Graduate Study *at*

RICE

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, structural control, structural health monitoring, infrastructure renewal, multihazard 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 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 and control, 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 control optimization, 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. (1998) Universidad de Los Andes, Colombia; M.Eng. (2001) Massachusetts Institute of Technology; Ph.D. (2005) Georgia Institute of Technology. Dr. Dueñas-Osorio's major fields of study span the computational modeling of complex networks, as well as the risk and reliability assessment of interdependent lifeline systems. Dr. Dueñas-Osorio also conducts research on wind turbine reliability, intelligent infrastructures and bridge-network performance prediction along with their bridge-pile-soil interactions. He received the Best PhD Thesis Award in Civil and Environmental Engineering at Georgia Tech in 2006 and the National Science Foundation CAREER award for young investigators in 2008. His research program is currently funded by the Department of Defense, the National Science Foundation, the City of Houston and the Shell Center for Sustainability. 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.

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 B. Basu, 2008. "Unavailability of wind turbines due to wind-induced accelerations." *Engineering Structures*, 30(4):885–893.

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

Dueñas-Osorio, L. and J. Rojo, (2011). "Reliability assessment of lifeline systems with radial topology." Computer-Aided Civil and Infrastructure Engineering, 26(2): 111-128.

GRADUATE STUDY IN CIVIL ENGINEERING

Department of Civil and Environmental Engineering
Rice University

WWW.CEE.RICE.EDU

For admission in 2015

Satish Nagarajaiah. Professor of Civil and Mechanical Engineering. Ph.D. (1990) State University of New York at Buffalo. Dr. Nagarajaiah's teaching and research interests are in the areas of structural dynamic systems, seismic protection; earthquake engineering; smart structures; vibration control; system identification; structural health monitoring; structural integrity assessment; offshore structures and applied Nanotechnology. His research is funded by the National Science Foundation, National Aeronautics and Space Administration, Department of Energy, Air Force Office of Scientific Research, other state and federal agencies. National Science Foundation has awarded him the prestigious CAREER award for his research in Adaptive Stiffness Structures. He has published extensively and presented keynote lectures at several international conferences. For full details visit his web site satishnagarajaiah.rice.edu. Dr Nagarajaiah currently serves as the managing editor of editor of Journal of Structural Engineering ASCE, and as the editor of the International Journal: Structural Control and Health Monitoring (Wiley) and serves on the editorial boards of several other international journals. He is an inaugural fellow of Structural Engineering Institute (SEI) of ASCE since 2012. He currently serves on the ASCE, SEI awards committee. He served as the chair/vice-chair/secretary/member (2006-to-2012) of ASCE, SEI, Technical Activities Division Executive Committee (Highest technical administrative committee in Structural Engineering Institute-SEI). 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.

Representative publications: Yang, Y., and Nagarajaiah, S. "Time-frequency Blind Source Separation using Independent Component Analysis for Output-only Modal Identification of Highly-damped Structures," Journal of Structural Engineering, ASCE, doi: 10.1061/(ASCE)ST.1943-541X.0000621 (2013).

Sarlis, A.A., Pasala, D.T.R., Constantinou, M.C., Reinhorn, A.M., Nagarajaiah, S., and Taylor, D. "Negative stiffness device for seismic protection of structures" Journal of Structural Engineering, ASCE, 10.1061/(ASCE)ST.1943-541X.0000616, (2013).

Pasala, D.T.R., Sarlis, A.A., Nagarajaiah, S., Reinhorn, A.M., Constantinou, M.C. and Taylor, D. "Adaptive Negative Stiffness: A New Structural Modification Approach for Seismic Protection", Journal of Structural Engineering, ASCE, 10.1061/(ASCE)ST.1943-541X.0000615, (2013).

Chen, B. and Nagarajaiah, S. "Observer-based structural damage detection using genetic algorithm," Structural Control and Health Monitoring Article, DOI: 10.1002/stc.512 (2013).

