and developing an algorithm to back-calculate the distribution of stiffness within the tumor.

Preliminary work with all of the medical research is promising, with one invention disclosure submitted for artery application. The next steps include continuing collaborations with partners in biomedical engineering as well as working to license the technologies to medical equipment manufacturers.

Guddati credits the success of his contributions to the bright and dedicated graduate students he has been fortunate to recruit, as well as his collaborators from various disciplines and institutions. His research has been supported by the National Science Foundation and National Institutes of Health.

At the encouragement of the University, Guddati's team created a company called Innovative Non-Destructive Testing of Infrastructure (INDTI), to commercialize not only EDAR technology, which is now patented, but also future technologies resulting from ongoing projects. ▪

Vivek Samu (Ph.D. 2018, MSCE 2014) field testing Effective Dispersion Analysis of Reflections (EDAR) equipment in 2015. Samu continues his work as a postdoctoral researcher with Dr. Guddati.

"I realized this technology can be used for different systems, and medicine is something that I was always interested in, so I began partnering with the Mayo Clinic to develop better biomedical ultrasound techniques."

DR. MURTHY GUDDATI

AWARDS & HONORS

Dr. Sami Rizkalla

The American Concrete Institute (ACI) conferred the highest honor of **ACI Honorary Membership** to CCEE's distinguished emeritus professor **DR. SAMI RIZKALLA** at the ACI Virtual Concrete Convention this year. The honor recognizes Rizkalla's extraordinary contributions and commitment to the advancement of the concrete industry and his valuable research contributions throughout his career.

Dr. Douglas Call

DR. DOUGLAS CALL, associate professor of environmental engineering, was selected to participate in the National Academy of Engineering's (NAE) 27th annual **U.S. Frontiers of Engineering** (USFOE) **symposium**. The event was held at the National Academies' Beckman Center in Irvine, Calif. in September and also allowed for virtual participation. The event brought together individuals from industry, academia and government from a variety of disciplines to collaborate.

Dr. George List

DR. GEORGE LIST, professor of transportation systems, was recently appointed to an ad-hoc committee for the **National Academies of Sciences, Engineering, and Medicine**. The committee will be responsible for reviewing the current plans for neutralizing, treating and permanently storing the nuclear waste being held in storage tanks at the Hanford Nuclear Reservation in Washington. The committee includes 15 experts from across the country, representing both educational institutes and national organizations.

From left to right, Ashtad Javanmardi, Min Liu and Alireza Abbasian-Hosseini.

DR. MIN LIU, associate professor of construction engineering, along with her former Ph.D. students, **DR. ASHTAD JAVANMARDI** (Ph.D. 2019) and **DR. ALIREZA ABBASIAN-HOSSEINI** (Ph.D. 2015), and co-author Dr. Simon Hsiang (University of North Carolina at Charlotte), were selected to receive the **2021 ASCE Thomas Fitch Rowland Prize** for their paper titled "Improving Effectiveness of Constraints Removal in Construction Planning Meetings: Information-Theoretic Approach." The award is given to papers that make valuable contributions to construction engineering and management and are published in ASCE journals. The paper appeared in the *ASCE Journal of Construction Engineering and Management* in April 2020.

Dr. Emily Berglund

DR. EMILY BERGLUND, professor of environmental engineering, was one of the top five finalists for NC State's **2021 Equity for Women Award**. The recognition honors Berglund's crucial and visible impact on the CCEE department. She has championed women graude students in the department and supported efforts to improve their welfare and well-being as they pursue an engineering career.

Dr. Detlef Knappe

DR. DETLEF KNAPPE, professor of environmental engineering, was honored with the **Outstanding Engagement Award** through the NC State Office of Outreach and Engagement. Having received the award, he became eligible for induction into the Academy of Outstanding Faculty in Extension and Engagement, and was one of just eight NC State faculty members to receive the distinction. Knappe was also one of only two individuals to receive the **Alumni Outstanding Extension and Outreach Award**.

Dr. Fernando Garcia Menendez

DR. FERNANDO GARCIA MENENDEZ, assistant professor of environmental engineering, was awarded the **George H. Blessis Outstanding Undergraduate Advisor Award**. The award recognizes his consistent commitment to student success through advising, counseling and mentoring. The award also recognizes his contributions to initiatives that promote the participation of underrepresented groups in higher education and STEM fields.

DR. ANDY GRIESHOP, associate professor of environmental engineering, was honored with the NC State **2021 Outstanding Global Engagement Award**. The award recognizes Grieshop's

AWARDS & HONORS
continued

Dr. Andy Grieshop

Dr. Ashly Cabas

sustained focus on improving energy access and environmental conditions in the developing world, including field evaluation studies in five countries in Africa, South Asia and Latin America. He also acts as faculty advisor to the NC State student chapter of Engineers Without Borders. In recent years, under his guidance, the chapter has completed multi-year water and energy projects in Sierra Leone and Guatemala. Grieshop was also recently engaged as an expert in a European Union-led process to provide guidance on measurements of important components of combustion particulate emissions.

DR. ASHLY CABAS, assistant professor of geotechnical engineering, was selected as one of twelve **2021 Strengthening the Impact of Research** (STIR) **Impact Scholars** by the Office of Outreach and Engagement at NC State. The STIR program seeks to enhance NC State's capacity to design and conduct research with broad impacts on society, and identifies scholars that are expected to have the largest influence on the University's broader impact mission. Cabas was selected from 50 applicants from across the university for her research related to seismic hazards and geotechnical problems.

