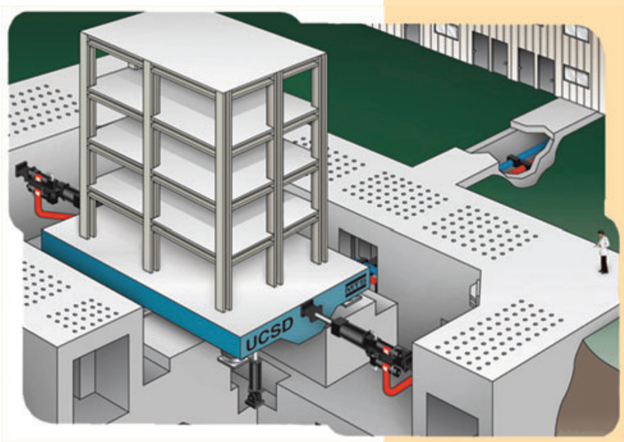
UCSD Jacobs | School of Engineering

Structural Engineering



Powell Labs Field Station

UCSD is constructing a $20 million Field Station which will be completed by Fall 2004. The Field Station will be equipped with the world's first outdoor shake table (25X40-ft) adjacent to the country's largest soil foundation-structure Interaction Facility, allowing researchers to perform dynamic earthquake tests on full-scale structural systems. A unique blast simulator will be used to study the effects of bomb blasts, and new technologies to harden buildings against terrorist bomb attacks.

Research Areas

Earthquake Engineering and Dynamic Loading

Renewal Engineering

Health Monitoring and Condition Assessment

Large Light-Weight Structural Systems

Composite Materials and Structures

Civil Structural Design

Structural engineering faculty with class of 2003

University of California, San Diego

Research Highlights

Blast Mitigation and Homeland Security

UCSD structural researchers will test the effects of bomb blasts on structures in a new explosive loading laboratory under construction at UCSD. The researchers will also test new technologies to harden buildings against bomb blasts, including a UCSD composite overlay technique (originally designed to protect structures from earthquakes) which has proven effective in full-scale explosive blast tests and has been deployed abroad in several U.S. buildings. The Explosive Loading Laboratory Testing Program is supported through a contract from the Technical Support Working Group (TSWG), the federal interagency organization for combating terrorism. TSWG has named UCSD as one of its primary contractors in the focus area of blast mitigation, and a key deliverable in the program will be a design manual describing proven methods for hardening high-risk buildings against terrorist bomb blasts.

New Technologies to Safeguard Long-Span Bridges during Earthquakes

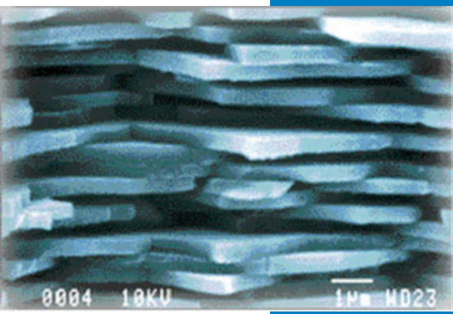
UCSD structural engineers conducted more than one year of proof tests on components for the new San Francisco-Oakland Bay Bridge East Bay Span. A single-tower, self-anchored suspension bridge and skyway is planned to replace the temporary East Bay Spans, which were built after part of the deck collapsed in the 1989 Loma Prieta Earthquake. Many of the new bridge components were designed and tested at UCSD, including the concept for the supporting piers, in which a hollow concrete pier has four confined corners made up of solid concrete reinforced with steel.

Unmanned Air Vehicle (UAV) Research

UCSD structural engineering researchers are actively improving the performance of existing unmanned air vehicles (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 a freely-suspended full-scale Northrop-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 working with Scripps Institution of Oceanography researchers are busy developing a new autonomous UAV for monitoring the atmosphere between Hawaii and Southern California.

