Graduate Study *at*

RICE

GRADUATE STUDY IN CIVIL ENGINEERING
Department of Civil and Environmental Engineering
Rice University

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For admission in 2017

THE PROGRAMS

The Department of Civil and Environmental Engineering offers programs of study in structural engineering, structural mechanics and infrastructure systems, which can lead to the following degrees: Master of Civil and Environmental Engineering, Master of Science and Doctor of Philosophy. The Master of Science and Doctor of Philosophy require research and theses, while the Master of Civil and Environmental Engineering is a nonresearch professional degree.

The graduate programs are designed to develop fundamental understanding of analysis, design, reliability and sustainability of structures and infrastructure systems. Rapidly advancing knowledge in the fields of structural dynamics, advanced protective systems, structural monitoring and identification, infrastructure renewal, multi-hazard mitigation and computational engineering presents a real challenge to the technical leaders of tomorrow. The graduate program is intended to develop in the students the knowledge and ability to contribute to future technical advancements in the areas of sustainable design, retrofit and advanced protection of urban infrastructure systems, computational mechanics, and quantification of uncertainty among others. The research program prepares students to conduct original research in these areas.

The instructional program covers the major areas of structural engineering, including structural dynamic systems, computational solid and structural mechanics, earthquake engineering, bridge engineering, advanced mechanics of solids, structural reliability, probabilistic structural dynamics, reinforced concrete behavior, steel design, foundation engineering, infrastructure network systems and computer-aided engineering. Additional courses in solid mechanics, systems and optimization, machine learning, and advanced computational and applied mathematics are encouraged and available in other departments.

GRADUATE FACULTY

Leonardo Dueñas-Osorio. Associate Professor of Civil and Environmental Engineering. M.S. Universidad de Los Andes, Colombia; M.Eng. Massachusetts Institute of Technology; Ph.D. Georgia Institute of Technology. Dr. Dueñas-Osorio's major fields of study span the computational and theoretical modeling of complex engineered networks, as well as the risk and reliability assessment of interdependent lifeline systems. Dr. Dueñas-Osorio also conducts research on algorithmic development, resilient infrastructures and bridge-network performance prediction. He received the Best PhD Thesis Award in Civil and Environmental Engineering at Georgia Tech in 2006, the National Science Foundation CAREER award for young investigators in 2008, and the best paper award for 2013 manuscripts in the journal *Earthquake Spectra*. His research program is currently funded by the Department of Defense, the National Science Foundation, and the City of Houston. He is also an Associate Editor for the Journal of Computing in Civil Engineering and Natural Hazards Review. Dr. Dueñas-Osorio is an associate member of the American Society of Civil Engineers (ASCE) and an active member of the Earthquake Engineering Research Institute, the Institute for Electrical and Electronics Engineers, the International Association for Structural Safety and Reliability, the Association for Computing Machinery, and the Complex Systems Society among others. Dr. Dueñas-Osorio also is the founding chair of the Committee on Lifeline Systems Interdependence of the ASCE Technical Council on Lifelines Earthquake Engineering, and the current chair of a task group on risk-based decision making for the Structural Engineering Institute of ASCE.

Representative Publications: Dueñas-Osorio, L., J. I. Craig, and B. J. Goodno, 2007. "Seismic response of critical interdependent networks." *Earthquake Engineering and Structural Dynamics*, 36(2):285–306.

Dueñas-Osorio, L., and S. M. Vemuru, 2009, "Cascading Failures in Complex Infrastructures," *Structural Safety*, 31(2): 157–167.

González, A. D., L. Dueñas-Osorio, M. Sánchez-Silva, and A. L. Medaglia 2016. "The Interdependent Network Design Problem for Optimal Infrastructure System Restoration." *Computer-Aided Civil and Infrastructure Engineering*, 31(5): 334–50. doi:10.1111/mice.12171.