Nancy Ingabire Abayo

Ph.D. student **NANCY INGABIRE ABAYO**, advised by **DRS. BRINA MONTOYA** and **ASHLY CABAS**, won **first place in the 2021 Geo-Institute Student Poster Competition**. Her poster was titled "Assessing the Influence of Fluvial Geomorphological Variables on Empirical Models of Liquefaction-Induced Lateral Spreading." Abayo was also selected as one of the **American Geophysical Union's "Voices for Science."** As part of the program, she plans to actively participate in several outreach efforts within the local community.

Ph.D. candidate **GONGFAN CHEN**, advised by **DR. MIN LIU**, received the **Best Student Paper Award** at the 2021 Canadian Society of Civil Engineers Annual Conference in May. His paper was titled "Situation Awareness Based Smart Contract for the Modular Construction." Chen hopes to improve construction management processes and reduce related inefficiencies.

Gongfan Chen

Morgan DiCarlo

Ph.D. candidate **MORGAN DICARLO**, advised by **DR. EMILY BERGLUND**, was selected as one of the **American Geophysical Union's "Voices for Science."** The program trains scientists to serve as effective communicators of the value of earth sciences to decision-makers, journalists and the general public. Recently, DiCarlo met with the offices of Sens. Richard Burr and Thom Tillis, and Rep. Deborah Ross, and shared insights from her research about community responses in North Carolina during hurricane recovery and water main breaks.

Chuanni He

Ph.D. candidate **CHUANNI HE**, advised by **DR. MIN LIU**, received a Construction Industry Institute (CII) **Outstanding Student Award**. This award recognizes a student's important contribution to a CII initiative that has the potential to significantly improve the construction industry. The award recognizes his innovative approach, referred to as information theory analysis, to evaluate the status of implementing collaborative scheduling practices in the construction industry and its impacts on project key performance indicators.

Megan Johnson

Ph.D. student **MEGAN JOHNSON**, advised by **DR. FERNANDO GARCIA MENENDEZ**, received a number of awards earlier this year. She was awarded a prestigious **Graduate Research Innovation** (GRIN) **award** from the U.S. Joint Fire Science Program (JFSP). The award funds student-authored proposals for original research that augments their dissertation work and enhances its policy relevance. The award will support Johnson's efforts to identify Southeastern communities impacted by smoke from wildland fires and investigate potential shifts under climate change. Johnson also received an **Outstanding Student Presentation Award** (OSPA) from the

American Geophysical Union for her presentation titled "Evaluation of Smoke Modeling Tools Used for Estimating Air Quality Impacts from Prescribed Burning." The OSPAs recognize graduate students for high-quality research in the geophysical sciences and only the top 2-to-5 percent of student presenters each year receive an OSPA. She was also honored with a **Science to Action Fellowship** from the U.S. Geological Survey. The Science to Action Fellowship program supports graduate students in developing a product that puts science into action.

Qian Luo

QIAN LUO, Ph.D. student advised by **DRS. JEREMIAH JOHNSON** and **FERNANDO GARCIA MENENDEZ**, received the **Energy Data Analytics fellowship** at Duke University, National Science Foundation (NSF) **INTERN Award**, and the **Air Pollution Control and Waste Minimization Research scholarship** from the Air and Waste Management Association (AWMA). The Energy Data Analytics fellowship program is organized by Duke's Energy Data Analytics Lab and funded by the Alfred P. Sloan Foundation. This fellowship offers research mentorship and training on a wide array of energy and data science topics, and research communication advice to broaden the impact of students' work. As one of the six fellows for 2021, Luo researched the impact of power systems in China on air quality and health impacts. The INTERN award provided by NSF allows her to work with scientists at Lawrence Berkeley National Lab as an intern, providing experiential learning opportunities to acquire core professional competencies and skills to support her future careers. Additionally, the AWMA scholarship aims to recognize outstanding students who are working in the field of air quality and waste management.

Mohammad Qambar

Ph.D. candidate **MOHAMMAD QAMBAR**, co-advised by **DRS. GREGORY LUCIER** and **GIORGIO PROESTOS**, won the **2021 Alan Mattock Graduate Scholarship** awarded by the Precast Concrete Industry Foundation. Qambar seeks to continue his research to understand how traditional dapped end members can be adapted to Ultra-High Performance Concrete (UHPC).

NOORALHUDA SALEH, a Ph.D. candidate supervised by **DR. RICHARD KIM**, was selected by the Association of Asphalt Paving Technologists (AAPT) to receive the **2021 Ward K. Parr AAPT scholarship**. The AAPT scholarship is one of the most prestigious awards available in the field of asphalt pavement infrastructure. In April, Saleh was also selected by the International Road Educational Foundation to be an **International Road Federation** (IRF) **Fellow** for 2021. She was selected along with four international candidates to join the IRF Fellows, a group of international professionals in the field of transportation systems and materials. She is invited to participate in the IRF Road Scholar Program, which will be held in conjunction with the Transportation Research Board 101st Annual Meeting in Washington, D.C., next January.

Nooralhuda Saleh

Jessi Thangjitham

Ph.D. candidate **JESSI THANGJITHAM**'s poster titled "The Seismic Performance of Grade 80 Rebar in RC Bridge Columns" was selected to receive **honorable mention** at the 2021 Earthquake Engineering Research Institute (EERI) annual meeting. Thangjitham hopes to improve the way in which we design reinforced concrete bridge columns by optimizing design, reducing material cost, decreasing construction time and building more robust infrastructure elements. She is advised by **DR. MERVYN KOWALSKY**.

Yixuan Wang

YIXUAN WANG, Ph.D. student advised by **DR. JAMES LEVIS**, received a **Waste Management Research and Study Scholarship** from the Air & Waste Management Association. The scholarship recognizes her exceptional work in waste management research.

