UCSD's Structural Engineering Department offers B.S., M.S., and Ph.D. degrees. Our programs and curricula provide education and training through a holistic approach to structural engineering, by emphasizing and building on the commonality in materials, mechanics, and analysis considerations across the disciplines of civil, aerospace, and marine engineering. The program features strong components in laboratory experimentation, basic theory, information technology, and engineering design.

For admissions information, contact Student Affairs Coordinator, Ms. Linda Floyd, via email at lfloyd@ucsd.edu, or by telephone at (858) 822-1421.

Pictured at top is the 7-story structure built recently at the Englekirk Structural Engineering Center, on the new UCSD-NEES Shake Table, with the goal of testing possible cost-effective ways to increase seismic safety of mid-rise concrete buildings. See page 5 for full story.

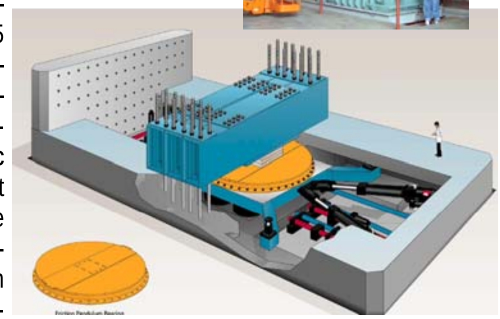
Research Areas

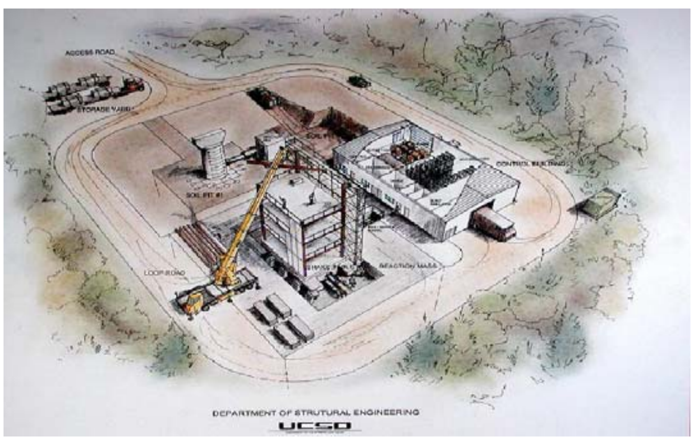
- Earthquake Engineering
- Mitigation of Blast Loading
- Health Monitoring & Condition Assessment
- Composite Materials & Light-Weight Structural Systems
- Hydrodynamics & Fluid-Structure Interaction
- Reliability & Risk Engineering
- Renewal Engineering
- Civil Structural Design

Structural Engineering Faculty with Class of 2005

Charles Lee Powell Structural Research Laboratories

UCSD's Powell Labs are among the largest and most active, full-scale structural testing facilities in the world. With fourteen (14) distinct testing facilities, federal and state governments and industry associations rely on the Powell Labs for tests to improve seismic hazard mitigation, verify new structural materials and concepts, advance structural safety, and increase U.S. industry's worldwide competitiveness. Facilities include the **Structural Systems Laboratory**, with its 50 ft-tall reaction wall and 120 ft-long strong floor, equipped for full-scale testing of bridges, buildings, ships and aircraft; the **Structural Components Laboratory** with its 10x16-ft shake table, a 65 ft-long reaction wall and strong floor, and three test bays; the **Fiber-Reinforced Composites Processing & Characterization Laboratories**, leading nationwide research in processing science, fabrication, and characterization of materials; and the **Caltrans Seismic Response Modification Device (SRMD) Testing Laboratory** (at lower right), the world's largest six-degree-of-freedom shake table for the dynamic testing of full-scale bearings, isolators, and dampers, powered by computer-controlled hydraulic actuators that can apply up to 12 million pounds of force during earthquake simulations.