Satish Nagarajaiah is a professor in the Civil and Environmental Engineering department, at Rice University and affiliated with Mechanical Engineering, Material Science and Nano Engineering departments as well, at Rice University. He obtained his Ph.D. from State University of New York at Buffalo, where he was a post-doctoral researcher before he started his academic career. His research is funded by the NSF, NASA, DOE, Air Force Office of Scientific Research, Office of Naval Research, other State, Federal, Private Agencies and Industries. Dr. Nagarajaiah is an expert in seismic protection, structural dynamic systems, structural control, modeling/identification, structural health monitoring, and sensing using applied Nanotechnology. He has developed advanced modeling and numerical techniques for nonlinear dynamic analysis of base isolated structures that has resulted in the computer software 3D-BASIS that is used widely by academics and design professionals for analysis and design of numerous base isolated structures, such as San Francisco International airport, within the United States and in many countries around the world. He has made significant contributions to advanced protective systems that have led to full-scale implementation. National Science Foundation has recognized his contributions to adaptive stiffness structural systems by awarding the prestigious NSF CAREER award in 1998. Recently he led a large NSF project of five universities and multiple investigators and invented/developed a new adaptive negative stiffness structural system that significantly enhances seismic/wind protection of buildings and bridges. He and his team received the 2015 ASCE Moissieff Award for their research on innovative adaptive negative stiffness structures. He has developed advanced real time damage/fault detection and structural system identification algorithms, and novel strain sensing using nano-films, with NASA funding. He has presented several keynote lectures at world conferences and invited lectures around the world. He holds several US Patents.

Dr. Nagarajaiah currently serves as the managing editor of the journal of structural engineering [ASCE International journal], editor of the structural control and health monitoring journal [Wiley International Journal] and editor of Structural Monitoring and Maintenance Journal. He is a fellow of Structural Engineering Institute (SEI) of ASCE. He currently serves on the ASCE SEI Board of Governors. He served as the chair/vice-chair/secretary/member (2006-to-2012) of ASCE, SEI, Technical Activities Division Executive Committee. He served as a member of the board of directors of the international association of structural control and monitoring (2008-2012). He served as the President of the U.S. panel on structural control and monitoring (2006-2008). He was the founding chair of ASCE structural health monitoring committee (2004-2006), ASCE-Engineering Mechanics Institute, and chair of the structural control committee (1998-2002), ASCE Structural Engineering Institute.

He has published extensively. Visit the following websites for citation/h-index details:

(1) Web of Science www.researcherid.com/rid/E-6291-2012

(2) ORCiD www.orcid.org/0000-0003-0088-1656

(3) scholar.google.com/citations?user=l_jZ3NgAAAAJ&hl=en.

Satish Nagarajaiah has been quoted in New York Times, Wall Street Journal, Associated Press, Reuters, Bloomberg News, Fox news, and many others, and has been interviewed live by BBC, CNN, MSNBC (Rachel Maddow), ABC (Diane Sawyer), NBC, NPR, Aljazeera English Channel and CCTV, many others. Visit his website: satishnagarajaiah.rice.edu.

Jamie Ellen Padgett. Associate Professor of Civil and Environmental Engineering. Ph.D. Georgia Institute of Technology. Dr. Padgett's research focuses on the application of probabilistic methods for risk assessment and protection of structural infrastructure. Her work emphasizes infrastructure portfolios exposed to multiple hazards, including earthquakes, hurricanes, or aging and deterioration. Ongoing projects quantify the resilience and sustainability of railway infrastructure, highway bridges, nuclear casks, chemical and petrochemical storage tank inventories. Dr. Padgett was the founding Chair of the ASCE technical committee on Multiple Hazard Mitigation, and is an active member of several national technical committees within ASCE and TRB. She currently serves on editorial boards for the *ASCE Journal of Bridge Engineering*, *Sustainable and Resilient Infrastructure*, and *Earthquakes and Structures*. Dr. Padgett has received several awards and recognitions including the 2011 National Science Foundation Faculty Early Career Development (CAREER) Award and ASCE's 2009 New Face of Civil Engineering for her work in the field of infrastructure risk assessment and protection. Among other projects, Dr. Padgett currently works as a part of several large national or regional research efforts including the NIST Center of Excellence for Community Disaster Resilience, the NSF NHERI Cyberinfrastructure "DesignSafe-CI", and the Severe Storm Prediction Education and Evacuation from Disasters (SSPEED) Center.