Kylee May

KYLEE MAY, an undergraduate student mentored by **DR. MERVYN KOWALSKY**, was chosen as one of five students to represent NC State at the 2021 Atlantic Coast Conference (ACC) Meeting of the Minds. May's presentation was titled "The Effect of Critical Angle Variability on Maximum Displacement Discrepancies in Bridge Columns."▪

GRADUATE STUDENT **SPOTLIGHTS**

Our research and teaching is only possible with the assistance of our more than 200 on-campus graduate students, each of whom has a strong personal history and a promising future. We shine a spotlight on a few students.

MEGAN JOHNSON

MEGAN JOHNSON is a fifth year Ph.D. candidate with a concentration in air quality engineering. Johnson, who grew up in Colorado Springs, Colo., is advised by **Dr. Fernando Garcia Menendez**. She's researching how smoke from wildfires and prescribed fires impacts air quality and human health. This year, she received a Graduate Research Innovation award from the U.S. Joint Fire Science Program and was awarded a Science to Action fellowship through the U.S. Geological Survey National Climate Adaptation Science Center.

What influenced you to go into engineering?

Megan Johnson: I have always found it fun to solve problems and thought that engineering would be the best way to pursue my interests in environmental issues. When it came down to choosing a major, I realized that I wanted to use my academic strengths in a way that could have a tangible, positive impact on the environment.

What problem(s) are you trying to solve? Why were NC State and CCEE a good fit for you?

MJ: CCEE and NC State are highly collaborative and interdisciplinary environments, which I find to be ideal for doing this type of research. The CCEE department is one of the friendliest and most intellectually stimulating places I have ever worked. The professors are open and approachable, and that makes all the difference to me as a graduate student.

Where did your passion for this particular focus come from?

MJ: I have been interested in air quality since I was an undergraduate student — I had a great summer research experience and things just took off from there — and wildfire and climate change issues were, and continue to be, at the forefront of daily life in my home state of Colorado. Looking back at my previous academic and working careers, I realize I was always finding ways to incorporate these topics into my work.

Where do you see yourself in five years?

MJ: I hope to continue working in the space between air quality, land management and wildland fire. I enjoy working on management-related science, communicating my research to broad audiences, and I am also interested in science policy. I hope that I will be doing something that can bring all of these interests together. ▪

HARLEEN SANDHU (MSCE 2015) is a fourth year Ph.D. student with a concentration in Computing and Systems. While earning her master's, she worked closely with **Dr. Abhinav Gupta**, who now serves as her advisor. She is studying artificial intelligence approaches for the condition monitoring of nuclear safety systems. Sandhu grew up in Jamshedpur, India.

What influenced you to go into engineering?

Harleen Sandhu: My interest in engineering started very young. My uncle Gurdas Sandhu was the first engineer in our family, and I loved hearing about his projects. He graduated with a Ph.D. from CCEE, and that exposed me to the department's research capabilities. My father worked as a real estate construction manager, and I learned by looking at his structural drawings for residential buildings.

What problem(s) are you trying to solve? Why were NC State and CCEE a good fit for you?

HS: I am trying to build a framework to continually monitor the health and safety conditions of nuclear safety equipment-piping systems at nuclear reactor plants using artificial intelligence (AI) and deep learning approaches. My research explores how automated condition monitoring of nuclear safety systems can be conducted in real-time to alert the operators of any breakdown in the system.

CCEE is one of the few departments in the U.S. that offers a focus in Computing and Systems. This was a game changer for me since I wanted to work on AI technologies within civil engineering applications. In addition to CCEE, NC State also has top computer science and nuclear engineering departments and my research involves collaborations with these departments. CCEE also has great faculty, including my advisor, Dr. Gupta.

Where did your passion for this particular focus come from?

HS: Since my childhood, I have been fascinated by computers and programming. I started studying Java and C++ in middle and high school. My interest grew as I kept achieving better results and understanding of coding languages. Pursuing a Ph.D. was my chance to combine my passion for building safe, reliable structures and work with state-of-the-art programming languages to create research-specific algorithms.

Where do you see yourself in five years?

HS: In five years, I hope to have a tenure-track faculty position at a university with research capability in structural, construction and artificial intelligence applications. ▪

GRADUATE STUDENT **SPOTLIGHTS**

continued

TUHIN ROY

TUHIN ROY is a fifth year Ph.D. student with a concentration in Structural Engineering and Mechanics. Roy grew up in India and is advised by **Dr. Murthy N. Guddati**. His research on the application of computational mechanics in the biomedical field focuses on the estimation of arterial stiffness which is a key biomarker for the early detection of multiple cardiovascular diseases. After defending his dissertation in July, he is transitioning to a postdoctoral fellow position in Dr. Guddati's research group.

What influenced you to go into engineering?

Tuhin Roy: TV shows like "Megastructures," "Extreme Engineering" and "Mega Builders" influenced me to go into engineering. My young mind was in awe of the problem-solving skills of the world-class engineers. Their strong determination to overcome challenges shaped my academic interest. The obstacles faced in making iconic engineering projects like the Hoover Dam, the Flatiron Building and the Tacoma Narrows Bridge and engineers' ability to find lessons in former mistakes to come up with a suitable solution for a particular engineering problem have strongly intrigued me.

What problem(s) are you trying to solve? Why were NC State and CCEE a good fit for you?

TR: I chose CCEE at NC State because I wanted to do research in Computational Mechanics, and Dr. Guddati is one of the pioneers in the field.

