

Civil and Environmental Engineering

In the [Department of Civil and Environmental Engineering \(CEE\)](#), we use innovative science and engineering to maintain a strong focus on fundamental issues related to infrastructure and the environment. CEE strives to create a better world by conducting research that starts with a fundamental understanding at the micro level, leading to the knowledge needed to achieve solutions to benefit society at the macro scale. We work in and out of the classroom every day in order to expose our students to small-scale change that produces large-scale global impacts.

The department continued to grow during the 2020 academic year, with notable advancements in research, newly enriched educational programs and subjects, as well as local, regional, and global gains in recognition. Through new faculty hires, we continue to enhance our leadership in the fields of structural engineering and the environment. Together, our new and current faculty collaborate to provide the inventive, intradisciplinary experiences and skills necessary to redefine and challenge the integrated boundaries of civil and environmental engineering in the 21st century.

Our students seek to rework traditional problems and discover unconventional solutions that include new approaches and insights to existing challenges. Whether in the classroom, out in the field, or in the labs, students are at the core of the department's initiatives. Through scaling and innovating from the nano to the macro level, our students strive to improve human lives and conditions anywhere in the world. We believe that the research and education we conduct today will influence lives tomorrow and in the decades to come, and that these opportunities and teachings will live on through the efforts of our alumni.

In the 2019–2020 academic year, we made efforts to further reach and interact with the MIT undergraduate student population. These efforts included increased outreach to potential students through events, posters, email campaigns, new events, symposiums, and other initiatives such as the CEE blog and social media takeovers.

CEE is motivated to understand and solve big engineering and scientific challenges. During the 2019 academic year, we launched our [new department website](#) to reflect this vision, and we have made continuous efforts throughout AY2020 to enhance the site and make it accessible and appealing to all members of the community. At CEE, we strive to create an inclusive and diverse community that provides the resources necessary for everyone to succeed.

In 2019–2020, an outside consulting agency was hired to perform a 360-degree audit of CEE's communications strategy to help identify areas for improvement and create a cohesive CEE brand, both within MIT and outside of the Institute. In general, the audit found that many of the department's communications were vague and did not capture CEE's unique qualities. In addition, a clear theme was lacking. The report recommended that CEE should focus on telling stories within the department to communicate a more unified vision—stories that emphasize the unique nature of our department and that connect the dots of how each discipline ties into the grand scheme. The report outlined

new marketing strategies and included a step-by-step guide on creating and releasing content. A new communications officer was hired in 2019–2020 to guide the department through strategic branding and communication decisions. Recognizing the importance of good communication in science, the department also established a communications lab to help students, faculty, and postdoctoral researchers share their research more successfully with a wider audience.

Researchers in the Henry L. Pierce Laboratory for Infrastructure Science and Engineering have contributed to groundbreaking methods and are actively designing impressively strong materials, often inspired by nature, while creating sustainability and eco-friendliness. In addition, CEE has continued to offer fieldwork opportunities to undergraduate students that put students directly in touch with the problems they seek to solve.

Our cross-disciplinary research culture also links seemingly dissimilar projects, such as Professor Benedetto Marelli's application of silk fibers to preserve fresh fruit to research focusing on optimal mechanical devices that effectively coat the fruit. A community working across boundaries toward broad-scale solutions has been a successful way to continue innovating and to keep up with both immediate and emerging societal needs.

Realizing a broadly empowered vision for the civil and environmental engineering profession requires effort. As educators, we need to anticipate shifts so that we can provide students with holistic and in-depth learning experiences and give them a well-rounded and solid foundation. This commitment is reflected in the core mission of the department—to educate at all levels, from undergraduate to postdoctoral.

The current Course 1 undergraduate program, established in 2014, integrates civil, environmental, and systems engineering into a single program. This forward-thinking program features increased flexibility, allowing students to fulfill Institute and departmental requirements while encouraging personalization of tracks that best match career and research interests.

In AY2020, the Undergraduate Education Committee put together new departmental roadmaps demonstrating subject sequencing to complete a degree in each CEE core (environment, mechanics and materials, and systems) while satisfying requirements in the computer science and design (Architecture) minor.

The Academic Programs Office collaborated with the Undergraduate Education Committee, the CEE Student Association (CEESA), and CEE Communications to promote and publicize the 1-ENG undergraduate program through numerous channels, including posters and email campaigns, student blog posts, career-oriented brochures, social media campaigns, photo and video projects, and department events. The department continues to provide the three minors introduced in fall 2016: civil engineering, environmental engineering science, and civil and environmental systems.

Goals, Objectives, Priorities

The Civil and Environmental Engineering Department has made strides this past year toward realizing the full potential of a more integrated and enhanced undergraduate

educational program. The department is experiencing a transformation similar to the major disruptions of the 1960s and 1980s, when the introduction of computation, environmental science, genomics, and microbiology influenced its direction. However, now the influences are around the Earth and its atmosphere, agriculture, and building sustainable cities.

Our students continue to change the world. From alumni entrepreneurs desalinating ocean waters to engineers designing more resilient, sustainable, and energy-efficient cities, MIT is redefining what it means to work in this increasingly comprehensive field. Working together across disciplines and educational and experience levels, our students, faculty, and researchers address the many questions and challenges civilization faces today.