The Englekirk Structural Engineering Center

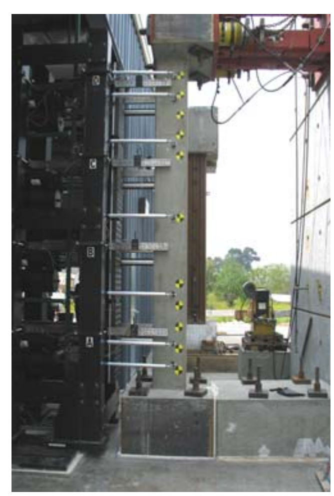
In 2005, UCSD completed its $20 million Englekirk Structural Engineering Center located approximately eight miles from the UCSD campus, and is equipped with truly unique facilities which allow researchers to perform earthquake testing on full-scale structural systems.

NEES Shake Table

The UCSD-NEES Outdoor Shake Table is capable of creating realistic simulations of the most devastating earthquakes ever and has no height restrictions, thus enabling structural tests which have never been possible before. The facility is part of the National Science Foundation's George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES). At 25 ft. by 40 ft., this is the largest shake table in the United States. Although this table is not the largest of its kind in terms of size in the world, the velocity, frequency range, and stroke capabilities make it the largest table outside Japan and the world's first outdoor shake table. The facility adds a significant new dimension and capabilities to existing United States testing facilities with no overhead space and lifting constraints.

Soil Foundation-Structure Interaction Facility (SFSI)

With its refillable soil pits, laminar soil shear box, and two reaction walls, this is the nation's largest facility for testing soil-structure reactions to earthquakes and other natural disasters, such as hurricanes. The reaction walls allow for full-scale testing of systems such as bridge abutments and pile foundations. Also unique to the facility are two soil pits that will enable controlled testing of deep foundations. Researchers will be able to tailor soil properties to simulate conditions in specific geographic locations, and to analyze soil-related phenomena caused by earthquakes such as liquefaction and lateral spreading. The facility is funded by the California Department of Transportation.



Blast Simulator

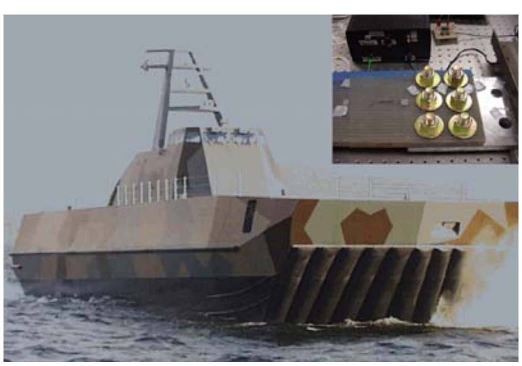
The UCSD Blast Simulator (shown at right) is the world's first laboratory to simulate the effects of bombs without the use of explosive materials. The device generates the speed and force of explosive blasts through a servo-controlled hydraulic system that punches test specimens at speeds of up to 26 meters per second during a 1-2 millisecond pulse. In the accumulator bank, nitrogen charges hydraulic fluid and builds up pressure. This pressure is released through velocity generators which propel steel plates carrying elastomeric pads precisely shaped to impart specific pressure distributions on the test specimen.

Advanced Sensor Networking Paradigms and Data Processing for Autonomous Structural Assessment

Damage assessment of large-scale structures such as bridges, buildings, or dams after an extreme event such as an earthquake or a blast load is a challenging task. In many cases, critical damage is not visible or obvious, human inspection poses serious life-safety concerns, and downtime for the structure equates with large economic losses. UCSD structural engineers, with partners in the Computer Science and Engineering Department, California Institute for Telecommunications & Information Technology (Calit2), and the Los Alamos National Laboratory, are developing components for a new system approach that combines radio-frequency identification (RFID)-based wireless sensing, advanced networking and embedded system architectures, and autonomous network interrogation via unmanned platforms such as robots or unmanned UAV. The unmanned platforms are programmed to move to and query these wireless sensor networks and compute features that help in making structural health assessments after such extreme events.

