USC Viterbi
School of Engineering
Sonny Astani Department of Civil and Environmental Engineering

SPRING 2020
NEWSLETTER

Improving Infrastructure Development, Design and Operation

USC Viterbi School of Engineering researchers have been awarded nearly $2 million by the National Science Foundation's Convergence Accelerator (C-Accel) pilot and Accelerating Research through International Network-to-Network Collaborations (AccelNet) programs. Two projects funded through these programs will promote multidisciplinary research to accelerate the process of scientific discovery and advancement in key areas, including human-building interaction and civil infrastructure design and implementation.

"Our team has been working on the development of analytical tools to improve the production of bridge deterioration models from existing bridge inspections and other data representing bridge conditions."

– Lucio Soibelman

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Big Impacts

Focusing on Building Features That Protect Occupants

A building's design and operations could potentially make people safer when facing emergencies like an active shooter incident. That's the focus of virtual environment research by **Burcin Becerik-Gerber**, professor of civil and environmental engineering, director of graduate programs in the Sonny Astani Department of Civil and Environmental Engineering and co-director of the Center for Intelligent Environments.

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Spotlight On...

Felipe de Barros, Associate Professor of Civil & Environmental Engineering

Felipe de Barros investigates variabilities in groundwater flow and contaminant transport. Because the majority of Californians rely on groundwater for their water supply and due to the presence of numerous hazardous waste sites, potential groundwater contamination has become a serious issue.

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Remarkable Research

Exploring the Removal of Antibiotic-Resistant Genes From Purified Water

A team led by **Adam Smith**, associate professor of civil and environmental engineering, has found that while advanced treatment facilities purify wastewater to a near-distilled quality suitable for drinking, returning it to Southern California aquifers for storage and reuse causes re-contamination with ARGs.

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Improving Infrastructure Development, Design and Operation

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If successful, such collaborations could create safer, healthier, more efficient and more cost-effective civil infrastructures. They could also lead to development of infrastructures that are more responsive to human needs, improving health and well-being through elements like spatial design, indoor air quality improvements and/or lighting.

Members of the research teams, awarded grants totaling $1 million and $750,000 respectively, include Lucio Soibelman, Dean's Professor and chair of the USC Sonny Astani Department of Civil and Environmental Engineering; Sami Masri, professor of civil and environmental engineering and aerospace and mechanical engineering; and Burcin Becerik-Gerber, professor of civil and environmental engineering, director of graduate programs and co-director of USC's Center for Intelligent Environments. Both projects focus on knowledge sharing and network building to improve the development, design and operation of infrastructure, such as bridges and buildings.

Setting the Stage for Sustainability

Soibelman and Masri will work to build knowledge networks in key fields to advance design, development and operation of national infrastructures. Their project, led by Professor Nora El-Gohary, associate professor of civil and environmental engineering at the University of Illinois at Urbana-Champaign, will create the Civil Infrastructure Systems Open Knowledge Network (CIS-OKN). This network will provide tools to assemble and analyze data and improve evaluation, planning, design, construction and operation of infrastructure systems in the United States.

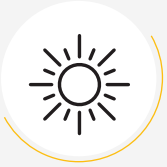
With a multidisciplinary, multi-institution team of civil engineering, data science, computer science and social science experts, the project seeks to improve understanding of the factors contributing to infrastructure deterioration. It also aims to help decision-makers identify and prioritize the elements most essential to creating sustainable U.S. infrastructure systems.

Both NSF-funded projects embrace the idea of convergence, which is a top priority of the USC Viterbi School of Engineering.

"Our team has been working on the development of analytical tools to improve the production of bridge deterioration models from existing bridge inspections and other data representing bridge conditions, such as images and streaming data from existing bridge sensors," Soibelman says.

With better deterioration models, he says, the team will be able to merge traffic and bridge-use data with economic and environmental data to better analyze bridge repair and replacement options, while considering the social and environmental costs of all available options.

"Our team will also try to test the generalization of the research results by applying the approach developed for bridges and transportations systems to other types of infrastructure systems, like water distribution networks," he says.



Building for Better Health

Becerik-Gerber's project will facilitate collaborative research and education through an international "network of networks" advancing knowledge about human health and well-being in buildings. She is collaborating with principal investigators from the University of Alabama, Drexel University and Arizona State University. The team seeks to emphasize the link between the health and well-being of people with the psychological and physiological impacts of the buildings in which they live, work, study or heal.

By sharing and analyzing data from a variety of fields in a collective, holistic way, this network hopes to form the basis for design recommendations that are not only sustainable, but also supportive of human health, productivity and overall well-being.