As engineers, we continue to build, but our direction is now better informed by discovery and innovation at nano levels. Data characterization, modeling, and analysis also have lent new insights to our work, allowing design experimentation to be accomplished in hours compared to what would have previously taken days, weeks, or months. New tools and instruments, such as high-powered Raman spectroscopy, along with renovated and newly created lab spaces increase our capacities. Collaboration with other scientific and engineering disciplines allows for new research paradigms and relationships.

CEE has five strategic objectives. This report articulates our activities during the 2020 academic year with respect to each objective.

- Objective 1: Renew, develop, and implement inspiring educational programs at the undergraduate and graduate levels, including the postdoctoral level
- Objective 2: Establish an effective departmental structure
- Objective 3: Focus on the future of CEE with accelerated faculty hiring and junior faculty development
- Objective 4: Show leadership in MIT-wide initiatives through engagement across the Institute, defining a clear positioning of CEE at MIT
- Objective 5: Enhance alumni engagement and resource development

Objective 1: Renew, Develop, and Implement Educational Programs

Over the past academic year, 208 students were enrolled in CEE (51 undergraduates and 157 graduate students/doctoral candidates). CEE awarded 16 PhD, 7 SM, 12 MST, and 17 MEng degrees in the graduate program and 10 SB degrees in the undergraduate program. Of the 16 PhD graduates, approximately half are proceeding to careers in academia.

Undergraduate Programs

The 2020 academic year saw the sixth full-year cohort of students in the department's 1-ENG bachelor of science degree program. The refined undergraduate program, which is accredited by the Accreditation Board for Engineering and Technology (ABET), is a comprehensive curriculum that better prepares graduates for their professional lives while emphasizing a strong foundation in math, computation, probability and statistics, data analysis, and design.

The department was reviewed by ABET in fall 2019, and the outcome was positive. The renewed accreditation was well received. When reviewing academic programs, the ABET Engineering Accreditation Commission takes into consideration curriculum and subject offerings, student outcomes, educational objectives, and signs of continuous improvement.

The Undergraduate Education Committee, led by Professor Saurabh Amin and made up of faculty from each CEE core, made significant strides in AY2020, improving the undergraduate curriculum through strategic partnership with Course 6 and creating new first-year discovery subjects. The committee also refined policies to assess undergraduate students' degree progress (now documented in our advising guide) and continued to work with the Academic Programs Office to optimize the subject schedule as a means of minimizing teaching conflicts with general departmental requirements and core subjects. In addition, the committee updated the capstone subject (1.013 Senior Civil and Environmental Engineering Design). The subject now spans the fall and spring terms, and the main impetus for the update is to offer additional time for seniors to process the idea generation and problem description phase in the fall so that they have a clear starting point to begin working on their projects in the spring. This improvement will allow for more systematic scheduling of student work (both team and individual) and provide a better overall capstone experience for our seniors.

The undergraduate officer continued the engagement of CEE in the Institute-wide New Engineering Education Transformation (NEET) initiative. CEE's faculty developed NEET tracks that aim to recruit new students to the department through project-centered learning. One CEE proposal (low carbon energy) was selected for inclusion in the initiative. A collaboration of Course 1 with Courses 22 and 2, the low carbon energy NEET thread introduces students to the rapidly developing and increasingly vital field of energy production and distribution without generating greenhouse gases.

Broadly, the 1-ENG program prepares students for today's jobs plus emerging new positions such as chief resilience officer, 3D infrastructure engineer, urban agriculturist, or global system architect. Class discussions in 1.007 Big Engineering: Small Solutions with a Large Impact showed that students studying civil engineering leaned toward careers in innovating structures, architectural design, material testing, promoting net zero energy buildings, sustainable infrastructure, and geo-technology. Environmental engineering students expressed interest in exploring bio-remediation, atmospheric modeling, hydrology modeling, pollution control, enhancing food security, and mitigating climate changes. Finally, systems engineering cohorts gravitated toward applications in biological networks, traffic and transportation engineering, carbon sequestration, city planning, and mitigating infectious diseases.

To provide students with more accessible opportunities to advance their careers, the department grew the CEE internship program that utilizes connections with CEE alumni in industry to provide high-level internships for current students. The Academic Programs Office also worked to maintain an alumni mentorship network to connect current students with meaningful mentorship experiences. In the 2020 academic year, they met with eight students regarding summer internship opportunities. In addition to these one-on-one conversations, 10 companies were brought to campus for lunch and learns. Two students received internship offers from Skanska and Kimley-Horn,

but unfortunately the offers were rescinded in light of COVID-19. As the likelihood of securing summer internships decreased significantly, the Academic Programs Office turned its attention to connecting CEE students with Undergraduate Research Opportunities Program (UROP) placements that could be executed remotely to ensure that every student who wanted a summer experience had that opportunity.

In fall 2019, with the guidance of Department Head Markus Buehler, the department organized the second annual Young Alumni Panel, bringing recent graduates to campus to connect CEE undergraduates to the great professions they can pursue upon completion of a civil and environmental engineering undergraduate degree.

The CEE Student Association's new leadership continued to work constructively with the Academic Programs Office and the department's leadership. The CEESA president meets regularly during the academic year with the Academic Programs Office to discuss upcoming events, provide feedback on the undergraduate curriculum and printed materials, and serve as a voice for the undergraduate student body.