Simulating Bomb Blasts

UCSD structural engineers, together with a team of industry and university partners, are developing and evaluating blast mitigation technologies to harden buildings and bridges against terrorist bomb attacks through a new $7.5 million federal contract. More than 40 tests will be performed over the next two years in the new blast simulator laboratory at the Englekirk Structural Engineering Center. Through the program, the structural engineers will create fully controlled and repeatable blast simulations. They will test a variety of building components, such as structural columns, which are most vulnerable to blast loads, as well as load-bearing and infill walls, and bridge elements, and will simulate a range of blast scenarios including the equivalent of 50 pounds of TNT detonated within a few feet of a structure to 5,000 pounds of TNT detonated from more than 100 feet away. The results, together with explosive field tests, will be used to create computer tools to design and assess blast mitigation strategies for important facilities such as federal buildings and embassies, as well as critical long-span bridges. Pictured above: Frames captured by high-speed digital camera allow researchers to view details of blast simulation impact caused when a reinforced concrete column is blasted with the equivalent of 1,100 pounds of TNT at curbside.



Advanced Sensors and Data Interrogation Procedures

The use of heterogeneous materials in aggregate structural systems is increasing for a number of applications where performance demands and/or cost considerations warrant such hybrid designs for the next-generation destroyer DD-X surface ship, which is expected to have a composite material superstructure and a metal hull. As the U.S. Navy officially transitions to a condition-based maintenance philosophy, an on-line, automated diagnostic condition assessment methodology is needed. UCSD structural engineers, in partnership with the Los Alamos National Laboratory, are developing advanced sensor networks and implementing novel vibration-based analysis routines using chaotic wave interrogation to assess the structural integrity of these hybrid joints and aid the Navy in developing such automated maintenance tools.

High-Speed, Non-Contact Ultrasonic Inspection of Rails

Researchers are developing a rail inspection prototype based on the use of ultrasonic guided waves and non-contact probing techniques to target transverse-type defects which are the leading causes of train derailments. The project was initially funded by the National Science Foundation and is currently funded by the U.S. Federal Railroad Administration (FRA). The project is also supported by San Diego Trolley, Inc.

A prototype is being developed for the FRA, that is aimed at the quantitative detection of small surface-breaking transverse cracks by using high-frequency waves, between 100 kHz and 900 kHz. A pulsed laser is used to generate the waves and an array of air-coupled sensors is used to detect the waves. The prototype will use real-time signal processing based on Wavelet Transform and Automatic Pattern Recognition to increase the reliability and the speed of the inspection.

Lightweight Composite Military Bridges

UCSD composite structural engineers are developing lightweight bridges for the military that make use of modern aerospace-grade advanced composite materials. These graphite/epoxy bridges weigh considerably less than existing metallic bridges but can still easily support 80-ton tanks. UCSD is involved with the design, analysis, fabrication, lab testing, and field testing.

Unmanned Aerial Vehicles:
Development & Improvements

UCSD structural engineering researchers are actively improving the performance of existing UAV as well as developing new unmanned aircraft. Vibration tests were performed on the wings of the General Atomics Predator aircraft as well as on freely-suspended full-scale Northup-Grumman Hunter UAV using modal shakers and a scanning laser vibrometer. These results are being incorporated into the finite element analysis models used for flutter analysis and structural health monitoring. UCSD researchers are also working with Scripps Institution of Oceanography researchers are developing a new autonomous UAV for monitoring the atmosphere between Hawaii and Southern California.

Built-in Structural Health Monitoring System

Manufacturing defects, fatigue and impact damage in aerospace structures result in inefficient flight performance and potential global failure. Quick, reliable structural integrity assessment of aircrafts comprised of mainly carbon fiber composites, such as UAV, is particularly critical. To monitor in-flight damage and reduce life-cycle costs of the UAV, a continuous built-in structural health monitoring system based on ultrasonic guided waves and vibration analysis is being developed at UCSD in collaboration with Los Alamos National Laboratory.