In Dr. Guddati's group, I have worked with researchers from the Mayo Clinic and Duke University. I have enjoyed working in this collaborative environment. In addition to my studies, I was president and vice president of the Civil Engineering Graduate Student Association for about three years. In addition to my involvement with CE-GSA, I was one of the co-chairs of the Teaching Effectiveness Committee under the University GSA. These leadership roles gave me managerial skills that will help me in the future, irrespective of the career path I choose.

Where did your passion for this particular focus come from?

TR: I got quite interested when Dr. Guddati presented this research challenge. At that time, I was not completely sure if I was the right fit, given my background. As I started solving challenges, I was intrigued by the fact that my existing knowledge can solve a problem which is undoubtedly in another field. In the past, I heard about the benefits of interdisciplinary research, now I am actually experiencing it.

Where do you see yourself in five years?

TR: I want to be in academia. In the next couple of years, I will try to gain more experience in doing research through postdoctoral positions at several different universities. Currently, I am transitioning to a postdoctoral scholar position in Dr. Guddati's research group. In addition, I have plans to visit the Mayo Clinic early next year to get more insights on the experimental side. ▪

SAMRIN KUSUM is a sixth year Ph.D. candidate majoring in Environmental Engineering. She grew up in Dhaka, Bangladesh, and is advised by **Drs. Moe Pour-Ghaz** and **Joel Ducoste**. Last year, she won CCEE's Three Minute Thesis competition by expertly describing her research that explores solutions to sewer line blockages.

What influenced you to go into engineering?

Samrin Kusum: Being a daughter of a contractor, I visited many construction sites from an early stage and saw the construction of megastructures like dams, bridges, buildings, roads, etc. I liked math and physics, which I knew could help me be an engineer, but choosing engineering as a career is not common for girls in my country. With strong support from my family and my childhood fascination with how things get built, I pursued civil engineering.

What problem(s) are you trying to solve? Why were NC State and CCEE a good fit for you?

SK: My research aims to reduce the formation of Fat, Oil, and Grease (FOG) deposits inside sanitary sewer lines. These FOG deposits lead to sanitary sewer overflows (SSOs) which are both costly and present health risks to the public. Along with my advisors, I developed a new sewer line construction material that incorporates Fly Ash (FA) as a binder material. Replacing cement with FA can significantly reduce FOG deposit formation and thereby reduce SSOs. I am also studying the use of other low-calcium aggregates to potentially decrease the ability of FOG deposits to adhere to the inside of sewer lines.

NC State's civil engineering department caught my attention because of its wide range of research in environmental engineering, and the large number of faculty members encourages cross-disciplinary research activities.

Where did your passion for this particular focus come from?

SK: I first thought civil engineering was all about construction and designing mega infrastructure. I found that environmental engineering is one of the integrated parts of civil engineering due to its array of applications, which ensure sustainable use of water, land and air resources. I chose to major in environmental engineering so that I can play an important role in environmental protection.

Where do you see yourself in five years?

SK: I plan to pursue a career in academia to continue my research work and educate the next generation. I will continue my research on sustainability of sewer collection systems and the development of sustainable alternative construction materials. I also want to get involved in different outreach programs so I can give back to the community. ▪

STUDENT GROUPS

"I am very excited for the students to have such a wonderful space in which to work together and collaborate. The visibility of the work and accomplishments of the student groups in this prominent space will certainly serve to encourage and spark others to join and further enhance their degree program."

STEVE WELTON

There are more than a dozen chapters of professional organizations available for CCEE students. Membership is a way to meet peers, make industry connections, strengthen leadership skills and engage in community service. Participation offers the chance to attend conferences, compete against peers from other institutions, learn outside of the classroom and interact with professional engineers.

Above, Steve Welton creates a large workspace by combining the rolling tool chests.

As we welcome students into Fitts-Woolard Hall, there has been a flurry of activity in our classrooms and laboratories. One busy space is the Stephen Shane Fincher Lab, which is used by several student groups to design and construct for competitions and field work.

Located on the first floor of Fitts-Woolard Hall, the Fincher Lab is 17 feet wide and 55 feet long and has large windows that overlook the first-floor lobby and the Glenn and Phyllis Futrell Plaza, the 'front porch' of our beautiful new building. Through these windows, previous student projects are displayed as motivation for current and future students to use the workspace to 'Think and Do.'

STEVE WELTON, who is a teaching professor and faculty advisor to many of the student groups using the space, was actively engaged during the design phase. Much thought was put into how to make the space flexible and useful to the student organizations. The space contains multiple rolling tool chests, with tools that are specific to each group's needs. Because the heavy-duty tool chests can easily move, the room can be configured in numerous ways. The chests can be rolled together to create one large workspace or separated for several smaller workspaces. An open space in the middle of the room can be used for large projects, and there are dedicated areas for use by specific groups.

American Society of Civil Engineers (ASCE) student members will practice assembling their steel bridge or build the traditional concrete canoe, both of which are entered in competitions. The Earthquake Engineering Research Institute (EERI) student group has an area to build and test wooden tower structures that are entered into national competitions. The Engineers Without Borders (EWB) student chapter will use the space to develop and test projects, such as water filtration systems, that eventually will be replicated in remote areas.

Other organizations that will be using the space include student chapters of the American Concrete Institute (ACI) and Associated General Contractors (AGC). It will also be used during summers by high school campers. ▪

Above, members of the 2021 ASCE Steel Bridge team practice building the bridge inside the student projects lab. From left to right, Bradley Howard, Cole Roberts, Andrew Cook, Larissa Blankenship, Nina Long and Connor Vaughn.