CEESA hosts numerous events throughout the year, including game nights, a career fair, study sessions, and monthly faculty luncheons. The faculty luncheons, at which undergraduate students are invited to have lunch with a CEE faculty member, are a great way for students to get to know the faculty on a more personal level and gain exposure to areas of research they may not have otherwise considered.

During the 2020 academic year, the senior capstone class focused on three main projects anchored around the cores of environment, mechanics and materials, and systems. Students were showcased during the electronic presentation of the CEE Awards Banquet through videos created for the communications component of the class. The electronic awards banquet, hosted in conjunction with an electronic commencement ceremony, was attended widely by both the CEE community and families of graduates. Through a real-time poll, the community voted to award first-, second-, and third-place Capstone Poster Prizes. Zoe Lallas won the first-place prize for her project focused on reimagining the Volpe Center site, Amy Vogel won second place for her project focused on electrifying the MBTA (Massachusetts Bay Transportation Authority) system, and Danielle Espinosa won third place for her project on salt marshes and how they are some of the most productive ecosystems on Earth at carbon sequestration and storage.

Building on the success of last year's unique mini-UROP program, the department again hosted 20 first-year students during the 2020 Individual Activities Period (IAP). In the program, Course 1 graduate students and postdocs are paired individually with first-year students, and the mini-UROP students work at least 30 hours per week in direct research. As a result of their interest and progress on their projects, a number of the participants continued on as full UROP students during the spring term.

Though the growth of the program, the organizers realized there were opportunities to extend the program benefits to include not only course credits but also community building. Projects were added to build the students' hard science and engineering skills, but other activities are now also included to develop soft skills such as collaboration, networking, and mentoring skills. In addition, during the 2020 IAP, the department

continued to offer subject credits to graduate students for their mentoring and time commitments. The Academic Programs Office coordinated with faculty members to host weekly luncheons to give first-year students a glimpse of the department's variety of research topics and opportunities.

The department continues to offer three undergraduate minors (civil engineering, civil and environmental systems, environmental engineering science) that debuted in fall 2016. The minors are intended to attract MIT students who are majoring in disciplines outside civil and environmental engineering but want to enhance their career path with complementary knowledge and experience. CEE also endorsed and participates in the environment and sustainability minor offered by the MIT Environmental Solutions Initiative.

The 2020 academic year saw the introduction of a new undergraduate subject. Professor Tami Lieberman launched 1.S993 Genomics and Evolution of Infectious Diseases in the spring term, a subject focusing on the forces driving pathogen evolution and discussions of topics relevant to public health.

Graduate Programs

CEE's graduate education programs also saw changes, improvements, and new activities over the past year. For example, new ways to support graduate student and doctoral candidate initiatives were introduced, including increased student support through an updated process for obtaining conference travel funds and bridge funding for students who may need to change advisors. Professor Heidi Nepf ran a six-unit professional development seminar for second-year graduate students. One of the first at the Institute, the seminar engages with campus partners through the Career Advising and Professional Development Office, the Office of Graduate Education, and the Writing, Rhetoric, and Professional Communication Office. The seminar helps prepare students for the general exam process and fulfills the breadth requirement for degree completion. In conjunction with the seminar, the first annual graduate student alumni panel was organized, hosting young alumni from New York University, the World Health Organization, and Amazon, among others. Building on the success of the seminar's first year, the Graduate Education Committee approved a permanent subject number and endorsed continuing growth and expansion of the seminar.

With the pivot away from campus during AY2020, Breene M. Kerr Professor of Hydrology and Climate Elfatih Eltahir introduced a timely special subject on disease transmission and spread in the spring term. The subject included an array of guest lectures and covered COVID-19-related research—examining how diseases interact with the environment and describing the work being done to mitigate future outbreaks.

Our graduate committee, along with other graduate students in the CEE community and faculty and staff, worked together closely during the past year to develop stronger relationships with the department head, tapping mutual resources for improved program delivery and support, and investing excitement and energy into the virtual graduate recruitment process by participating in webinars and organizing online social events during the graduate open house.

Postdoctoral Program

CEE's postdoctoral committee has continued its path of success, providing a forum for discussion and involvement with the approximately 65 postdoctoral researchers in the department. The committee has made progress in understanding and addressing the professional and career development needs of postdoctoral researchers, identifying and improving mentoring networks, providing the researchers with opportunities to contribute to the department's educational programs, and enhancing their MIT and CEE experience. Professor John Williams serves as the postdoctoral committee chair, working together with three other CEE faculty members, including an Institute Professor. Postdoctoral liaisons selected by the committee each year ensure that there is ongoing communication between the postdoctoral community and the department leadership.

This year the CEE postdoctoral committee launched the CEE Diversity, Equity, and Inclusion initiative with the goals of starting a dialogue around the topics of diversity, equity, and inclusion; addressing the relative lack of representation of certain groups; and presenting examples of those who were able to overcome their unique challenges. This lunch seminar series—which consists of research presentations and customized career advice as it relates to speakers' individual challenges associated with diversity, equity, and inclusion—has been very successful both in person and virtually. The series, targeting the CEE postdoctoral community and beyond, is the first of its kind at MIT and warranted a featured story in *MIT News*. Work on continuing and enhancing efforts around diversity, equity, and inclusion in CEE is ongoing and will be incorporated in existing departmental events for the postdoctoral community, such as the CEE Research Speed Dating event as well as in new initiatives and collaborations with historically Black colleges and universities.