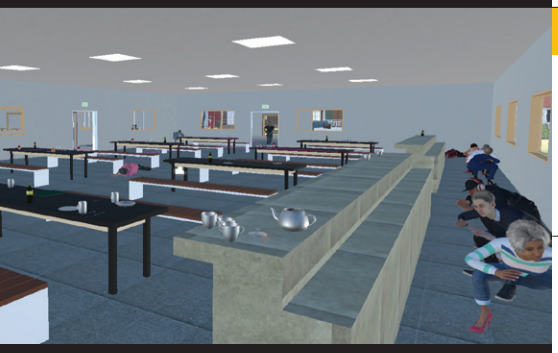
$1,750,000

total awarded grants

"This network of networks brings together healthcare professionals, architects, engineers and data scientists to understand the health implications of buildings from a broad and international perspective," Becerik-Gerber says. "Working with 34 networks across five continents, we aim to identify collaborative opportunities to study primary building features and quantify their impact on health, well-being and productivity."

Both projects embrace the idea of convergence, which is a top priority of USC Viterbi. In an increasingly interconnected, but also complicated, world, networks and programs bringing together experts from different fields will be better able to provide a viable context and basis for effective decision-making that addresses a project's costs, risks and impacts from many relevant angles.

Big Impacts



Researchers have designed virtual environments to test how building security features in schools and offices influence occupant behavior during active shooter incidents.

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Focusing on Building Features That Protect Occupants

USC Viterbi School of Engineering's Burcin Becerik-Gerber was in London as part of her Rutherford Fellowship at the Alan Turing Institute, when she received several voicemails from her sons' elementary school back in Los Angeles. They were on lockdown due to a suspected active shooter in the area. Though she quickly received word that the threat had been disarmed, she felt helpless being so far away from her sons.

After returning to USC, Becerik-Gerber, professor of civil and environmental engineering and director of graduate programs in the Sonny Astani Department of Civil and Environmental Engineering and co-director of the Center for Intelligent Environments (CENTIENTS), wanted to do something to combat that helplessness. She wondered how she could use her expertise – in intelligent buildings' responsiveness to humans – to help make students like her sons safer in the spaces they occupy daily.

In 2018, Becerik-Gerber partnered with Gale Lucas, research assistant professor of computer science and co-founder of CENTIENTS, a human-centered initiative to improve built environments, and Erroll Southers, professor of practice in national and homeland security at the USC Sol Price School of Public Policy. The team put together a proposal, funded by the National Science Foundation in August 2018, to design a virtual environment that they could use to study the influence of building design and operations on occupant behavior and safety. In this environment, they can model various design options while simulating active shooter incidents.

The Value of Virtual Environments

The team began working with Runhe Zhu, a doctoral student double-majoring in civil engineering and computer science, to design four virtual environments: two "regular" layouts and two "enhanced" versions. Utilizing these virtual environments, they can test security recommendations by federal agencies that were validated by focus groups including security designers, building engineers, law enforcement and security personnel. These recommendations include security measures such as frosted glass, various exit locations and quantities, and staggered doorways.

Becerik-Gerber sees these models translating to other emergency scenarios as well.

"This is where dynamism will come into play," she says. "How can a building adapt itself to these events? Can the building lock up the shooter in a portion of the building, or eliminate airflow to a section of the space in the case of a chemical or biological attack?"

The researchers also hope to study how familiarity with a building can change how individuals respond in an active shooter situation.

"How much do decisions to hide, run or fight change in response to the design of the building, and how does familiarity with the building design influence individual decision-making?" Becerik-Gerber asks.

In the coming months, the team will bring in more than 200 teachers and office workers to experience the virtual reality environments and provide answers to some of those questions.

SPOTLIGHT ON...

Investigating Variabilities in Groundwater Flow and Contaminant Transport

A Q&A Session with Felipe de Barros, Associate Professor of Civil and Environmental Engineering

Q: What are your research goals?

A: I conduct basic research on the fundamental and computational aspects of flow and transport in porous media and develop methodologies to quantify the probability of the risks associated with groundwater contamination.

Q: You received the prestigious National Science Foundation CAREER award in 2017. What research has that supported?

A: My research combines probabilistic concepts with hydrological connectivity measures to further investigate the joint interaction between aquifer heterogeneity, source zone architecture, preferential flow paths and toxicity of chemical mixtures and their impact on risk.

Q: Tell me about some of your recent research collaborations.

A: The dissertation work of one of my doctoral students, Calogero Benedetto Rizzo, utilizes graph theory to compute preferential flow paths in aquifers. With collaborators in Italy, I have explored the benefits of combining natural heterogeneity with oscillating flows to increase mixing rates of a contaminant plume. With another of my doctoral students, Jinwoo Im, I am looking at the effects of toxicological dose-response models for emerging contaminants on aquifer resilience.

Q: What do you consider is the impact of this research?