Below, Ph.D. students Jessi Thangitham and Julio Samayoa are demonstrating structural response using a shake table. They are shaking a structure made from K'NEXs to explore the behavior under earthquake loading.

FACES OF CCEE

Our **FACES of CCEE** media project celebrates outstanding alumni and illustrates to current students the varied careers available to them. This is an ongoing project, so if you'd like to bring someone to our attention (including yourself!), then please do so. We are always interested in keeping up with what our alumni are doing. Please send an inquiry or information to our new communications director, Taylor Wanbaugh (**twanbau@ncsu.edu**).

DEBORAH BELL YOUNG
(BSCE 1977)

Debbie spent 35 years at Honeywell, International (AlliedSignal). She rose to leadership positions including director of Health, Safety, and Environmental (HSE) for several divisions. Her roles combined engineering with strategic planning, regulatory oversight, and assessment of capital projects. She led teams that oversaw manufacturing around the globe, representing billions of dollars and thousands of employees. After earning her degree from CCEE, Debbie earned an M.S. in environmental engineering from the Univ. of Pittsburgh, and an M.B.A. from Duke University. She has served several terms on the NC State Engineering Foundation Board, and was elected vice president in 2020. In addition to her work for NC State, Debbie has dedicated significant time to community service.

LILIANA VELASQUEZ MONTOYA
(Ph.D. 2018)

Liliana is an assistant professor of ocean engineering at the U.S. Naval Academy. She splits her time between teaching midshipmen, and her research. Her work explores morphological changes in coastal regions and their effect on infrastructure vulnerability. During her time at NC State she founded the ASCE's Coasts, Oceans, Ports, and Rivers Institute (COPRI) student chapter. Liliana also served as President of the Latin American Student Association.

DONALD KATZ, Ph.D.
(BSCE 2007)

Donald is the manager of flight profitability for Delta Air Lines, forecasting markets and assessing aircraft economics. During his time at NC State he concentrated on transportation systems. As a Fulbright Scholar, he spent a year in Bangladesh evaluating the operational effects of bus overcrowding. He worked at NC State's Institute for Traffic Research and Education (ITRE) where he studied new techniques to improve pavement marking visibility. Donald also earned a Master's and Ph.D. in civil engineering from Georgia Institute of Technology.

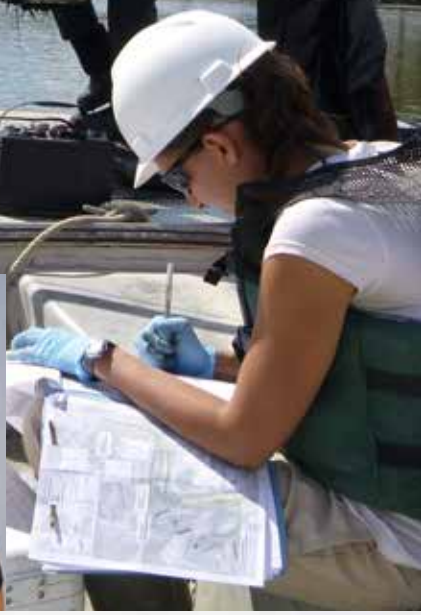
DANNY SMYL
(Ph.D. 2017)

Professor
University of Sheffield
United Kingdom

Danny's focus is finding better ways to monitor the structural health of bridges and buildings, detecting damage before it leads to safety concerns. He served as a Combat Engineer with the U.S. Marines in Afghanistan before completing his doctorate at NC State.

LAUREN WELLBORN
(BSENE 2006, MSENE 2009)

Lauren's expertise is in environmental site investigation and remediation design for complex, multi-stakeholder projects. Her work focuses primarily on contaminated sediments. She manages large teams through all phases of environmental site characterization including sampling plan design, work plan development, quality assurance, health and safety, data management and analysis, data visualization, and report preparation.



WILLY E. STEWART, P.E.
(BSCE 1981, MSCE 1983)

Willy is the founder and CEO of Stewart, an engineering firm headquartered in Raleigh, with more than 200 employees in offices throughout NC and SC. He has been involved in the design and quality assurance of more than $1 billion of construction including commercial, educational, government, industrial, medical, and sports facilities. He also founded i2 Integrated Intelligence, a management consulting organization, and Elevar, a software development firm. Willy was born in Colombia and came to NC State to study engineering. He is now an advocate for promoting diversity in engineering education. He serves numerous community organizations, and is an avid cyclist and Ironman finisher.

How Your Support Makes A Difference

From top to bottom, Ph.D. student Leah Weaver working in the Hydraulics Lab. Dr. Francis de los Reyes, III working with research technician Judy Kays in the microbiology lab.

ENDOWED FACULTY SUPPORT

Faculty members are the heart and soul of the Department of Civil, Construction, and Environmental Engineering, which is home to more than 50 dedicated scholars and educators. Endowments and named professorships are an essential part of our effort to recruit and retain the very best faculty and then provide them with opportunities to explore new research ideas with the involvement of graduate and undergraduate research assistants. Relative to our peer institutions, the department has a low number of endowed professorships.

ENDOWED GRADUATE FELLOWSHIPS AND AWARDS

We strive to attract the best and brightest graduate students from the U.S. and around the world. Departmental rankings, faculty recruitment, research success and undergraduate education all depend on the presence of talented graduate students. Competition for the best graduate students is intense, and finances can be a deciding factor for students when choosing a graduate program. To recruit the best students, and to create a vibrant learning environment for undergraduate students, CCEE must be able to provide competitive graduate fellowships.