Jamie Ellen Padgett. Assistant Professor of Civil and Environmental Engineering. Ph.D. (2007) Georgia Institute of Technology. Dr. Padgett's rsearch focuses on the application of probabilistic methods for risk assessment of structures and lifelines, including the quantification and promotion of infrastructure sustainability. Her work addresses the protection of bridge infrastructure exposed to multiple hazards, such as earthquakes, hurricanes or corrosion, as well as the use of advanced materials for retrofit and rehabilitation. Within the field of earthquake engineering, she emphasizes seismic design, analysis and retrofit of bridges and other structures. Dr. Padgett is Chair of the American Society of Civil Engineering (ASCE) technical committee on Multiple Hazard Mitigation, and an active member of several national technical committees, including the Structural Engineering Institute's Technical Council on Life-Cycle Performance, Safety, Reliability, and Risk of Structural and Infrastructure Systems, and the Transportation Research Board (TRB) Committee on Seismic Design and Performance of Bridges. She currently serves on editorial boards for the ASCE Journal of Bridge Engineering, Earthquakes and Structures, and Natural Hazards Review. 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 contributions to the field of infrastructure risk assessment and protection.

Representative publications: Ataei, N. and Padgett, J. E. (2012) "Limit State Capacities for Global Performance Assessment of Bridges Exposed to Hurricane Surge and Wave," Structural Safety, Vol. 41, pp. 73-81, March, 2013.

Ghosh, J. and Padgett, J. E. (2011) "Probabilistic Seismic Loss Assessment for Aging Bridges using a Component Level Cost Estimation Approach," Earthquake Engineering and Structural Dynamics, Vol. 40, No. 15, pp. 1743-1761, February, 2011.

Padgett, J. E., Dennemann, K., Ghosh, J. (2010) "Risk-Based Seismic Life-Cycle Cost-Benefit (LCC-B) Analysis for Bridge Retrofit Assessment," Structural Safety, Vol. 32, No. 3, pp. 165-173, May, 2010.

Rouzbeh Shahsavari. Assistant Professor of Civil and Environmental Engineering. M.S. (2004) McGill University, Ph.D. (2010) Massachusetts Institute of Technology. Dr. Shahsavari's research focuses on developing a multiscale, multiparadigm materials modeling approach extending from the quantum level to the continuum level 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, which are the most widely used synthetic materials in the world, with large societal and environmental impacts. 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 won various awards, including the $100,000 first prize in the MIT enterpreneurship contest in 2010 (against 204 other entries) for a nanoengineering concrete idea based on his research. Prior to MIT, he was a project engineer at an engineering, procurement and construction management firm in Canada.

Representative publications: Sakhavand N, Muthuramalingam P, Shahsavari R, Toughness Governs the Rupture of Interfacial H-bond Assemblies at a Critical Length Scale in Hybrid Materials, Langmuir,DOI: 10.1021/la4014015.

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.

2Shahsavari R., Buehler M.J., Pellenq R., Ulm F.-J., (2009), First-principles study on elastic constants and interlayer interaction of complex hydrated oxides: the case study of tobermorite and jennite, Journal of American Ceramic Society, 92 (10) 2323-2330

Shahsavari R., Pellenq R., Ulm F.-J., (2011), Empirical force fields for complex caclio-silicate layered materials, Physical Chemistry Chemical Physics, 13, 1002-101

Pol D. Spanos. Lewis B. Ryon Professor of Mechanical Engineering and Civil Engineering. Ph.D. (1976) 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. Assistant Professor of Civil and Environmental Engineering. Ph.D. (2005) Duke University. Dr. Stanciulescu has research interests in nonlinear computational mechanics (with par-

ticular emphasis on multiscale and multiphysics formulations), nonlinear dynamics, constitutive modeling of materials, structural analysis and inverse problems. Prior to coming to Rice University, she was a postdoctoral research associate at Duke University (2005–06)and an assistant professor at the University of Illinois at Urbana- Champaign.

Representative Publications:

Tamas Kalmar-Nagy and Ilinca Stanciulescu, Can complex systems really be simulated? (2014), DOI:10.1016/j.amc.2013.11.037, Applied Mathematics and Computation, v 227, 199-211.

Yenny Chandra, Richard Wiebe, Ilinca Stanciulescu, Lawrie Virgin, Thomas Eason and Stephen Spottswood, Characterizing dynamic transitions associated with snap-through of clamped shallow arches (2013), DOI:10.1016/j.jsv.2013.06.001, Journal of Sound and Vibration, v 22, 5837-5855.

Soheil Soghrati and Ilinca Stanciulescu Systematic construction of higher order bases for the finite element analysis of multiscale elliptic problems (2013), DOI:10.1016/j.mechrescom.2013.06.002, Mechanics Research Communications, v 52, 11-18.

Behrang Moghaddasie and Ilinca Stanciulescu, Direct calculation of critical points in parameter sensitive systems (2013), DOI: 10.1016/j.compstruc.2012.11.001, Computers & Structures, v 13, 34-47.

