Northwestern ENGINEERING

FALL 2018

CIVIL AND ENVIRONMENTAL ENGINEERING

CREATING A HOME ON MARS

Northwestern team imagines deep-space construction as part of NASA's 3D-Printed Habitat Centennial Challenge



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Our hope has always been to build something that will live beyond the competition and afford us a chance to perform more meaningful research in this new field.

- PROFESSOR GIANLUCA CUSATIS, who is leading an interdisciplinary team of students and faculty to design Martian housing as part of NASA's 3D-Printed Habitat Challenge.



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FROM THE CHAIR

Dear friends and colleagues,

am happy to be writing to you at the (late) start of our 2018-19 academic year and to share the many accomplishments of our faculty, students, and alumni in the Department of Civil and Environmental Engineering (CEE). We continue to hire exciting young faculty, renovate our facilities, and improve our curricula. In fact, after a couple of years of planning, we are launching new programs of study for undergraduates in both civil and environmental engineering. Let me highlight just a few of the exciting events that took place over the last year.

A few years ago we began a large-scale 3D printing initiative and it has really taken off. Our feature story reports the recent progress and successes of an interdisciplinary team of students and faculty, led by Professor Gianluca Cusatis, who are competing in the NASA Mars Habitat Challenge (page 5). The Martian 3Design team placed fifth in the Virtual Design Competition and was the only university team among the winners of this phase of the Challenge. The next phase of the Challenge moves to actually constructing a scale model of their design using 3D printing. Professor Cusatis has been busy developing a robotic facility that will allow largescale 3D printing and advance material development adapted to the Mars environment. We are particularly eager to discover how the Martian concrete that Professor Cusatis developed a couple of years ago will perform under test conditions.

We initiated another new effort around urban resilience. In April, I hosted a workshop on resilient communities titled "Bounce Forward: Moving Communities from Crisis to Resilience" (page 3). The workshop featured the work of many CEE faculty, as well as experts from England and around the country. Given the vulnerability of communities to rapidly changing economic, social, political, and climatic conditions, this is a topic that is only growing in importance for designers, policy makers, and researchers. The strong interest in resilience among the Northwestern community and the stimulating discussions at the workshop reinforce the department's comitment to develop research and teaching in this area.

The department conducted a very successful search for a new faculty member in the general area of earth surface engineering and intelligent geotechnical systems. We are thrilled to welcome Alessandro Rotta Loria (page 2) who will join CEE in April 2019. Dr. Rotta Loria recently completed his PhD studies in geomechanics at the Swiss Federal Institute of Technology in Lausanne, Switzerland (EPFL), and works at the intersection of geotechnical and energy engineering in the urban environment.

Among the many awards our students and faculty receive,

I am particularly pleased that a CEE faculty member was again recognized for excellence in teaching. Professor Arancha Alarcon-Fleming (page 8) received the Cole Higgins Teaching Award for "her relentless enthusiasm for Engineering Mechanics and encouraging student success." Although she has taught one or two courses each year since 2015, Professor Alarcon-Fleming officially joined our faculty as an associate professor of instruction in 2017. Professor Alarcon-Fleming has a talent and passion for teaching the fundamentals of civil engineering and for transforming large impersonal lecture classes into engaging sessions that inspire students. We are very lucky to have her as a colleague.

Enjoy reading about the unique research findings and impressive accomplishments of our students and faculty. We are looking forward to an exciting 2019 academic year where we will continue to push intellectual boundaries and search for solutions to the world's most pressing problems. We thank our alumni, students, faculty, staff, and friends for their support and commitment to our department. We are particularly proud of the creative efforts of our faculty to reach out to younger students and show them the exciting work of civil and environmental engineers.



Kimberly Gray Kay Davis Professor and Chair of Civil and Environmental Engineering

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Kimberly Gray, Kay Davis Professor of civil and environmental engineering, became department chair in 2015. With a courtesy appointment in the Department of Chemical and Biological Engineering, Gray is an expert in environmental catalysis and physicochemical processes in natural and engineered environmental systems. Her research focuses on energy and urban sustainability applications. As chair, she aims to further the department's work addressing many of the world's most pressing problems, including infrastructure, urban redevelopment, transportation, energy, and water.