Other specific activities included once-a-semester town halls with the department head, mini-UROP mentoring, workshops on grant writing, and the CEE Rising Stars Workshop. Also, teaching fellowships are available that allow postdoctoral researchers to be involved in teaching and education as part of their career development. Networking events for CEE postdoctoral researchers and faculty members with a focus on enhancing mentoring networks beyond postdocs' immediate faculty supervisors and research groups have been very well received and continue on a regular basis. On February 10, the department held its CEE Research Speed Dating event, at which a number of CEE postdocs had a chance to present their research via electronic posters and short talks. A CEE communications lab was launched in June 2020, with two postdocs trained to serve as communication fellows teaching others how to write for science and engineering. The communication fellow position is a special opportunity for a select group of CEE postdocs interested in scientific writing as part of their career development. Increasing numbers of CEE postdocs have volunteered to present their research at the weekly Parsons and Pierce seminar series.

There has been a steady increase in the number of women receiving postdoctoral training from the department, with a 12% rise since 2016. Approximately 80% of the postdoctoral scholars who leave CEE move on to academic and faculty positions in institutions all over the world. The postdoctoral committee introduced a certificate that is provided to postdoctoral scholars as they leave the department to pursue next steps

in their careers. Postdocs continue to contribute to CEE teaching activities through the postdoctoral teaching fellows program. The department keeps track of the career paths and feedback of exiting postdocs, and continues to customize offerings to the CEE postdoctoral community.

Objective 2: Establish and Maintain an Effective Departmental Structure

The administrative staff continues to evolve and engage with all CEE communities, including current and prospective students, their parents, faculty, staff, external peers, alumni, and the news media. We accomplish this outreach through workshops, seminars, stories in print and online, social media, speaking engagements, and other activities.

The department strengthened the collaboration between its two laboratories, the Ralph M. Parsons Laboratory for Environmental Science and Engineering (Building 48) and the Henry L. Pierce Laboratory for Infrastructure Science and Engineering (Building 1). The Parsons Lab focuses on natural systems and on understanding and engineering human adaptation to a changing environment. The Pierce Lab engages in science and engineering research critical to improving living conditions for humankind, advancing the innovation of materials, transportation systems, cities, and energy resources. This increased interaction continues to bind the disparate locations and was apparent at many formal and informal gatherings through the year. Examples include CEE Research Night and the continuation of the CEE Band, an inclusive department-sponsored ensemble featuring students and researchers from both labs.

CEE continued to refine its strategic focus around five challenge areas: ecological systems, resources and sustainability, structures and design, societal systems, and global systems. Our research and education within and across these strategic objectives are imperative to help create a better world and improve lives.

MIT Context for the Role of Civil and Environmental Engineering

The department's intellectual focus is discovery and innovation to sustain life and society in changing conditions. CEE's two research labs, the Pierce Laboratory and the Parsons Laboratory, conduct research designed to better understand and solve the grand challenges of our time, from problems created by human activity to those that exist as natural systems. Our contributions are at the core of new products and applications that are being developed today in agriculture, wetlands management, renewable energy, sustainable structures, and large-scale systems design. The Department of Civil and Environmental Engineering is committed to playing a central role to support MIT's leadership in these domains.

- Our long-term objective in the area of infrastructure, implemented in the Pierce Laboratory, is to become a center of excellence in the design, manufacturing, and operation of infrastructure. The Pierce Lab pushes the frontiers of infrastructure science and engineering by exploring the fundamental issues critical to society and the environment. Through our faculty's diverse expertise and collaborations with others, CEE addresses such critical issues as infrastructure sustainability, resilience to catastrophic events, durability, and improved energy management.

- Our long-term objective in the area of the environment, implemented in the Parsons Laboratory, is to engineer human adaptation to a changing environment. Human activities are affecting the global environment at historically high rates, and the impact of these changes on people and the environment is not known at present. Working from very small discoveries to large-scale solutions, researchers in the Parsons Lab aim to better understand global environmental changes in water, agriculture and food, species evolution and coexistence, environmental quality, natural hazards, and public health, among other areas.

Space Renovations

The department's efforts to improve laboratories and other departmental space over the past several years have been extraordinary. With our faculty renewal efforts came new faculty laboratories, and a constant flow of renovations, including state-of-the-art laboratories and work spaces in both the Pierce Laboratory (Building 1) and the Parsons Laboratory (Building 48). In addition to technical lab spaces, other spaces for computation, offices, and teaching are being renovated at a pace commensurate with the growing needs of CEE. Space updates in 2019–2020 are as follows:

- Completion of the expansion of Professor Marelli's Laboratory for Advanced Biopolymers in Building 1
- Completion of the shared instrument room in Building 1
- Completion of Professor John Williams' GPU station lab space
- Space renovations and improvements for Professor Josephine Carstensen's lab
- Various student office renovations and improvements

Objective 3: Accelerated Faculty Hiring and Junior Faculty Development

Using the momentum of the visiting committee recommendations, the department embarked on aggressive faculty searches over the past few years.