ENDOWED UNDERGRADUATE SCHOLARSHIPS

Undergraduate scholarships enable us to prepare tomorrow's leaders in civil, construction, and environmental engineering. Students are drawn to NC State and CCEE by our reputation for excellence. Cost is a major consideration for students and their families. Scholarships represent a mechanism to support and reward our top students.

CCEE ENHANCEMENT FUND

A regular gift to the CCEE Enhancement Fund makes it possible to provide students the best possible education and extracurricular experiences. The enhancement fund allows us to respond to emerging needs and exciting challenges.

For example, this year we deployed teams to the field for time sensitive monitoring of SARS-CoV-2 before external funding was available. Your support enables recruitment and retention of the best and brightest faculty and students, support for our student organizations, field trips to complement classroom instruction, and opportunities for faculty and students to present at conferences. Our enhancement fund is critical to the department as we strive to continue to provide opportunities for students and faculty.

RECOGNIZING OUR CORPORATE SPONSORS

Our corporate sponsors may opt to provide support for specific research areas, enabling faculty members to pursue a new research idea. Sponsorships are also available for this newsletter, the welcome back ice cream each fall and our graduate symposia. These symposia allow students to prepare a poster to describe their research and make a presentation to the local engineering community. The activities of our student groups are also dependent on external financial support.

The ***Firm of the Month*** program recognizes corporate partners who have made an ongoing commitment to the department. It allows us to thank and promote our partners while educating our students about current engineering practice. Our new large monitors in Fitts-Woolard Hall will provide opportunities for firms to display information highlighting notable projects and other information. The Firm of the Month program provides participating firms with name recognition for recruiting and business opportunities, demonstrates to students the ways in which they can use their degrees, and provides information on employment opportunities. ▪

2021 CORPORATE DONORS

The firms listed here have provided endowments or made contributions from January 2021 through August 2021. Many on the list have supported multiple activities in the department. We extend our sincere appreciation.

ACI Carolinas Chapter
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Structural Engineers Association
Terracon Consultants, Inc.
Trisure Corporation

The department has a wide variety of programs that are made possible by private financial support. For more information on opportunities to help, please contact **Lindsay Smith**, our Senior Director of Development at **lksmith4@ncsu.edu** or **919.515.7738**.

ALUMNI BRIEFS

AMR OSAMA ABDEL-AZIZ (Ph.D. 2003), the president of INTEGRAL Consult based in Cairo, Egypt, is an adviser to the Egyptian Minister of Environment on Climate Change Affairs. He recently attended a climate dialogue in the United Arab Emirates, where he met former U.S. Secretary of State, former U.S. Senator, and current U.S. Special Presidential Envoy for Climate John Kerry.

ANAHID BEHROUZI (BSCE 2011, valedictorian) received the Young Alumni Achievement Award from the University of Illinois CEE Alumni Association, where she received her M.S. and Ph.D. in 2013 and 2016. She also was recently promoted to associate professor in the Department of Architectural Engineering at California Polytechnic State University-San Luis Obispo. Behrouzi teaches structural analysis, dynamics and reinforced concrete design, and conducts research in engineering education as well as earthquake behavior of concrete structures.

MOHAMMAD INNAB (BSCE 2018) joined KS Engineers, PC in New York. Innab is a field engineer and will contribute to a flood mitigation project around Coney Island, including the design and installation of floodwalls, floodgates and new drainage to protect from storm damages similar to what happened during Hurricane Sandy.

S M A BIN AL ISLAM (Ph.D. 2021) joined Amazon as a research scientist in summer 2021. He obtained his B.S. in civil engineering from Bangladesh University of Engineering and Technology in 2014 and M.S. in civil engineering from Washington State University in 2018. Islam worked under the direction of Dr. Ali Hajbabaie and focused on traffic control in signalized intersections in the presence of connected and automated vehicles.

ZHANGWEI NING (Ph.D. 2013) co-authored a book on remote sensing that was recently published by ASCE. Ning is the area technical manager for the U.S. and Canada with Sixense Inc. based in Seattle. Ning obtained his B.S. in civil engineering and M.S. in geotechnical engineering in 2005 and 2013, respectively, from Tongji University.

JO SIAS (MSCE 1996, Ph.D. 2001) was inducted as president of the Association of Asphalt Paving Technologists (AAPT). She has served on the AAPT Board of Directors for the last three years and will serve as president for the upcoming year. Sias conducted her graduate work on asphalt pavements under the direction of Dr. Richard Kim from 1994 - 2001 and is currently a professor in the Department of Civil and Environmental Engineering at the University of New Hampshire.

MEHRDAD TAJALLI (Ph.D. 2021) joined UPS as a senior operations research analyst in spring 2021. He obtained his B.S. in civil engineering from Iran University of Science and Technology in 2011 and M.S. in transportation engineering from Sharif University of Technology in 2013. Tajalli worked under the direction of Dr. Ali Hajbabaie and focused on transportation engineering and applying operations research techniques to optimize complex transportation problems such as the control of automated vehicles in signalized intersections.

WEICHANG YUAN (Ph.D. 2021) started as a postdoctoral associate at Yale University in June 2021. He is developing and deploying smart environmental sensors for use with bicycles to collect street-level data on heat stress and air quality. He and his team install sensors on public and private bicycles. Participating cyclists become citizen scientists, collecting data as they travel the city streets, in addition to improving physical health via biking. His work will gain new insights into intra-city variations in health-related environmental variables, including temperature, humidity, carbon dioxide, ozone and particulate matter. ▪

SHARE YOUR NEWS

There are thousands of alumni of the Department of Civil, Construction, and Environmental Engineering working throughout the nation and around the globe. We invite you to provide us with updates about career accomplishments, awards or recognitions, as well as other news. We aspire to create a community of alumni that remain connected to the department and to each other. We also want to keep your contact info current so we can keep you up to date on department events. Send your information to **Taylor Wanbaugh** at **twanbau@ncsu.edu**.