Representative publications: Kameshwar, S., Padgett, J.E. (2014). "Multi-hazard risk assessment of highway bridges subjected to earthquake and hurricane hazards," *Engineering Structures, Vol. 78, pp. 300-310*, July, 2014.

Ataei, N., Padgett, J. E. (2015) "Fragility Surrogate Models for Coastal Bridges in Hurricane Prone Zones," *Engineering Structures, Vol. 103, pp. 203-213.*

Kameshwar, S., Padgett, J.E. (2015). "Stochastic modeling of geometric imperfections in above ground storage tanks for probabilistic buckling capacity estimation," ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part A: Civil Engineering, *DOI: 10.1061/AJRUA6.0000846 , C4015005.*

Tapia, C., Padgett, J.E. (2016). "Multi-Objective Optimization of Bridge Retrofit and Post-Event Repair Selection to Enhance Sustainability," *Structure and Infrastructure Engineering, Vol. 12, No. 1, pp. 93-107*, January, 2016.

Rouzbeh Shahsavari. Assistant Professor of Civil and Environmental Engineering. M.S. McGill University, Ph.D. Massachusetts Institute of Technology. Dr. Shahsavari's research focuses on developing a multiscale materials modeling approach followed by advanced synthesis, characterization and testing to study key functional behavior of complex materials that are critical to the infrastructure underlying the science and technology enterprises of society. His primary research is on cement-based materials, hybrid materials and nanocomposites. He develops a multiphysics framework to enable a bottom–up approach applicable to the broad science of composites for the needs of a low carbon/low energy world. Shahsavari has given +35 invited speaker and seminars and has won various awards, including the $100,000 first prize in the MIT entrepreneurship contest in 2010 (against 204 other entries), silver medal at MRS, and the best paper award of the American Ceramics Society. Prior to MIT, he was a project engineer at an engineering, procurement and construction management firm in Canada.

Representative publications: Sakhavand N, Shahsavari R, (2015), Universal Composition-Structure-Property Map for Natural and Biomimetic Platelet-matrix Composites and Stacked Heterostructures, Nature Communications, 6:6523

.Abdolhosseini Qomi MJ, Krakowiak K, Bauchy M, Stewart K, Shahsavari R., Jagannathan D, Brommera D, Baronnet A, Buehler M, Van Vliet K, Yip S, Ulm FJ, Pellenq R, (2014), Combinatorial molecular optimization of cement hydrates, Nature Communications, 5:4960

Pellenq R., Kushima A., Shahsavari R., Van Vliet K., Buehler M., Yip S., Ulm F.-J., (2009)," A realistic molecular model of cement hydrates, Proceedings of National Academy of Sciences, 09021180106, 1-6. Chemical Physics, 13, 1002-101

M. A. Rafiee, T. N. Narayanan, D. P. Hashim, N. Sakhavand, R. Shahsavari, R. Vajtai, P. M. Ajayan, (2013), Hexagonal Boron Nitride and Graphite Oxide Reinforced Multifunctional Porous Cement Composites, Advanced Functional Materials, 23, 5624-5630Kim N., Metzger A., Hejazi V., Li Y., Kovalchuk A., Lee S.K., Ye

R., Mann J., Kittrell C., Shahsavari R., Tour J.M., (2016) Microwave Heating of Functionalized Graphene Nanoribbons in Thermoset Polymers for Wellbore Reinforcement, ACS Applied Materials and Interfaces, 8, 12985-1299