Our future success depends in large part on internalizing our new vision across our two research labs (Pierce and Parsons), developing our junior faculty, and attracting top new faculty. The following are associated highlights and accomplishments in these critical areas. Our strategic priorities also include fueling emerging frontiers of innovation and creative design and empowering our students and faculty to lead Institute-wide cross-cutting initiatives. Hiring excellent faculty is arguably the most critical component in supporting these activities.

The faculty search process has been changed to focus on several necessary criteria that differ from those of searches conducted in past years:

- Identify the highest-caliber candidates in compelling intellectual frontiers
- Look for relevance to the vision and domains of CEE, especially those identified as critical needs

- Build on CEE's strengths in areas where it can lead; candidates should be dedicated to educating our students in such a way as to equip them to work as scholars and academic leaders, professionals, and entrepreneurs
- Find candidates who support and are supported by intellectual communities

New Faculty Hires

Josephine Carstensen joined the department as an assistant professor of civil and environmental engineering in September 2019. Carstensen received her PhD in civil engineering at Johns Hopkins University. Her research focuses on the new opportunities arising as digitalization of design and manufacturing is transforming the way we create the built environment. Carstensen's group will develop and evaluate new design methods and tools that use structural mechanics and mathematical optimization to advance the design of structures on length scales ranging from material architectures to large scale structural design.

Michael Howland was hired in spring 2020 with a start date of July 2021.

Faculty Promotions

Lydia Bourouiba was promoted to associate professor without tenure. Bourouiba's research is focused on the fluid mechanics of disease transmission in plants and humans.

Otto Cordero was also promoted to associate professor without tenure. Cordero's research focuses on explaining the cycling of elements such as carbon, nitrogen, and sulfur in the environment.

Faculty Professorships

Cathy Wu was named the Gilbert W. Winslow Career Development Assistant Professor effective July 2019. Wu's research focuses on machine learning, optimization, and large-scale societal systems.

Oral Buyukozturk was named the Macomber Professor in Construction Management for a five-year term (July 1, 2019, to June 30, 2024). His research focuses on structural engineering, infrastructure mechanics, sustainable materials, and sensing and monitoring.

David Des Marais was appointed as the Walter Henry Gale (1929) Career Development Professor for a three-year term effective July 1, 2019. His research is focused on plant ecology and evolution, physiology, functional genomics, sustainable agriculture, and plant-water relations.

Annual Rising Stars Workshop for Early-Career Women in Academia

In October 2019, CEE held its third Rising Stars Workshop, geared toward women looking to further their careers in academia. Women in STEM (science, technology, engineering, and mathematics) can find it more challenging to navigate an academic career path simply because it has not been well traveled to date. MIT is working to change this with a well-designed map. In 2019, the workshop brought together 20

distinguished early-career women interested in careers in academia. The workshop included research presentations, an hourlong mentoring discussion with MIT chancellor Cynthia Barnhart, panel discussions on building an academic career, and many networking opportunities.

Forum on the Future of Civil and Environmental Engineering Education

In fall 2019, CEE hosted a workshop aimed at helping to chart a path to the future for the study of civil and environmental engineering. Global problems such as climate change, food and water security for a growing population, and navigating an ever more crowded urban landscape are becoming critical issues that future generations will need to address. Historically, CEE has been equipped with both the tools and knowledge to help solve these problems, and this workshop was the first step toward making that effort a present reality.

Civil and environmental engineering is among the oldest of engineering disciplines, both within and outside the constructs of formal education. The most fundamental of human needs are addressed within civil and environmental engineering departments, from shelter (i.e., structures and mechanics) to critical infrastructure that supplies food, water, and access (i.e., transportation and systems) to securing human and ecological health via management of basic resources (e.g., air, water, and waste treatment). Indeed, MIT was founded with only two departments: Civilian Engineering (Course 1) and Military Engineering (Course 2). Created in the service of society, Course 1 was meant to reflect the primary importance of civil and environmental engineering services and innovation. However, it is precisely the foundational nature of civil and environmental engineering that challenges its evolution to serve the needs of the modern world while accommodating the fundamental educational tenets of the past. In the United States, departments struggle to balance the use of established principles to address the needs of students seeking careers as practicing professional engineers and the use of forward-looking research paradigms to address societal grand challenges more broadly and acutely. To address this apparent paradox and revisit the concept of what it means to obtain a foundational education in civil and environmental engineering, we convened a set of thought leaders at the Civil and Environmental Engineering Education Frontiers Forum in October 2019 at MIT.

Objective 4: Leadership at MIT and Beyond

Over the 2019–2020 academic year, efforts were made to maintain and improve the CEE website, maintain active social media platforms, and curate a popular student blog initiative that invites current CEE undergraduate and graduate students to write about their experiences in the department, including studying abroad, extracurricular activities, internships, and innovative classes. Online as well as offline, we are empowering the department to share new research and happenings and to start new conversations.

CEE Communications and the Academic Programs Office collaborated to recruit undergraduate students to write about their experiences being a Course 1 major. The blogs share the undergraduate experience in a casual setting and encourage students to share how they use civil and environmental engineering principles around the world. Topics ranged from interning at the World Bank during social distancing to running a

marathon in order to raise money and awareness for social justice issues. The blogs also help in obtaining information on students' perspectives regarding fieldwork experiences such as the 1.091/1.092 Traveling Research Environmental Experience (TRES) subject and the ONE-MA³ (Materials in Art, Archaeology and Architecture) program. Through this new initiative, Communications and the Academic Programs Office have strengthened their connection with undergraduate students.