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Department Welcomes Alessandro Rotta Loria

Rotta Loria joins from the Swiss Federal Institute of Technology



A orthwestern University is excited to welcome **Alessandro F. Rotta Loria** as an assistant professor of civil and environmental engineering.

Joining from the Swiss Federal Institute of Technology, Rotta Loria is an expert in geomechanics and structural mechanics in the context of energy production and storage applications. His research focuses on both fundamental and applied multiphysical and multiscale problems involved with the development of innovative urban environments.

As co-author of 13 refereed journal papers and 19 refereed conference articles, Rotta Loria has been awarded research prizes and honors by international journals and institutions. He is often involved as a presenter in scientific conferences and he serves as a reviewer for the international scientific journals Geomechanics for Energy and the Environment, Journal of Geotechnical and Geoenvironmental Engineering, Géotechnique Letters, and Engineering Geology. ROTTA LORIA IS AN EXPERT IN STRUCTURAL MECHANICS IN THE CONTEXT OF ENERGY PRODUCTION AND STORAGE APPLICATIONS.

Rotta Loria obtained his PhD in mechanics from the Swiss Federal Institute of Technology in Lausanne (EPFL), Switzerland, and his BS and MS degrees in building engineering from the Politecnico di Torino, Italy.

STEM Students Explore Role of Nanoscience in Civil Engineering

Students toured Northwestern labs and conducted experiments during the workshop

he Department of Civil and Environmental Engineering welcomed 23 female high school students from Chicago Bulls College Prep in May for an interactive workshop on the role of nanoscience in civil engineering.

Hosted jointly through the labs of Ange-Therese Akono, Oluwaseyi Balogun, and Gianluca Cusatis, the visiting students enjoyed the opportunity to tour faculty labs and participate in cutting-edge experiments that tackled topics related to advanced nanoscale characterization methods, novel contactless mechanical probing, and durability of concrete materials.



The workshop was the first in a series developed in coordination with Northwestern's Office of Diversity and Inclusion that seeks to promote the recruitment and retention of underrepresented groups in STEM disciplines. Students from Chicago Bulls College Prep visited the Department in May to tour faculty labs and participate in nanoscience experiments.

Converting CO₂ to Valuable Products

Researchers use light source and sand to split CO₂ bonds in glass reactor



The research could lead to a new understanding of how to create closed-loop carbon cycles. Credit: ChemSusChem, Wiley-VCH

Northwestern Engineering research team led by Professor **Kimberly Gray** has demonstrated the basic process by which carbon dioxide could be converted at surprisingly high yields to a product used as feedstock in the synthesis of useful and profitable chemicals.

The researchers used high-energy ultraviolet light to catalyze the splitting of CO_2 bonds in a glass reactor, which initiated a self-propagating set of "chain reactions." The process was further enhanced by incorporating hydrogen and silica into the reactor. " CO_2 is very stable and long-lasting in the Earth's atmosphere, which is why it poses such a problem," Gray said. "We discovered a simple process through which we could transform a waste product into a useful product. All that is needed is a light source and some sand. This is an example of resource recovery and also makes possible ways to develop closed-loop carbon cycles in industry."

The research, presented in a paper titled "Photo-Initiated Reduction of CO_2 by H_2 on Silica Surface," was featured on the cover of the journal *ChemSuSChem*.

Workshop Tackles Resilient Communities

Two-day event brought together leading architects, civil and environmental engineers, and transportation experts

n April, Northwestern welcomed more than 80 architects, civil and environmental engineers, and transportation experts for a two-day workshop titled "Bounce Forward: Moving Communities from Crisis to Resilience." Organized by Professor **Kimberly Gray**, director of Northwestern's Center for Resilient Cities, the event not only explored the definition of resilience, but also what it means to be a resilient community in an age of changing climate, technology shifts, and economic and political surprises.

Plenary speakers included David Waggonner, a New Orleans architect who discussed how cities are being designed with water in mind. Robert Lempert, director of the RAND Pardee Center for Longer Range Global Policy and the Future Human Condition, and Koen Steemers, professor of sustainable design at the University of Cambridge, spoke about policy and decision-making in uncertain conditions, designing for diversity and equity, and sustaining the vibrancy of cities.