Pol D. Spanos. Lewis B. Ryon Professor of Mechanical Engineering and Civil Engineering. Ph.D. California Institute of Technology. Dr. Spanos is interested in structural dynamics, with particular emphasis on nonlinear and probabilistic aspects and applications to earthquake engineering, offshore engineering, wind engineering, modern materials, and energy harvesting. His research is funded by the Department of Energy, the National Science Foundation, the U.S. Department of Defense and several oil companies. He has supervised the work of numerous M.S. and Ph.D. students. Dr. Spanos has received several prestigious awards from ASME, the Hubert Research Prize, the Freudenthal Medal, the Newmark Medal and the Von Karman Medal from ASCE. He is a corresponding member of the National Academy of Greece (Academy of Athens) and a member (academe) of the National Academy of Engineering (U.S.). He has authored numerous books and articles and serves on the editorial board of several journals; he is the editor-in-chief of the *International Journal of Non-Linear Mechanics* and editor of *Probabilistic Engineering Mechanics*. He also is a foreign member at the Indian National Academy of Engineering and of the Academy of Europe (Academia Europaea).

Ilinca Stanciulescu. Associate Professor of Civil and Environmental Engineering. Ph.D. Duke University. Dr. Stanciulescu has research interests in nonlinear computational mechanics with particular emphasis on multiscale and multiphysics formulations, non- linear dynamics, and modeling biological and bio-inspired materials. Her research is funded by the National Science Foundation, the Air Force Office of Scientific Research and the DOD-High Performance Computing Modernization Program.

Representative Publications:

Jin, T., Stanciulescu, I. Numerical simulation of fibrous biomaterials with randomly distributed fiber network structure (2016) Biomechanics and Modeling in Mechanobiology, 15 (4), pp. 817-830.

Jin, T., Stanciulescu, I. Computational modeling of the arterial wall based on layer-specific histological data (2016) Biomechanics and Modeling in Mechanobiology, Article in Press.

Chandra, Y., Zhou, Y., Stanciulescu, I., Eason, T., Spottswood, S. A robust composite time integration scheme for snap-through problems (2015) Computational Mechanics, 55 (5), pp. 1041-1056.

Zhou, Y., Chang, W., Stanciulescu, I. Non-linear stability and remote unconnected equilibria of shallow arches with asymmetric geometric imperfections (2015) International Journal of Non-Linear Mechanics, 77, pp. 1-11.

PROFESSORS OF THE PRACTICE

James B. Blackburn—Blackburn Carter, Houston, TX
Ed Segner, Former President and Chief of Staff—EOG Resources, Inc., Houston, TX

LECTURERS

Moyeen Haque, Principal—Matrix Structural Engineers, Houston, TX
Steve Wilkerson, Engineer—Haynes Whaley and Associates

PROFESSORS EMERITI

Ahmad Durani, Professor Emeritus—Rice University, Houston, TX
Ron Nordgren, Professor Emeritus—Rice University, Houston, TX
Anestis S. Veletsos, Professor Emeritus—Rice University, Houston, TX

CURRENT RESEARCH

The department's current research activities are in the areas of:

- structural dynamic systems
- structural monitoring and identification
- advanced protective systems
- computational mechanics
- resilience and multi-hazard analysis
- earthquake engineering
- bridge engineering
- probabilistic response and reliability
- infrastructure systems
- computational nano mechanics and advanced materials

Research activities in recent years have been funded by the National Science Foundation, NIST, NASA, U.S. Department of Defense, U.S. Department of Energy, various national laboratories, Private industries and other organizations. Graduate study in environmental engineering and water re- source development is also offered by the Department of Civil and Environmental Engineering. Graduate study in other areas of civil engineering, such as geotechnical, transportation, and construction management, is not available at Rice.