The department also placed an emphasis on documenting and creating videos for two undergraduate subjects, 1.101 Introduction to Civil and Environmental Engineering Design I and 1.007 Big Engineering: Small Solutions with a Large Impact. The videos were created to accurately communicate to prospective students the exciting opportunities that can be found in CEE subjects.

CEE increased its presence on social media in AY2020 with accounts on Facebook, Twitter, Instagram, and LinkedIn. With a growing focus on sharing stories of the students, postdocs, faculty, and staff who make our department go, each account has seen a rise in followers and engagement from the previous year, greatly increasing our reach. This investment in CEE's online presence enhances the department's ability to connect with alumni, potential students, industry leaders, and news media outlets.

Objective 5: Alumni Engagement and Resource Development

In September 2019, the department hosted its second annual Young Alumni Panel and Network Reception, where recent Course 1 undergraduate alumni shared their career experiences and provided insight to current students. The event was very successful and will be repeated in fall 2020.

In partnership with Resource Development, the Alumni Association, and friends of MIT, CEE has continued to strive to increase philanthropic support for its students, faculty, and research priorities. Department fundraising efforts helped support our mission of providing faculty and students with innovative education and research programs to develop bold solutions for sustainability at scale.

Through fundraising efforts, CEE successfully secured its first endowed UROP funding, which enables undergraduate students from the department to dive head first into research areas that expose them to opportunities in research, academia, industry, and start-ups. Thanks to our loyal friends and alumni, CEE was also able to help in the recruitment and retainment of some of our most talented faculty and students.

CEE Resource Development has worked to increase the visibility of the department's central themes, with a strong focus on the environment and innovative faculty research, in order to inform and engage both alumni and friends. Departmental faculty and their work have been showcased through a variety of speaking engagements as well as MIT Campaign for a Better World and MIT Corporation engagement opportunities. Although we experienced a strange end to the academic year, our cohesive mission continues on through the common goals of the department's faculty, students, supporters, and alumni.

Accomplishments

Student Outreach

In 2019–2020 the department formed a new committee to help foster community while students, faculty, and staff were asked to transition to remote learning and practice social distancing due to the outbreak of COVID-19. Composed of students, administration, and staff, the [CEE Wellness and Connectedness Initiative](#) was created as an outlet for focusing on health and well-being. The group promotes monthly challenges and activities centered around MIT's four pillars for staying well: mind, body, relationships, and purpose. Participation is meant to be flexible, and community members are encouraged to participate and share their experiences as much or as little as they personally prefer.

CC Mei Distinguished Speaker Series

Professor Lydia Bourouiba expanded her CC Mei Distinguished Speaker Series to include more speakers, further raising visibility for CEE and its vision beyond MIT audiences. Topics and speakers included:

- “Challenges in the Modeling of Multi-phase Flow from Large to Small Scales” by Professor Stephane Zaleski of Sorbonne University
- “Physics of Fluids” by Professor Detlef Lohse of Twente University
- “Resolved Simulations of Particulate Flows” by Professor Andrea Prosperetti of the University of Houston

Research Highlights

The department's research is diverse and crosses many disciplines. Over the past year, CEE had 83 research proposal submissions and had a research volume of approximately \$12 million.

In December 2019, Professor Penny Chisholm and research scientists Paul Berube and Steven Biller were collaborators on a multidisciplinary research project led by the Bigelow Laboratory for Ocean Sciences and published in *Cell*. The Bigelow research team analyzed over 12,000 individual microbial genomes to build the Global Ocean Reference Genomes Tropics database. Surprisingly, every cell the team analyzed was genetically unique. Their work demonstrates an amazing amount of biological diversity that defies contemporary definitions of microbial species, illuminates reasons behind challenges in metagenomic studies, and offers clues as to how marine microbes may respond to climate change.

In December 2019, Professor Ruben Juanes was part of a team of researchers that published research in *Risk Analysis* estimating that improved rates of handwashing among travelers passing through just 10 of the world's major airports could significantly reduce the spread of infectious diseases. The study was based on epidemiological modeling and data-based simulations.

In January 2020, Professor Benedetto Marelli and doctoral candidate Hui Sun published new research (“Polypeptide Templating for Designer Hierarchical Materials”) in *Nature Communications*. The researchers demonstrated a way of templating the growth of silk that combines molecular control with scalable production.

In March 2020, Professor Otto Cordero published an article in *Nature Communications* (“Context-dependent Dynamics Lead to the Assembly of Functionally Distinct Microbial Communities”) that sheds light on the forces that shape microbial communities.

In March 2020, Professor Lydia Bourouiba published COVID-19-related research in the *Journal of the American Medical Association*. The work discussed the limitations of current guidelines on respiratory disease transmission, including transmission of COVID-19, and recommended updated guidelines more accurately reflecting what actually happens with respiratory emissions and better protecting patients and health care workers.