San Francisco-Oakland Bay Bridge: Advancing Bridge and Seismic Design

UCSD led the seismic proof testing for the new San Francisco-Oakland Bay Bridge East Span, a 1,850-ft long span currently under construction. The self-anchored suspension design includes a novel steel single tower. The tower is comprised of four separate hollow shafts, interconnected by horizontal links, which are designed to dissipate energy and stiffen the tower during an earthquake. Pictured at right is an illustration of the proposed bridge.

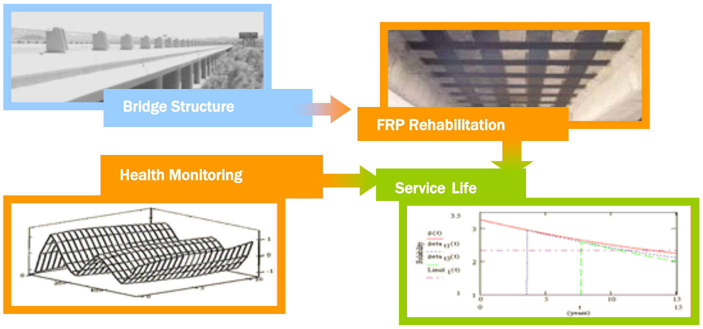
Seismic Rehabilitation of Steel Structures

Damage to welded steel moment-frame buildings occurring during the 1994 Northridge earthquake revealed a previously unrecognized welded beam-column connection fracture vulnerability. UCSD researchers worked with the California Department of General Services, Degenkolb Engineers, and the Crosby Group to perform full-scale laboratory testing and finite element analysis of moment connection rehabilitation schemes for the Caltrans District 4 Office Building located in Oakland, California. Results from testing at UCSD were applied to the rehabilitation design of hundreds of moment connections for this 15-story steel moment frame building. The photo shows one rehabilitated steel moment connection specimen, 30 ft long and 14 ft tall, ready for laboratory testing. The two hydraulic actuators applied cyclic loading to simulate the seismic effect.

New Concrete Construction Systems for Mid-Rise Residential Buildings

In a series of dynamic tests on a full-scale, seven story building, UCSD structural engineers and industry partners are evaluating new reinforced concrete seismic design methodologies for medium-rise residential buildings such as condominiums and hotels. The researchers are testing whether reducing longitudinal reinforcement in shear walls by as much as 50 percent will increase earthquake safety while at the same time reducing construction costs. The testing program is particularly targeted to housing needs in densely populated seismic regions in Los Angeles, and throughout southern California. Such full-scale, dynamic testing has never been possible before because of space limitations of indoor shake tables. The tests are taking place on the new UCSD-NEES outdoor shake table at the Englekirk Structural Engineering Center. At 25 ft. by 40 ft., this is the largest shake table in the United States, and the world's first outdoor shake table.

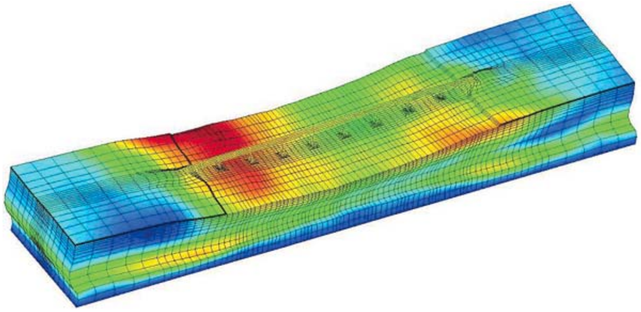
Application of Structural Health Monitoring for Service-Life Prediction



Structural Health Monitoring principles are being applied not just for the condition assessment of bridges and structural systems but also as a means of moving from time-based inspection to condition-based inspection of structures. In collaboration with engineers from the California Department of Transportation, new and rehabilitated bridges are monitored using an array of sensors. Data is coupled to analysis tools, which include an assessment of materials deterioration to enable prediction of remaining capacity and service-life. This is also being enhanced in cases of FRP based rehabilitation with time-based probabilistic analysis of risk.