PROFESSORS OF THE PRACTICE

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

LECTURERS

David Gornet, Executive Director—The Grand parkway Association,
Moyeen Haque, Principal—Matrix Structural Engineers, Houston, TX
Nadathur Varadarajan, Engineer—J. Ray McDermott
Steve Wilkerson, Engineer—Haynes Whaley and Associates

PROFESSORS EMERITI

Dr. Ahmad Durani, Professor Emeritus—Rice University, Houston, TX
Dr. E. C. Holt, Professor Emeritus—Rice University, Houston, TX
Dr. John Merwin, Professor Emeritus—Rice University, Houston, TX
Dr. Ron Nordgren, Professor Emeritus—Rice University, Houston, TX
Dr. 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 and control
- structural health monitoring
- system identification
- smart structures
- seismic base isolation
- computational mechanics
- nonlinear vibrations
- earthquake engineering
- bridge engineering
- offshore structures
- probabilistic response and reliability
- analysis and design of reinforced concrete buildings for earthquake loading
- applications of probability theory to structural dynamics and fatigue behavior
- infrastructure systems

Research activities in recent years have been funded by the National Science Foundation, the Texas Advanced Technology Program, NASA, the U.S. Department of Defense, the U.S. Department of Energy, various national laboratories, Shell Oil Company, Exxon and other organizations.

GRADUATE COURSES IN CIVIL ENGINEERING

Advanced Mechanics of Materials
Structural Mechanics
Applications of Probability Theory
Theory of Elasticity
Structural Dynamic Systems and Control
Bridge Engineering and Extreme Events
Computational Methods in Structural Mechanics
Nonlinear Vibrations
Elasticity, Plasticity and Damage Mechanics
Earthquake Engineering
Concrete Building Design
Steel Building Design
Behavior of Reinforced Concrete Members
Foundation Engineering
Advanced Stochastic Mechanics
Research and Thesis
Reliability of Complex Systems
Nonlinear Finite Element Analysis
Special Problems

SELECTED OTHER COURSES OF INTEREST

Nonlinear Systems and Control
Continuum Mechanics
Finite Element Methods
Nonlinear Elasticity
Foundations of Applied Mathematics
Engineering Approach to Mathematical Programming
Engineering Approach to Optimal Control
Introduction to Statistical Methods
Introduction to Mathematical Probability
Markov and Renewal Processes
Partial Differential Equations
Complex Variables
Computational Methods for Differential Equations
Operations Research
Managerial Decision Making
Project Management
Hurricane Risk Assessment

Graduate study in environmental engineering and water resource 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 campuswide 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.

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 control, smart structures, and system 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 acquistion systems and real-time control hardware and software are available for study of dynamic systems and control.

Experimental work in the area of geotechnical engineering is conducted using an axial/torsional frame for advanced soil testing. An HP workstation controls the frame and a device for high-speed data acquisition. This system is used for both static and dynamic testing of hollow and solid cylinder specimens of soil.

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

Candidates for the professional, nonthesis M.C.E.E. degree will be expected to complete, with acceptable grades, 30 semester hours of graduate level courses in our civil engineering subtrack including the required core courses, 24 of which must be in residence at Rice, and a final project. The program should include at least 24 hours of advanced technical courses in one or more areas of structural/civil engineering. No thesis is required, but credit can be given for research on a specific topic. The requirements for this degree can be completed in two semesters (nine months).

The Master of Science degree may be obtained after completion of at least 30 semester hours of study, including research and thesis. Twenty-four semester hours must be in residence at Rice, and for at least one semester, the student must be registered full-time. The department requires at least 24 hours of advanced technical courses in the general area of structural engineering and applied mathematics. Specialization in computational mechanics, structural dynamics, smart structures, earthquake engineering, structural and systems reliability 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 work for the Master of Science degree normally takes three semesters and the intervening summer, a total of 16 months of full-time effort.

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 60 semester hours must be done in full-time residence at Rice.

The candidate for this degree will typically complete the equivalent of 48 semester hours of advanced technical courses with high standing, including at least six hours of advanced-level courses in applied mathematics. 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.

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 most students admitted to the Ph.D. program and some M.S. degree candidates. (M.C.E.E. 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. A loan fund is available for qualified graduate students, including those in the M.C.E.E program, who are U.S. citizens or permanent residents.

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 2,275 graduate students and 3,485 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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RICE

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City of Houston homepage:
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Houston information from Citysearch:
houston.citysearch.com