In March 2020 Professor Markus Buehler translated the spike protein of the novel coronavirus (SARS-Cov-2) into sound to visualize its vibrational properties, which provided a unique perspective on the virus structure and may aid in finding ways to stop the virus through analysis of the nanomechanical vibrational signature. *MIT News* published a recent Q&A session with Professor Buehler in which he provided details on his work.

In April 2020, Professor Marelli and graduate student Yunteng Cao, in collaboration with their colleagues, introduced a new method of delivering biological payloads in plants through the use of microneedles. Microneedles are made of silk-based biomaterials that can be used to deliver nutrients, drugs, genetic materials, or other molecules to specific parts of a plant. In addition to its potential use in sampling plant fluids to assess diseases and metabolic activity, this new method can be used to mitigate epidemic diseases in plants such as citrus greening.

Awards and Recognition

Faculty Awards and Recognition

The faculty in CEE have received numerous awards, reflecting their impact within the Institute and beyond.

In January 2020, the *New York Times* featured a story on an app that will turn a smartphone into a tool to track potholes and measure overall road quality. Professor Franz-Josef Ulm’s team and colleagues at the University of Massachusetts Dartmouth and Birzeit University in the West Bank are currently testing their app, called Carbin.

Also in January, Professor Juanes was profiled by the US Department of Energy’s Office of Science as part of the agency’s series of stories following researchers who received their Early Career Award 10 years ago. According to Professor Juanes, who won the award in 2010, one of his most widely recognized contributions has been in the area of CO₂ sequestration.

In February 2020, a proposal by Professor Elfatih Eltahir and colleagues was selected among the top 100 proposals for the MacArthur Foundation 2020 100&Change competition. The foundation announced that a proactive climate resilience system co-developed by MIT and BRAC, a leading development organization, was one of the highest-scoring proposals in the competition. The top 100 proposals are competing for a single \$100 million grant to help solve one of the world's most critical challenges.

In March 2020, Professor Ulm received an honorary doctoral degree from the Technical University in Vienna, Austria.

In March 2020, Professor Eltahir and his research group published a book, *A Path Forward for Sharing the Nile Water: Sustainable, Smart, Equitable, Incremental*, that discusses a way forward for sustainable future development in the Nile basin.

In March 2020, Professor David Simchi-Levi was featured in an *MIT News* article forecasting the potential impacts and pitfalls of COVID-19 with respect to manufacturing and supply chains.

In March 2020, Professor Yossi Sheffi was featured in an *MIT News* article describing the outlook for US supply chains still reeling from the shock of the COVID-19 outbreak.

In April 2020, Professor Kathy Wu was featured on *TWIML AI Podcast (This Week in Machine Learning & AI)*. The discussion focused on Professor Wu's transition to applying machine learning to civil engineering, in particular understanding the potential impact autonomous vehicles would have on traffic.

In May 2020, Professor Desiree Plata was featured in an *MIT News* special video. Professor Plata and her research team demonstrated how they are advancing their work remotely while balancing family life.

In June 2020, Two faculty members were chosen to receive 2020 Abdul Latif Jameel Water and Food Systems Lab (J-WAFS) grants. Saurabh Amin was announced as one of the winners of the 2020 J-WAFS Grant for Water and Food Projects in India for his project Sustainable Agricultural Planning for Small Farm Holders in the Bist Doab Region of Punjab. This grant program supports solutions-oriented research by members of the MIT community focused on water and food challenges in India. Otto Cordero's project Data-driven Development of Probiotics for Shrimp Aquaculture in Ecuador was selected for a seed grant aimed at catalyzing innovative research across the Institute that can improve the world's water and food supply.

Student Awards and Recognition

Simone Cenci and Lucas Medeiros developed new mathematical tools for nonlinear systems to identify when the probability of making a prediction error is small or large. Nonlinear systems are in general difficult to predict. Any small difference in initial conditions or small external perturbations can lead to large dynamical differences in the long run. These tools can have broad applications in ecology, physics, finance, and management. The team's study, "[Assessing the Predictability of Nonlinear Dynamics under Smooth Parameter Changes](#)," was published in the *Journal of the Royal Society Interface*.

Graduate student Josh Moss received the Outstanding Student Presentation Award from the American Geophysical Union (AGU) for “Detailed Comparison of Chamber Measurements and Mechanistic Predictions to Improve Understanding of SOA Formation Mechanisms,” presented at the fall 2019 AGU meeting. Outstanding Student Presentation Awards recognize and reward undergraduate, master’s, and PhD students for quality research in the geophysical sciences.

Postdoc Daniel J. Short Gianotti had a research letter published by the American Geophysical Union. In his work, “Terrestrial and Moisture Drainage in a Warmer Climate,” Gianotti used satellite observations of soil moisture and expected increases in air temperature to determine how evaporation and soil drainage will change in a warmer climate.

Postdoc Chuliang Song was the winner of the *American Naturalist* 2020 Student Paper Award from the American Society of Naturalists, one of the most important awards for students working in ecology. His paper, “On the Consequences of the Interdependence of Stabilizing and Equalizing Mechanisms,” was one of 70 eligible submissions published in 2019.

Graduate student Cherry Gao and former MIT professor of civil and environmental engineering Roman Stocker published research in *Nature Communications* that quantified the way specific marine bacteria process a key chemical called dimethylsulfoniopropionate, which is produced in enormous amounts by phytoplankton. This chemical plays a pivotal role in how sulfur and carbon are consumed by microorganisms in the ocean and released into the atmosphere.