Other presentations featured the work of experts from around the country and Northwestern, including faculty and researchers from the Department of Civil and Environmental Engineering, Pritzker School of Law, Kellogg School of Management, Weinberg College of Arts and Sciences, Northwestern University Transportation Center, and the Buffet Institute for Global Studies.

The workshop was organized into three sessions: "Stories of Flooding: Vulnerability and Persistence," "Resilience and Uncertainty: Attitudes, Data and Policy," and "Design for Resilience: Metrics and Strategies."



A workshop on resilient cities explored what it means to be a resilient community in an age of changing climate, technology shifts, and economic and political surprises.

The highly interdisciplinary event presented stimulating perspectives on the challenges and opportunities of changing how to design cities and encourage changes to human behavior in an age of rapidly changing climate.

Engineering the Next Generation of Structural Materials

The Akono Lab investigates new types of ceramic-like structural materials

oping to one day see buildings that are taller, stronger, and more energy efficient, Professor **Ange-Therese Akono**'s research group is investigating new types of ceramic-like structural materials. The lab is working to combine the strength and high-thermal stability of ceramics with the formability and ductility of polymers. Other potential applications of the new materials include low-level nuclear waste containment and heavy metal waste encapsulation.

With cement contributing approximately seven percent to average global CO₂ emissions, Akono and her group are also exploring ways to develop lowcarbon Portland cement alternatives. This multiscale and interdisciplinary research is part of a project funded jointly



by the National Science Foundation, the Northwestern High Performance Computing system, and the National Center for Supercomputing Applications at the University of Illinois at Urbana-Champaign. Preliminary findings using experiments and advanced mathematical modeling and numerical simulations have shed light on the complex relationships between mix design, pore structure, and strength development. THE LAB IS WORKING TO COMBINE THE STRENGTH AND HIGH-THERMAL STABILITY OF CERAMICS WITH THE FORMABILITY AND DUCTILITY OF POLYMERS.

Members of the Akono I ab

Jiaxin Chen, Ange-Therese Akono,

(from left): Devon Dulan,

and Elyse He'bert

Construction, Deconstruction, and Jazz

Alumnus Julius Tucker credits engineering background for his rise as a jazz pianist s a student at Northwestern, Julius Tucker ('17) spent his mornings studying civil engineering and his afternoons exploring jazz. After graduating in 2017 with a BS in civil engineering from the McCormick School of Engineering and a BA in jazz



Julius Tucker

piano from Northwestern's Bienen School of Music, Tucker is now a rising Chicago jazz pianist. He has played at numerous venues around the city, including The Green Mill, Room 43, Andy's Jazz Club, and — with the Julius Tucker Quintet at the Chicago Jazz Showcase.

Tucker, who has played piano for more than 15 years, credits his engineering background for helping him think of music in more objective terms. "Incorporating hard-set goals and rules is helpful when there are so many possibilities when writing and playing music," he said.

As his career takes him to new heights, Tucker remains appreciative of his wholebrain education at Northwestern.

"Engaging both halves of my brain was invaluable during my time in school and will continue to be an important part of my career."

NORTHWESTERN TEAM COMPETES IN NASA'S MARS HABITAT CHALLENGE

Scheduled to end in 2019, the team most recently earned a top five finish in the Challenge's Virtual Design Competition





Left: An interior view of the habitat. Above: An overview of the team's habitat design, which separates lab space and the kitchen from bedrooms to preserve privacy and limit resources needed for construction.

n interdisciplinary team from Northwestern is among the leaders in NASA's 3D-Printed Habitat Challenge, a \$2.5 million competition inviting groups to design and build a 3D-printed habitat that could be used as part of the agency's astronautled missions to Mars in 2030.

Launched four years ago, the multiphase challenge seeks to advance the construction technology needed to create sustainable housing solutions for Earth and beyond.