A: More than 90% of the available freshwater present on our planet is contained in the subsurface environment. Groundwater is a critical resource for municipalities, industry, energy sectors and agriculture. The majority of Californians rely on groundwater for their water supply and, due to the presence of numerous hazardous waste sites, potential groundwater contamination has become a serious issue.

Q: How do natural and human-made variabilities affect groundwater?

A: Variability has a profound impact on groundwater fluxes and contaminant spreading. However, due to limited financial resources, a full characterization of the subsurface environment is not feasible. Hydrogeologists and engineers only have access to groundwater information at limited locations, so risk managers have to rely on mathematical models that aim to forecast the evolution of a contamination plume and associated uncertainties. These predictions are critical because they help estimate the risks associated with contaminated groundwater and evaluate the failure or success of a remediation campaign.

Exploring the Removal of Antibiotic-Resistant Genes From Purified Water

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New and emerging contaminants like antibiotic-resistant genes (ARGs) pose a potential hazard to public safety and water security. A spread of ARGs through the water system could increase development of antibiotic-resistant superbugs, for which our healthcare system has no effective treatment.

Adam Smith's team has found that while advanced treatment facilities can purify wastewater to a near-distilled quality suitable for drinking, reducing nearly all targeted ARGs to below detectable limits, the next step in the reuse scheme unravels their efforts. Purified water returned to Southern California aquifers for storage and reuse blends with antibiotic-resistant bacteria already found in these aquifers.

Smith's team of researchers, including postdoctoral scholar Moustapha Harb and doctoral students Phillip Wang and Ali Zarei-Baygi, studied and compared samples from an advanced water purification facility in Southern California and groundwater aquifers to detect differences in ARG concentrations. Their findings, published in *Environmental Science & Technology Letters*, indicate that the facility takes purified water and uses it to replenish (recharge) the local aquifer to maintain a plentiful supply of groundwater to be used as local drinking water. In their aquifer samples, they found the ubiquitous presence of ARGs in both control locations and locations recharged with water from the advanced water treatment facility.

"Antibiotic-resistant genes are not regulated in any way and are a challenging emerging contaminant of concern due to our reliance on biological treatment in the engineered water cycle."

– Adam Smith

Treatment facilities that use an "environmental barrier," like the aquifer recharge in this case, for a process called indirect potable reuse, have traditionally been considered more reliable and are better accepted by the public than more direct forms of water reuse. However, Smith's group found that blending purified water with environmental water, where antibiotic resistance exists, reduces its quality.

Understanding How ARGs Spread

Some ARGs naturally occur in microbial communities, but antibiotics, ARGs and antibiotic-resistant pathogens are on the rise in water sources as a result of antibiotic overuse. To reuse water for potable use, one approach is to first process the wastewater at a wastewater treatment facility, followed by additional physical and chemical treatment at a reuse facility. Then the treated water is handled in one of two ways:

1. **In indirect potable reuse**, the purified water is infused back into an environmental buffer, like an aquifer. Later, water is pulled from the aquifer and further treated at a drinking water treatment plant before being added to the public water supply.

2. **In direct potable reuse**, purified water does not return to an environmental buffer, but instead remains within the engineered water cycle. It goes from the wastewater treatment plant to the water reuse plant to the drinking water treatment plant and then out to the tap.

Since conventional wastewater treatment plants are not generally designed for removal of micropollutants like antibiotics, they tend to persist in these treatment systems. However, advanced treatment used for potable reuse removes nearly all ARGs to below detection. Reintroducing them to the aquifer is the problem.

"ARGs are not regulated in any way and are a challenging emerging contaminant of concern due to our reliance on biological treatment in the engineered water cycle," Smith says. "Because they are biological contaminants – small fragments of DNA that are released to the environment – bacteria present in receiving environments can uptake them, becoming resistant themselves and further perpetuating the spread of resistance."

HIGHLY ACCOMPLISHED

Le Val Lund Award Given to University of Maryland Professor

Bilal Ayyub, professor of civil and environmental engineering and director of the Center for Technology and Systems Management at the University of Maryland, received the 2019 Le Val Lund Award for Practicing Lifeline Risk Reduction. The American Society of Civil Engineers, USC and Caltech give this annual award, in honor of Le Val Lund, Jr., a professional engineer who devoted his career to public service. The award recognizes an individual for contributions to the practice of reducing risks to lifeline systems and preparing communities for natural and man-made hazards. An esteemed member of the ASCE, Ayyub's passion has contributed to the ASCE's manual of practice incorporating climate change requirements. His lecture focused on adaptive design and risk management for climate-resilient infrastructure.

Lucio Soibelman Inducted Into the National Academy of Construction

In October 2019, **Lucio Soibelman**, Dean's Professor of Civil and Environmental Engineering and department chair, was inducted into the National Academy of Construction in Nashville, Tennessee. The academy is made up of exceptional leaders who serve one of our nation's largest industries in a positive and impactful manner.