RESEARCH FACILITIES

The department has excellent facilities for both analytical and experimental research. Numerical computations for analytical studies are performed on a network of workstations that consists of PC computers. This network is connected to a campus wide network for access to the Internet and other resources. Additional high-performance computational resources are also available in the George R. Brown School of Engineering and Rice University.

Experimental studies are conducted in the Ryon Engineering Laboratory, which includes a structural test bay of about 5,000 square feet served by a 20-ton overhead crane. Reinforced concrete subassemblies are tested in a versatile steel reaction frame capable of simulating earthquake-type loading. It is equipped with an automated computer-controlled servo-hydraulic load application system with a high-speed data acquisition system capable of scanning more than 100 data channels.

Material testing is performed on four independent closed-loop static and dynamic axial load test systems. Each system is equipped with hydraulic power supply, servo controllers, function generator and a computer for test control. The loading capacities of these frames vary from 22 kips to 220 kips. A considerable amount of supporting hardware is also available to facilitate testing of a variety of materials.

Research in the area of structural dynamic systems and, smart structures, structural monitoring and identification is conducted on a computer-controlled shaking table. The shaking table is capable of four-g acceleration, 35 in/sec velocity and three-inch displacement and can excite one-seventh scale structural models weighing up to 3,000 pounds. Advanced data acquisition systems and real-time control hardware and software are available for study of dynamic systems and control.

The Ken Kennedy Institute for Information Technology (K2I), together with the Office of the Vice Provost for Information Technology (IT), provides faculty, staff, and students access to a shared research cyberinfrastructure (computing, storage and visualization infrastructure), application and software support, data management services, and user training, all at minimal cost. Rice currently owns and operates several large-scale computational resources built around x86, Power7, Power8 and BlueGene technology capable of delivering about 90 million computing hours per year (see http://rcsg.rice.edu), and a display wall with more than 33 million pixels (see http://viz. rice.edu).

CAMPUS VISIT

We encourage you to visit Rice at any time for a firsthand look at the department and the beautiful, tree-lined campus near the heart of historic Houston. In the meantime, feel free to contact the department with any questions you may have about the university.

DEGREE REQUIREMENTS

The Master of Science degree may be obtained after completion of at least 30 credit hours of study, including research and thesis. Twenty-four credit hours must be completed from approved graduate level courses; this should include one course each in structural engineering, mechanics, applied mathematics, structural dynamic systems, systems reliability and earthquake engineering. Graduate residence at Rice is 24 semester hours with at least one semester in full-time status. Specialization in computational mechanics, structural dynamics, smart structures, earthquake engineering, structural and systems reliability, advanced materials and nano-mechanics is possible within the structures concentration. The candidate for the degree also must complete a research study, submit an acceptable thesis and pass a final public oral examination on the thesis and related topics. The department will not grant an automatic master's degree to doctoral candidates who have not written a satisfactory master's thesis.

The Doctor of Philosophy degree is awarded after successful completion of a program of advanced study and an original research investigation reported in an approved thesis. Normally, three or four years of study are required beyond the M.S. degree. Some of the study can be part-time or transferred to Rice, but at least four semesters must be done in full-time residence at Rice.

The candidate for this degree will complete 90 credit hours of approved courses past BS (60 credit hours past MS degree) with high standing. The student must also pass a preliminary examination designed to test the candidate's knowledge of structural engineering and a qualifying examination on the proposed thesis topic. The research and thesis must constitute an original contribution to knowledge. As final evidence of preparation for the Ph.D., the candidate must pass a public oral examination. In addition, if the candidate's ability to write English is deficient, he or she may be required to pass an appropriate English course. For more details on core course requirements and the preliminary exam, please visit our Web site, www.cee.rice.edu.

The Master of Civil and Environmental Engineering is a professional non-thesis degree requiring 30 credit hours of approved courses at the 500-level or above, including a final project of 2 credit hours. Students pursuing the MCEE must complete a minimum of 30 credit hours of graduate-level courses in the civil engineering sub-track, including a 2 credit final project, a minimum of 24 credit hours at Rice, and a minimum residency of one fall or spring semester in full-time or part-time graduate study.