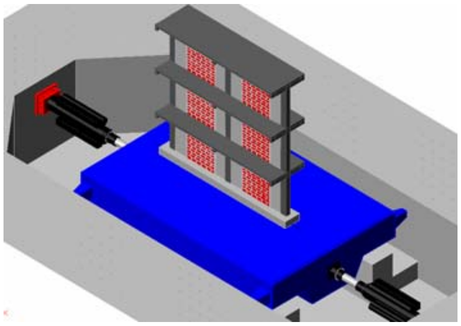
Ground Seismic Response & Effect on Structures

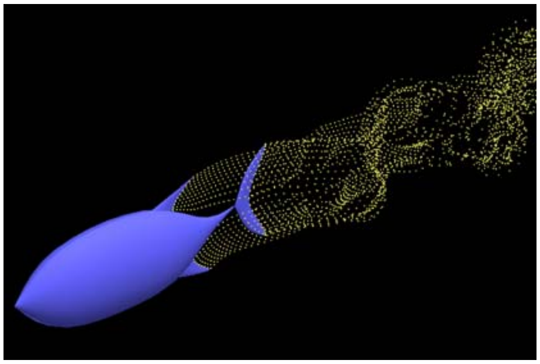
In collaboration with researchers in Japan, UCSD is conducting large-scale shake-table experiments (see photo at left) to increase the safety margin of foundation systems during earthquakes. On this basis, computational simulations are calibrated, allowing parametric studies of seismic loading scenarios. Parallel computing environments are utilized and complete nonlinear ground-foundation-bridge models are currently under investigation (see graphic at right).



Seismic Strengthening of Masonry-Infilled Nonductile Reinforced Concrete Frames

Assessing the seismic performance of masonry-infilled reinforced concrete (RC) frames presents a most difficult problem in structural engineering. Currently, there are no reliable engineering guidelines for this type of structures. As part of the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) program, UCSD researchers are leading a research project to address this problem, and develop practical and effective techniques for the seismic retrofit of these structures using conventional as well as innovative materials. The project will include the development of reliable analysis tools that range from advanced computational models to simple analytical methods. Final proof-of-concept tests will be conducted on a 3/4-scale three-story RC frame using the Large High Performance Outdoor Shake Table at UCSD.



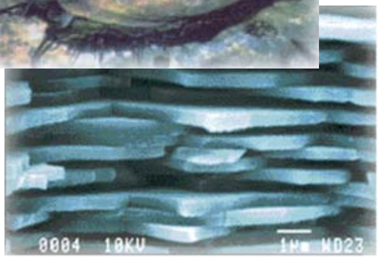


Biomimetic Investigation of Fish-Like Propulsion

Inspired by the efficient locomotion of fish, insects, and other creatures, innovative ocean vehicles that imitate animal propulsion and maneuvering are now being developed. This requires a multi-disciplinary effort involving unsteady fluid dynamics, structural mechanics, autonomous sensing and control, ship-building technology, as well as advanced materials. UCSD researchers are developing state-of-the-art computer models to help understand the underlying fluid-structure interactions in locomotion of aquatic animals. They are also creating numerical tools for the design and operation of biomimetic flapping-foil actuators, which will be implemented on autonomous underwater vehicles, high-performance surface vehicles, and ocean energy harvesting devices.

Biomineralization: The Process of Forming Composite Structures

Biomineralization is the genetically planned and controlled process by forming composite structures. It is the process of forming composite structures. It is the process by which living organisms "build" structures of enormous complexity, beauty, and functionality. Researchers at UCSD are analyzing the protein structures, including sequencing, determining structure, cloning and determining mechanical properties & modeling. In collaboration with Los Alamos, they are using AFM and SCIP microscopy to probe molecular structure of the framework. They are also using x-ray and neutron diffraction to determine structure, e.g. chitin in the framework. Based on their discoveries, valuable insights will propel development of novel man-made composite materials and structures. Photos depict Abalone shell and Scanning Electron Microscopy (SEM) photo of infant Abalone nacre.