Name, Mailing and Email Address
Company Name and Address
Degree, Major and Class Year
Announcements

Also, we invite you to connect with us on social media to keep up with the latest news.

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The following distinguished alumni and friends of the department currently serve on the board:

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Retired
Co-Founder of Eagle Engineering

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We invite you to invest in the future of the department. Your gift will help us take CCEE to a new level of excellence.

You can choose an annual gift, an endowed gift or a one-time gift. Outright gifts of cash can be made by simply writing a check payable to:

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Please indicate on the check, or with a note, the purpose of your gift and that it is directed to CCEE.

If you prefer to make your donation online, you can use your credit card with our online feature at **www.engr.ncsu.edu/alumni-and-giving/ways-to-give**. Drop down menus will allow you the chance to specify that you want your gift to be directed to our department or to the Fitts-Woolard Hall Building Project Fund.

For more information contact:

Lindsay Smith, Senior Director of Development
Phone: **919.515.7738**
Email: **lksmith4@ncsu.edu**

MEET OUR **FACULTY**

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KATHERINE ANARDE
Coastal, *Assistant Professor*

SANKAR ARUMUGAM
Water Resources / Computing and Systems, *Professor and University Faculty Scholar*

TAREK AZIZ
Environmental, *Assistant Professor and Coordinator of Undergraduate Advising*

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AKHTAR TAYEBALI
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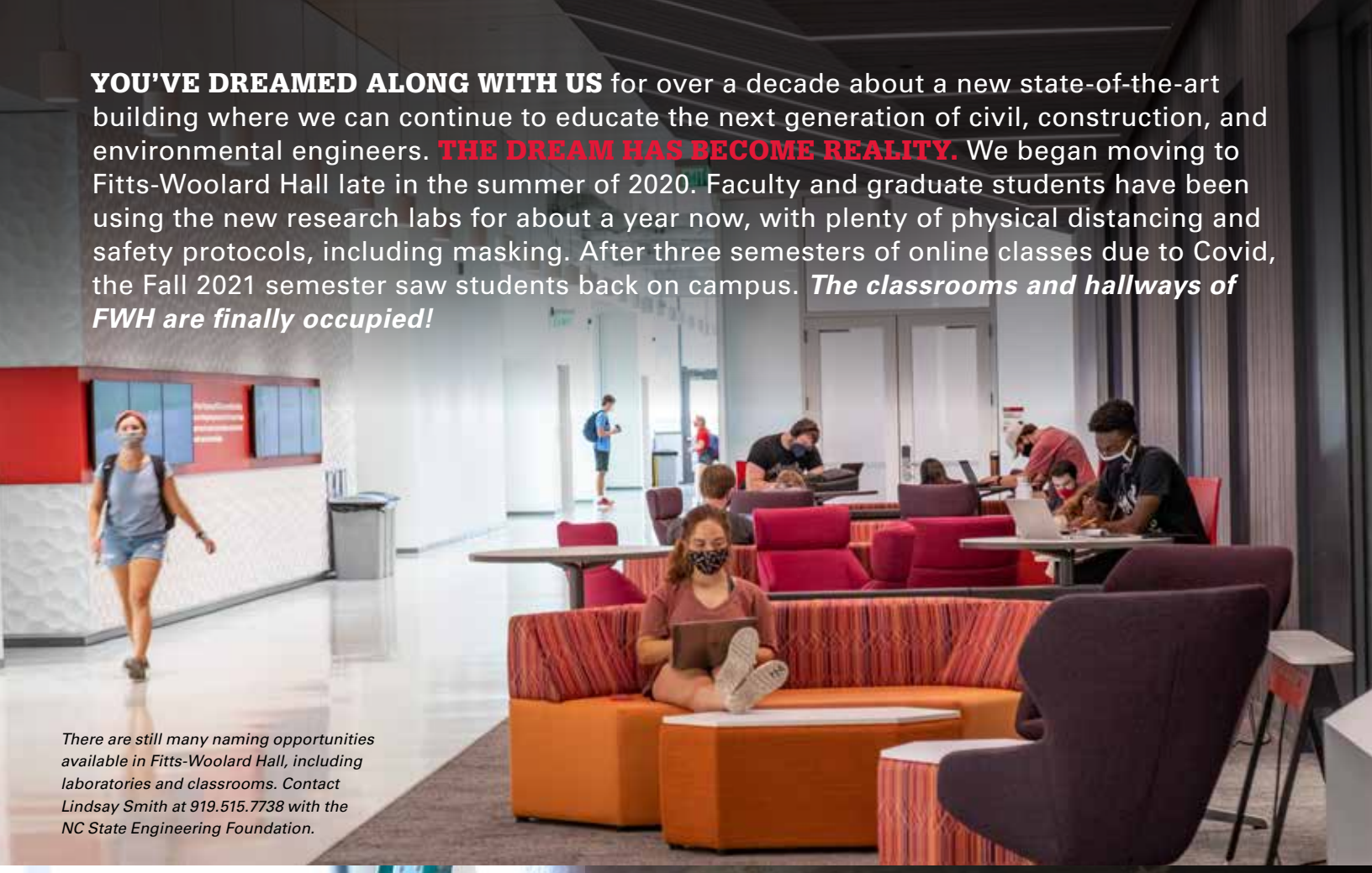
SHANE UNDERWOOD
Transportation Materials, *Associate Professor*

STEVEN WELTON
Structures, *Teaching Professor*

BILLY WILLIAMS
Transportation Systems, *Professor and Director of ITRE*

YOU'VE DREAMED ALONG WITH US for over a decade about a new state-of-the-art building where we can continue to educate the next generation of civil, construction, and environmental engineers. **THE DREAM HAS BECOME REALITY.** We began moving to Fitts-Woolard Hall late in the summer of 2020. Faculty and graduate students have been using the new research labs for about a year now, with plenty of physical distancing and safety protocols, including masking. After three semesters of online classes due to Covid, the Fall 2021 semester saw students back on campus. ***The classrooms and hallways of FWH are finally occupied!***



There are still many naming opportunities available in Fitts-Woolard Hall, including laboratories and classrooms. Contact Lindsay Smith at 919.515.7738 with the NC State Engineering Foundation.