Graduate student Augustine Zvinavashe ’16, who works in Professor Marelli’s lab, was selected as a 2020–2021 Legatum Fellow. Legatum Fellows are chosen based on their abilities to embrace the broader mission of the Legatum Center, to demonstrate principled entrepreneurial leadership, and to act as catalysts for positive change across the MIT and developing world ecosystems. According to the center, this year’s candidate pool was the strongest since the fellowship’s inception.

Postdoc Alison Hoyt published research in *Nature Geoscience* showing that much of the peatland in Southeast Asia has been deforested, drained, and dried in the last three decades. In their work, Alison and her colleagues detailed how they made the first large-scale satellite measurements of subsidence across tropical peatlands and their results showing that almost all of the peatlands are subsiding at a rate of one to five centimeters per year.

The Xi Chapter of the Phi Beta Kappa honor society invited seniors Joseph Noszek and Sierra Rosenzweig to join the group. This is a tremendous accomplishment achieved by fewer than 10% of the class of 2020. Phi Beta Kappa is the oldest and most prestigious academic honor society in the United States.

2020 Annual Awards: Faculty, Staff, and Students

Due to the incredible challenge of closing the Cambridge campus and transitioning to remote learning in spring 2020—brought on by the outbreak of COVID-19—CEE was forced to cancel many of the traditional in-person events and celebrations held at the end

of the year. In response, the department administration worked quickly and diligently to re-create digital versions of many of these ceremonies.

In May 2020, CEE hosted a virtual hooding ceremony for PhD students who completed their program.

In addition, CEE hosted a virtual commencement and awards ceremony in May. The annual departmental awards celebrate all that is part of Civil and Environmental Engineering.

Senior Emily Condon received the CEE Leadership and Community Award, which recognizes an undergraduate student who makes exemplary contributions to improving the CEE community, fosters excellence and diversity, and contributes to our inclusive culture.

Senior Amy Vogel won the Leo (Class of 1924) and Mary Grossman Award for her strong interest in transportation and impressive academic record.

Junior Athikom Wanichkul earned the Juan Jose Herмосilla (1957) Prize for demonstrating exceptional talent and potential for future contributions at the intersection of mechanics, materials, structures, and design.

Senior Jarek Kwiecinski was awarded the Paul Busch (1958) Prize, given to an undergraduate student in environmental science and engineering for academic achievement and contributions to the CEE community. Kwiecinski is recognized by his peers and professors as an exceptionally bright, hard-working, outgoing, and ambitious scholar.

The Tucker-Voss Award winner was MEng student Alexandra Kavar. This award was created in the 1950s, when the Department of Building Construction merged with the Department of Civil Engineering. The award is named in memory of Professors Ross F. Tucker and Walter C. Voss, who were the first two heads of the Department of Building Construction.

Graduate student Linda Seymour was awarded the Trond Kaalstad (Class of 1957) Fellowship, which recognizes an outstanding graduate student who has displayed leadership and/or contributed significantly to the wellbeing of the CEE community. Linda played an integral role in defining and leading the CEE mini-UROP program and the ONE-MA³ summer course.

Yifei Xie and Youssef Medhat won the Maseeh Award for Excellence as a Teaching Assistant, which recognizes the most outstanding teaching assistant in the past academic year. Xie and Medhat were chosen for being fantastic in their roles, proactively addressing the needs of students, and adjusting their office hours to make schedules work, going above and beyond their teaching assistant roles.

The Best Doctoral Thesis Award was given to Sam Silva. This award honors scholarly and academic excellence and a high level of distinction of a CEE graduate student in any area of research.

The CEE Postdoctoral Scholar Mentoring, Teaching, and Excellence Award recognizes mentoring, teaching, and other exceptional contributions by a postdoc. Boya Xiong received the award in recognition of her exemplary skills as a role model for the students she worked with and for inspiring those around her to do their best.

The Samuel M. Seegal Prize, which honors faculty members for inspiring students to pursue and achieve excellence, was awarded to Professor Harry Hemond. The CEE community cited Professor Hemond for being a beloved teacher and mentor who leads by example and who inspires students long after their time at MIT.

Lydia Bourouiba received the Ole Madsen Mentoring Award, which honors faculty members for conspicuous contributions to mentoring and educating CEE students outside the classroom and inspiring them to pursue careers in the fields of civil and environmental engineering. Professor Bourouiba teaches students the skills, qualities, and critical thinking required to succeed in their studies and research; more generally, she prepares them to be successful in their professional lives.

Professor Jesse Kroll was presented the Distinguished Service and Leadership Award. This award recognizes outstanding departmental service and leadership contributions on the part of a CEE faculty member. Its purpose is to acknowledge colleagues who foster a culture of diversity, inclusiveness, and innovation. Professor Kroll was chosen for his dedication and commitment to addressing issues that arose in the Parsons Laboratory and for his eagerness to help wherever needed.

Two staff members received CEE Excellence Awards for their outstanding contributions to the CEE community, including their commitment to professionalism, dedication, and best practices and their fostering of a culture of diversity, inclusiveness, and innovation. The recipients were Marygrace Aboudou and Elein Covey.

Markus J. Buehler
Department Head
McAfee Professor of Engineering