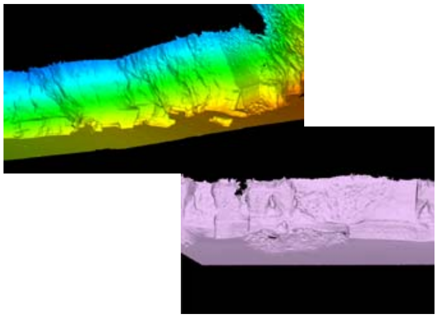


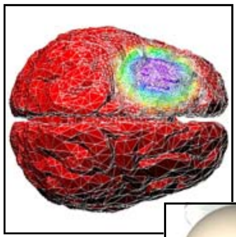
Liquefaction Using Controlled Blasting

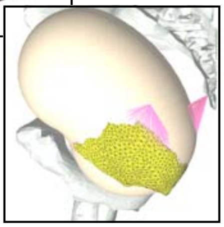
In order to simulate seismically-induced liquefaction, UCSD geotechnical engineers use buried explosives to raise the water pressure in the soil. This method of controlled blasting has led to testing of deep foundations in liquefied ground all over the world. This type of full-scale testing gives ground truth to many of the numerical modeling efforts carried out by UCSD students and other researchers worldwide.

Understanding Coastal Bluff Erosion

Erosion of our coastal bluffs and beaches has reached a crisis point in California. UCSD geotechnical engineers work with scientists and engineers at Scripps Institution of Oceanography on a variety of projects to develop a better understanding of the erosion process. This multi-disciplinary area of research requires interest in engineering, geology, and coastal processes, as well as advanced sensing technologies such as the LIDAR 3-D laser scan shown.

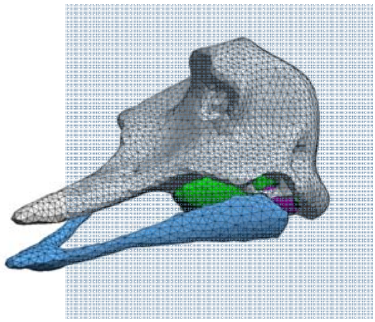






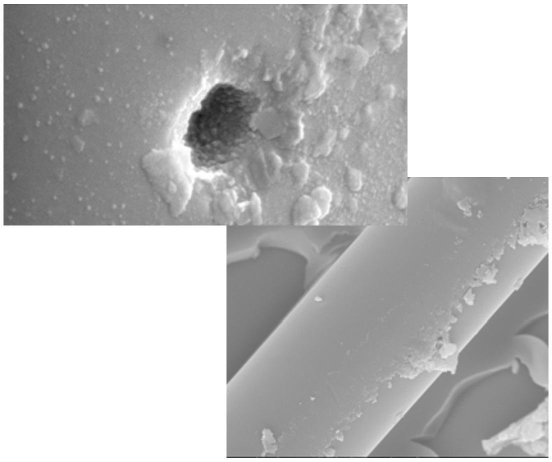
Analysis of the Structural Response of Biological Systems

Advanced computational techniques are beginning to enable *in silico* investigations of biological systems. Recent projects include investigation of the interaction of sound waves with the anatomy of beaked whales (see graphic at right) to test hypotheses concerning both pathways for sound reception, and pathways for sound generation (echolocation), adaptive finite element inverse brain EEG and computational non--rigid registration guided neurosurgery (see graphic at upper left) , and simulations of the musculature of the pelvic floor during natural birth (see graphic at lower left).



Durability of Fiber Reinforced Polymer Matrix Composites & Service-Life Prediction

Researchers from the Department of Structural Engineering and the Materials Science Program have been conducting research aimed at the investigation of durability of polymers and fiber reinforced composites for use in the renewal of civil infrastructure, and for use in marine and aerospace applications. Unique accelerated tests combine mechanical characterization with physio-chemical analysis enabling assessment at both the constituent (fiber and polymer) and composite level. In collaboration with the California Department of Transportation, the Federal Highway Administration, the Civil Engineering Research Foundation, and industrial partners, research results are being used in determining reliability and service-life of products used in seismic retrofit of columns, external strengthening of slabs and girders, bridge decks, and structural members.