ADMISSION

Admission to this graduate program requires a background in civil engineering equivalent to that provided by the basic option of the Rice curriculum leading to the degree of Bachelor of Science in Civil Engineering. These requirements are essentially equivalent to a structures major in civil engineering at many larger schools. Consideration will be given to applicants with some other undergraduate bachelor's degree, provided that the preparation in mathematics, mechanics, and structural analysis and design is essentially equivalent to that described above, or provided that the deficiencies can be made up, without graduate credit, in a short time. However, degrees in areas such as engineering technology or building construction technology are not sufficient, and Rice has no program to remedy the deficiencies. Students are normally admitted in the spring for the following fall semester.

FINANCIAL ASSISTANCE

Tuition scholarships, fellowships or research assistantships are available for students admitted to the Ph.D. program and some M.S. degree candidates (MCEE candidates are not eligible for these awards). Fellowships and research assistantships provide tuition plus a stipend. All recipients of scholarships, fellowships and assistantships are expected to devote full time to their graduate studies. A modest amount of service to the department such as grading, teaching, research or laboratory assistance, is customarily required as a part of our advanced degree program.

GRADUATE COURSES IN CIVIL ENGINEERING

Adv.Mechanics of Materials
Applied Monte Carlo Analysis
Adv. Stochastic Mechanics
Bridge Engr/Extreme Events
Computational Struc. Mech.
Computational Nano Mech.
Concrete Building Design
Earthquake Engineering
Elasticity, Plasticity & Damage
Foundation Engineering
Modeling/Complex Urban
Nonlinear Finite Element
Offshore and Marine Systems
Steel Building Design
Structural Dynamic Systems
Time Dependent Sys.Reliability

SELECTED OTHER COURSES OF INTEREST

Nonlinear Systems and Control
Continuum Mechanics
Finite Element Methods
Differential Equations
Applied Math
Managerial Decision Making
Statistical Learning
Introduction to Mathematical Probability
Markov Processes
Partial Diff. Equations
Operations Research
Project Management

ABOUT RICE AND HOUSTON

Rice is a leading American research university—small, private and highly selective—distinguished by a collaborative, interdisciplinary culture and a global perspective. Only a few miles from downtown Houston, it occupies an architecturally distinctive, 285-acre campus shaded by nearly 4,000 trees. State-of-the-art facilities and laboratories, internationally renowned centers and institutes and one of the country's largest endowments support an ideal learning and living environment.

The university attracts a diverse group of highly talented students and faculty with outstanding graduate and professional programs in the humanities, social sciences, natural sciences, engineering, architecture, music and business. With just 2,744 graduate students and 3,879 undergraduates, it offers an unusual opportunity to forge close relationships with eminent faculty scholars and researchers and the option to tailor graduate programs to specific interests.

Houston offers all the expected educational, cultural and commercial advantages of a large urban center, and more. It's home of the Texas Medical Center, the largest concentration of medical schools, hospitals and research facilities in the world, as well as several other universities. Rice has cooperative programs with the University of Houston, Baylor College of Medicine, the University of Texas Health Science Center and Texas Southern University. Houston is one of the few U.S. cities with resident companies in all four major performing arts—drama, ballet, opera and symphony. It also boasts a museum district featuring exhibits of national and international prominence.

As urban as it is, Houston also is a surprisingly green city. Houstonians enjoy the outdoors in more than 300 municipal parks and 120 open spaces, and many frequent the beach at Galveston Island, only a 45-minute drive away. Other short trips include Austin, the state's capital, and historic San Antonio, both of which are a little more than three hours away.

FOR ADDITIONAL INFORMATION, CONTACT:

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www.houstontx.gov
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Houston information from the Greater Houston Partnership:
www.houston.org
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houston.citysearch.com