In July, NASA announced that the Northwestern team earned a fifth-place finish among 18 teams in the Challenge's Phase 3 Virtual Design Competition, which tasked teams to create virtual renderings of a Martian house that could be constructed using 3D-printing. The team's habitat design, called Martian 3Design, combines sound structural engineering principles, building techniques that leverage Martian materials, and an intuitive floor plan that maximizes private and public spaces and resource efficiency.

Features of the team's habitat design include:

A 3D-printable inner spherical shell and outer parabolic dome that protect the house against the harsh Martian climate

An interior layout that separates wet rooms (lab, kitchen, bathroom) from dry rooms (bedrooms, workstations) to limit the resources needed for construction

Two hatch openings, located directly across from each other, which allow habitat units to easily connect to each other, fostering community on the planet's surface

The team is currently hard at work on the challenge's 3D-Printed Construction Competition, which includes designing a 3D printer capable of printing large infrastructure components on the planet, as well as building the challenge's culminating project: a 1:3 scale model of the habitat designed in the Virtual Design Competition.

The interdisciplinary team is composed of more than two dozen students and faculty from across Northwestern, with backgrounds ranging from civil engineering, materials, chemical engineering, journalism, political science, and more.



Gianluca Cusatis, associate professor of civil and environmental engineering, is the team's faculty adviser, while **Matthew Troemner**, a PhD student in civil and environmental engineering, is the team's student project manager.

DEPARTMENT NEWS

Capstone Design Group Visits Goose Island



Top: Capstone Design Students at the Goose Island industrial island.

his spring, civil engineering and environmental engineering seniors collaborated on a multidisciplinary project in Capstone Design, a course that showcases the function, design, and operation of modern infrastructure systems. The course, co-taught by Clinical Professor David Corr and Adjunct

TAUGHT BY PRACTICING ARCHITECTS AND ENGINEERS, THE COURSE SHOWCASES THE FUNCTION, DESIGN, AND OPERATION OF MODERN INFRASTRUCTURE SYSTEMS.

Professor Joe Rossabi, culminated with a master plan for the redevelopment of Goose Island in Chicago. The design included a multi-use district with residential and commercial building space, along with greenspaces and shared water and energy infrastructure. Capstone Design builds off of the winter quarter course, Design of Sustainable Urban Districts, taught by practicing architects and planners at Perkins+Will.

Students Work Toward Sustainable Building Design



The team's building design provides enough natural light to eliminate the need for artificial lighting during the day.

ichael Aronson, a recent graduate of the department's BS/MS program, spent his final months as a student exploring the intersection of architecture and structural engineering in the CIV-ENV 395: High Performance Building Design course. Aronson, along with team members **Kunhao He** and **Manos Proussaloglou**, were challenged to rehabilitate and reimagine an existing building on Northwestern's Evanston campus to make it more environmentally friendly.

In designing the renovation, the team focused on incorporating passive sustainability strategies, including:

A double-skin façade that insulates the building and provides enough natural light to illuminate its interior without the need for artificial lighting during the day

A four-story atrium that acts as a solar chimney during the summer to naturally cool and ventilate the building

A greenhouse, which sits near the atrium's top floor, that grows bamboo for furniture and architectural model-making

Dowding Honored with Symposium

n April, the Department of Civil and Environmental Engineering hosted a symposium in celebration of Professor Emeritus **Charles Dowding**. Dowding, whose research focuses on construction vibrations, rock mechanics, subsurface exploration decisions, and micrometer crack response, was honored by friends and colleagues for his commitment, loyalty, and comradery shown during his 42-year teaching career at Northwestern.



Professor Emeritus Charles Dowding with Chair Kimberly Gray

Undergraduates Conclude Crowdfunded Experiment on Coral Bleaching



The team evaluated 88 diverse coral species using data analysis to uncover patterns among species.

n September 2016, a team of Northwestern Engineering undergraduate students crowdsourced funding for an experiment to identify the skeletal and morphological characteristics of coral reefs at larger scales. The team hoped to learn how coral architecture may or may not increase the risk of coral bleaching.

After successfully achieving their funding goal, the team evaluated 88 diverse coral species using data analysis and applying modern phylogenetic comparative methods to uncover patterns among species. In doing so, the team overturned a widely held understanding that integrated coral colonies were more susceptible to thermal stress, a significant cause of bleaching.