> faculty and their research <

Robert J. Asaro, Professor
Experimental and computational studies of nonlinear material behavior. Marine civil structural design. Advanced structural materials.

Scott Ashford, Assoc. Professor
Geotechnical earthquake engineering, soil dynamics. Foundation engineering. Soil-structure interaction. Slope stability. Landfill linear design.

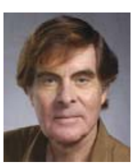
Joel P. Conte, Vice-Chair/Professor
Structural reliability and risk analysis. Probabilistic design. Computational structural mechanics. Experimental structural dynamics. System identification. Structural health monitoring.

Robert Dowell, Assistant Adjunct Professor
Non-linear seismic analysis of reinforced concrete. Bridge engineering. Bridge retrofit strategies.

Ahmed Elgamal, Chair/Professor
Health monitoring sensor networks, database and data mining applications. Computational and experimental simulation of soil/structure systems, and seismic load mitigation solutions.

Robert Englekirk, Adjunct Professor
Reinforced concrete. Design of buildings and bridges. Seismic response of mid-rise buildings. Large-scale structural analysis and design.

Charles Farrar, Adjunct Professor
Integrated approaches to Structural Health Monitoring. Damage detection. Damage prognosis technologies and solutions.



Gilbert Hegemier, Professor
Mechanics of composite materials with applications to aerospace and civil structures. Infrastructure renewal via composites. Large-scale experiments on structures. Blast mitigation.

Vistasp M. Karbhari, Professor
Mechanics of composites. Manufacturing/processing science of polymers and composites. Durability of polymers and composites. Damage and crash energy management. Infrastructure renewal and blast mechanics.

John B. Kosmatka, Professor
Advanced composites for aerospace, civil, and sports structures. Linear and nonlinear structural dynamics, stability, aeroelasticity, and structural health monitoring. Vibration control using embedded passive and electro-active materials.

Petr Krysl, Assoc. Professor
Finite element and meshless discretization methods applied to problems of structural and solid mechanics. Mesh generation, shell modeling, adaptive finite element methods, dynamic crack growth, parallel algorithms, and optimal models for nonlinear dynamic problems. Computational biomechanics and bioacoustics.

Francesco Lanza di Scalea, Assoc. Professor
Nondestructive evaluation. Structural health monitoring. Experimental mechanics.

J. Enrique Luco, Professor
Earthquake engineering. Strong motion seismology. Wave propagation in solids. Dynamics. Soil-structure interaction. Foundations. Active control of seismic response of structures. Effects of topography on earthquake ground motion.

José Restrepo, Assoc. Professor
Seismic design and retrofit of buildings and bridges. Development of construction alternatives suited to performance-based design. Large-scale shake-table tests, and nonlinear dynamic response of buildings and structural components.

Frieder Seible, Dean, Jacobs School/Professor
Bridge design. Earthquake engineering. Structural concrete and advanced composite design. Large scale structural testing.

P. Benson Shing, Professor
Theoretical and experimental investigations of nonlinear behavior of concrete and masonry structures under extreme static and dynamic loads, including nonlinear finite element modeling and large-scale testing. Development and applications of pseudodynamic and real-time hybrid test methods. Seismic retrofit of existing structures.

Michael Todd, Asst. Professor
Structural health monitoring methodologies. Applied nonlinear dynamics and chaos. Structural dynamics and vibrations. Time series analysis. Fiber optic sensors for structural monitoring.

Chia-Ming Uang, Vice-Chair/Professor
Seismic design of steel structures. Earthquake engineering. Seismic design methodology. Large-scale testing. Seismic design of wood frame structures.

Qiang Zhu, Asst. Professor
Nonlinear free-surface waves, wave-body interactions. Dynamics of highly-flexible mooring systems. Computational simulation of offshore structures. Locomotion of aquatic creatures. Modeling of biopolymers.

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