ENGINEERING ONLINE

We offer great opportunities for development

NC State has been offering distance education in engineering for more than four decades and is consistently **ranked among the top online engineering programs in the country**. Our CCEE Department offers two degrees, master of civil engineering (MCE) and master of environmental engineering (MENE). In 2018 rankings by *Best College Reviews*, our **online environmental engineering degree** was ranked **#1 in the country**, and our **civil engineering degree** earned the **#2** spot! With numerous courses available each semester, our online students can customize their degrees to support their area of professional interest. The online degree requires the completion of 10 courses, which some students complete in as little as two years, though three to four years is more typical given their other responsibilities.

Join the hundreds of professional engineers who have advanced their career by taking graduate courses online. Take just a few courses to support your area of interest, or commit to earning an online master's degree.

www.engineeringonline.ncsu.edu/apply-and-enroll/enroll

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Department of Civil, Construction, and Environmental Engineering
NC State University
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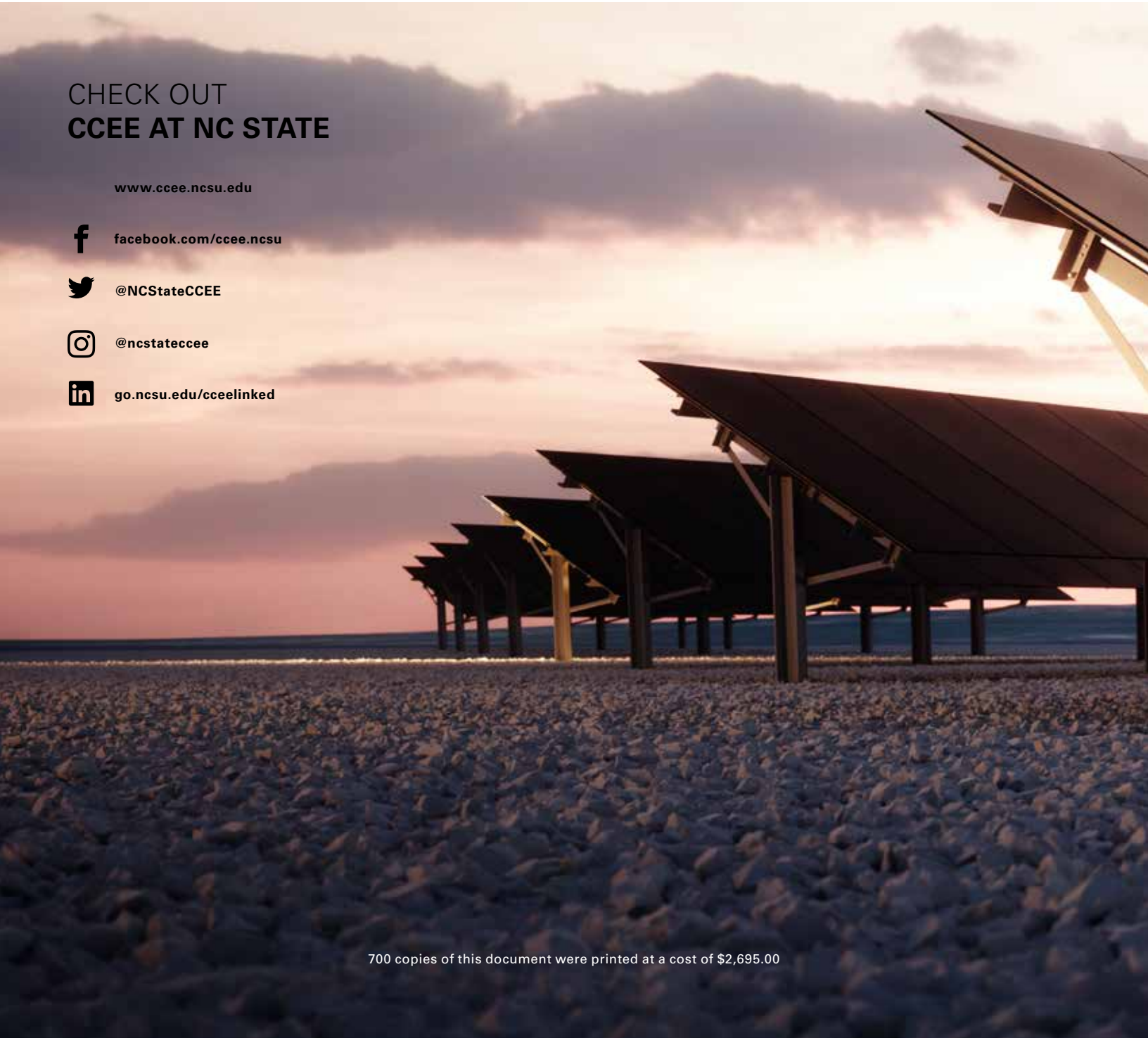

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