The team's results were published in January in the journal *Marine Ecology*. **Phillip Osborn**, an environmental engineering senior, was listed as one of the paper's co-authors. Research Assistant Professor **Luisa Marcelino** was the paper's corresponding author.

Third Annual Water Symposium Tackles Transboundary Challenges

orthwestern hosted the Third Annual Symposium on Water in Israel and the Middle East on May 15. Guided by the theme of "Transboundary Disputes and Collaborative Solutions," the day-long event invited guests to learn about the transboundary water challenges in the Middle East, and hear from experts in the field about sustainable solutions to these issues.

The event was presented by the Northwestern Center for Water Research and the Crown Family Center for Jewish and Israel Studies in the Weinberg College of Arts and Sciences. Professor **Aaron Packman**, who directs the Center for Water Research, served as the co-chair of the symposium.



Aaron Packman (left) and Elie Rekhess of Northwestern's Crown Family Center for Jewish and Israel Studies

Some of the panel discussions included, "The Economic, Health, and Psychosocial Consequences of Household Water Insecurity," "Water Diplomacy and National Security: The Case of Israel," and "The Perils and Potential of a Panacea: Sustainability Challenges in the Desalination Era."

Department Hosts 'Career Day for Girls' Events



Guests are introduced to the Soil-Structure and Soil-Machine Interaction Laboratory.

undreds of Chicago-area middle school and high school girls performed hands-on experiments and toured Evanston campus laboratories in February during Northwestern's 48th annual Career Day for Girls.

As part of the festivities, the Department of Civil and Environmental Engineering ran experiments for more than two dozen guests, which included a demonstration by Professor **Karen Chou** on how to make molds and ornaments out of floating concrete.

Professor **James Hambleton** and PhD students **Anastasia Nally** and **Zhefei Jin** hosted sessions in the Soil-Structure and Soil-Machine Interaction (SSI & SMI) Laboratory. Guests met Ernie, the Lab's six-axis robot, and discovered how he is providing insights into how machines move and shape earth.

FACULTY NEWS



Jan Achenbach received an honorary

professorship from Xiamen University, China.



Arantzazu Alarcon-Fleming received

Northwestern Engineering's 2018 Cole-Higgins Award for her relentless enthusiasm for teaching engineering

mechanics and supporting student success.



Zdeněk P. Bažant

received the ASME Medal from the American Society of Mechanical Engineers, as well as the ASCE Alfred M. Freudenthal Medal,

which is regarded as the highest recognition in probabilistic mechanics and structural safety. He was cited for "developing a comprehensive theory of probabilistic mechanics of strength, lifetime, and size effect of quasi-brittle structures."



Karen Chou was

awarded Northwestern's T. William Heyck Award for her exemplary use of time, perspective, and expertise in creating a more seamless

undergraduate experience



named a fellow of the American Society of Civil Engineers's Engineering Mechanics Institute in recognition of his distinguished record

Gianluca Cusatis was

of research, accomplishments, and service to the Institute and the engineering mechanics community.

Isaac Daniel was



elected a member of the Academy of Athens, the most prestigious academic recognition in Greece. He also delivered the keynote lecture on

his new composites theory at the US National Congress of Theoretical and Applied Mechanics in Chicago.



Richard J. Finno received the 2018 Ralph B. Peck Award in recognition of his transformative contributions in the field of excavation systems.

Kimberly Gray was

appointed to the Board of Scientific Counselors of the United States Environmental Protection Agency. She gave a plenary talk at the AIChE

Midwest Regional Meeting called "Unexpected Behavior of Photoactive Nanocomposites in Energy & Environmental Applications."

Yonggang Huang was



elected foreign member of Academia Europaea, as well as foreign member of the Chinese Academy of Sciences for his

significant achievements and contributions to promoting the development of science and technology in China. He also received the Zdeněk P. Bažant Medal for Failure and Damage Prevention from ASCE and was named honorary professor from Xiangtan University, China.