USC's Construction Management Association of America Shares Fall/Winter Highlights

USC's student chapter of CMAA held its 25th Annual Symposium in November 2019, centered around one of Los Angeles' biggest projects, SoFi Stadium. More than 100 industry professionals and almost as many students and USC faculty gathered for a night of networking, inspiration and innovation as Lance Evans, principal and director of sports from HKS Architects, and Reid McManus, general manager for Turner Construction, presented on this nearly $5 billion project.

The USC CMAA also partnered with local general contracting and construction management firms for weekly informational sessions and networking opportunities. And, in February, its teams returned home from the ASC Regions 6 & 7 competition in Reno, Nevada, with two third-place finishes in the Mixed Use and Preconstruction categories.

USC's American Society of Civil Engineers Celebrates Engineers Week

The USC student chapter of ASCE hosted more than 120 local high school students and chaperones on campus in February 2020 for faculty lectures, hands-on activities and an engineering club fair with USC student design teams. With help from 20 USC volunteers and 10 ASCE Younger Member Forum volunteers, attending students built catapults and competed in Engineering Jenga, enhancing their collaboration and communication skills.

HIGHLY ACCOMPLISHED

Student Spotlight: Ashrant Aryal

Ashrant Aryal, a fifth-year doctoral candidate advised by Burcin Becerik-Gerber, seeks to improve the comfort, satisfaction and well-being of office occupants. He is working to create intelligent systems that learn occupant preferences for the indoor environment and control the microclimate using localized environmental control systems under different levels of automation. His work uses sensing, artificial intelligence, machine learning and the Internet of Things to improve indoor environmental quality while maintaining energy-efficient operations.

Born and raised in Nepal, Aryal received his undergraduate degree in civil engineering from the Technion – Israel Institute of Technology before coming to USC Viterbi. Here, he has published six peer-reviewed journal articles, three peer-reviewed conference articles, and has received the Viterbi Undergraduate Mentorship Award in 2018 and the outstanding researcher award from the Sonny Astani Department of Civil and Environmental Engineering in 2019.

CEE Doctoral Student Named "Top Innovator Under 35"

MIT Technology Review named **Ghena Alhanaee,** a doctoral candidate in the Astani Department of CEE, one of the "Top Innovators Under 35" in the Middle East and North Africa. The distinction recognizes Alhanaee's work to prevent a regional catastrophe in the Persian Gulf by providing a linked emergency response plan.

Alhanaee is only the second doctoral student at USC to achieve this distinction before graduating.

Alhanaee's research focuses on environmental sustainability, energy resources, water and food security. She is designing a framework to prevent and prepare the Persian Gulf region in the event of a disaster.

"One-third of oil production is in the Gulf and so is half of the world's desalination," Alhanaee says. "Now, add nuclear energy to the mix. We have one reactor operating in Iran, four being built in the United Arab Emirates and at least two planned in Saudi Arabia. These three industries are heavily reliant upon each other. If disaster occurs in one of these, it will impact the other two."

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We're eager to hear about the great things our alumni are doing. Please share your successes with the Trojan community by emailing your updates to **salinapa@usc.edu**.

CHAIR'S MESSAGE

This semester has presented challenges we have never encountered before here at USC, but these difficulties have not stopped our Sonny Astani Department of Civil and Environmental Engineering students and faculty from continuing to learn, innovate and grow.

Halfway through the term, classes transitioned online in response to health recommendations regarding the COVID-19 outbreak. The process of learning to work remotely has introduced fresh challenges for our students, faculty and staff, but I am confident that we have been able to overcome them.

Though physically distant, with students and faculty now distributed all over the world, we are – in some ways – more connected than ever before. I am confident that we can continue the progress that we have been making in our department by remaining dedicated, open-minded and optimistic as we pursue new opportunities.

I would like to celebrate some of the great recent accomplishments within our department. First, I would like to congratulate assistant professors Qiming Wang and Daniel McCurry for their NSF CAREER Awards, which they have received for showing exceptional promise in their fields. We are lucky to have such remarkable faculty supporting our goals and vision and furthering scientific knowledge.

Our USC Construction Management Association of America's 25th Annual Symposium in November 2019 and Engineers Week in February 2020 were great successes, with the latter serving as a heartening example of one of the many ways that our ASCE student chapter is actively working to inspire future engineers.

In closing, I strongly agree with Dean Yortsos' vision that this crisis provides us opportunities to practice innovation and reinvention and to understand and support our fellow humans through "heroic engineering," with the objective of engineering a better world for all of humanity. I hope everyone and their families are well, safe and healthy, and I wish you all a safe and successful end of the semester.

Lucio Soibelman, PhD
Chair of the Sonny Astani Department of Civil and Environmental Engineering