If you live there, you ought to have a rain gauge sitting on your deck that's connected to your smartphone and pings you with an alarm when rain levels reach a critical level. For me, this kind of citizen science is the solution to the problem."

- PROFESSOR JAMES HAMBLETON, who discussed the benefits of rainwater technology in mudslide prevention in the April issue of Meteorological Technology International.



Sinan Keten was

awarded the 2018 SES Young Investigator Medal from the Society of Engineering Science.





Surendra Shah presented Columbia University's inaugural Carlton Lecture and Lehigh University's Fazlur Khan Distinguished Lecture Series in February.

The Leap from Dance to Design

Mehri Paydar ('11) trades in the ballet studio for the construction site as a civil engineer

fter performing for the Colorado Ballet and Tulsa Ballet in productions of *Dracula*, *Western Symphony, Fancy Free*, and *The Sleeping Beauty*, **Mehri Paydar** left the world of professional ballet in 2007 to pursue a degree in civil engineering at Northwestern. She quickly developed a passion for architecture, structural art, and the built world. Mehri used her knowledge of the body in relation to space and structures to create innovative projects throughout her studies, which included a trip to the Harvard Graduate School of Design's summer architecture program, and a week-long workshop with architect Helmut Jahn at his Berlin office.

Since graduation, Mehri has worked on several large-scale infrastructure programs, including Washington, DC's WMATA Red Line Rehabilitation Program with Mass. Electric Construction Co., and the City of Chicago's Department of Water Management Capital Improvement Program with ARCADIS.

Mehri has received a number of honors since she entered the workforce in the construction industry. She was selected as one of the "New Faces of Civil Engineering" by the American Society of Civil Engineers in 2012, and traveled to Hong Kong and Guangzhou as an ARCADIS Global Shaper to help harness the ideas of Generation Y within the company.



Mehri Paydar dancing with Tulsa Ballet. Photo © Christopher Jean-Richard cjeanrichard.com. All Rights Reserved.

STUDENT AND ALUMNI NEWS



From left: Professor James Hambleton, Molly Lazar, and Irsilia Colletti

Bill Bach received the Civil Engineering Senior Award.

Erin Balasky received the Environmental Engineering Senior Award.

Molly Lazar, a sophomore studying civil engineering, received the American Society of Civil Engineers (ASCE) Illinois Section's Technical Institute 2018 Scholarship.



Elham Ramyar

Vivien An

Vivien Anne Rivera

Jo Machesky received the Jimie E. Quon Memorial Award for Environmental Engineering Senior.

Allison Mark and Alex Toporek each received the Wallis S. Hamilton Award given to a civil engineering senior.

PhD student **Elham Ramyar** received the Best Overall Award and the Best Value Award of Next Generation Transportation at the ASCE Innovation Contest. Ramyar and her team used the concept of redistribution of load forces to create an entirely new bridge design archetype. Vivien Anne Rivera, a PhD student studying environmental engineering, recevied the US Department of Energy's Office of Science Graduate Student Research Award for her research project, "Data Fusion and Machine Learning for Analysis of Soil Saturation in Urban Landscapes," which she conducted at Argonne National Laboratory.

Sophie Sisson received the Department of Civil and Environmental Engineering Edwin C. Rossow Prize for Structural Engineering Senior. She also earned the Thorton Tomasetti Foundation Scholarship.

Andrew Sonta ('15) received the Norman Foster Foundation Workshop Scholarship. He is currently pursuing a PhD in sustainable design and construction at Stanford.

Northwestern BINGINEERING Civil and Environmental Engineering

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Engage with Civil and Environmental Engineering

Gifts to the Department of Civil and Environmental Engineering are used to support innovative educational experiences and help the department reach a new level of excellence and impact by investing in these priorities:

Enhancing the student experience with new classes, co-curricular activities, and lab research opportunities

Supporting outstanding faculty, who teach and mentor undergraduate and graduate students

Advancing research that tackles challenges in environmental engineering and science; geotechnics; mechanics, materials, and structures; and transportation systems analysis and planning

To give to the department, please visit the WE WILL campaign homepage at wewill.northwestern.edu and direct your gift to Civil and Environmental Engineering using "Search additional gift designations."