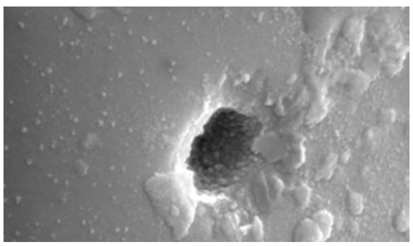
Sensor Nets: Structural Health Monitoring

Research is ongoing in conjunction with the California Department of Transportation to develop and implement Structural Health Monitoring and Damage Assessment techniques related to bridges. In one such project, a sensor array (that includes accelerometers, linear potentiometers, strain gauges and a PZT camera) on the Kings Stormwater Channel Bridge on State Route 86 was connected to the NSF funded HPWREN network to allow wireless transmission of data from the bridge site to UCSD. Information on the response of the bridge to seismic events and vehicular traffic loads can now be simultaneously accessed by staff at the California Department of Transportation (Caltrans) and UCSD. The system allows for both routine monitoring of bridge response and identification and assessment of damage severity, thereby providing both a research tool and a tool for bridge operations and maintenance. The technique is also being researched for use in capacity and remaining service-life assessment and prediction of rehabilitated bridge structural performance.

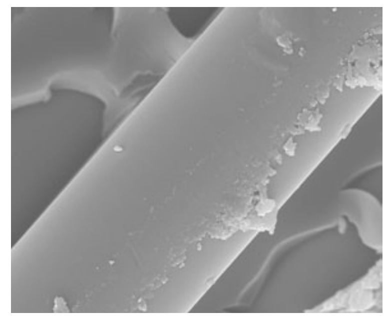


Biomineralization: The Process of Forming Composite Structures

Biomineralization is the genetically planned and controlled 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.



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



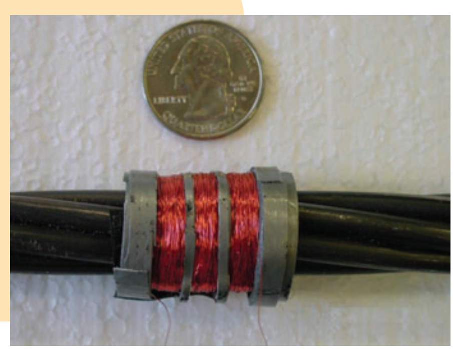
Researchers from the Department of Structural Engineering and the Materials Science Program have been conducting research aimed at the investigation of durability of polymers and fiber reinforced composites for use in the renewal of civil infrastructure, and for use in marine and aerospace applications. Unique accelerated tests combine mechanical characterization with physico-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.

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 example, the U.S. Navy is considering such a hybridized design for the next generation destroyer DD-X surface ship, which is expected to have a composite material superstructure and a metal hull. Currently, the inspection and re-torquing of bolted connections is performed by rote schedule without regard to condition. As the U.S. Navy officially transitions to a condition-based maintenance philosophy, an on-line, automated diagnostic condition assessment methodology is needed. UCSD engineers are developing advanced fiber optic 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.

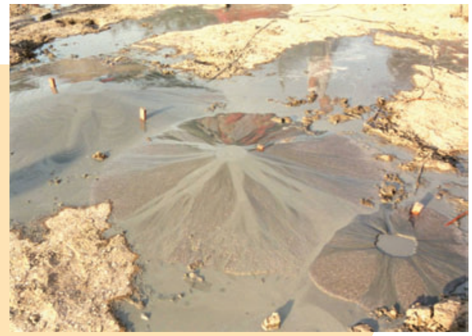
Sensors to Monitor Civil Structures

UCSD structural engineers are developing a method to monitor the health of multi-wire steel tendons and cable stays that are used in civil structures such as cable-supported bridges and pre-stressed concrete members. The National Science Foundation is funding this research. The project includes the development of new sensors that can be embedded in the structure for in-situ monitoring. Results of this study will help ensure the safety of existing as well as new structures that use multi-wire strands as the main load-carrying components.



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 lead 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.

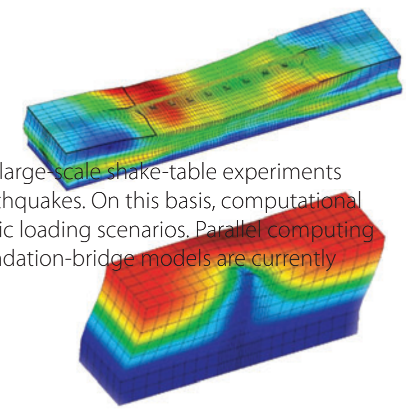


Mitigating Coastal Bluff Erosion

Erosion of our coastal bluffs has reached a crisis point in California. UCSD geotechnical engineers work with Scripps Institution of Oceanography on a variety of ways to mitigate coastal bluff erosion, focusing on methods that minimize impacts on the environment. This multi-disciplinary area of research requires interest in engineering, geology, and coastal processes, as well as remote sensing technologies.

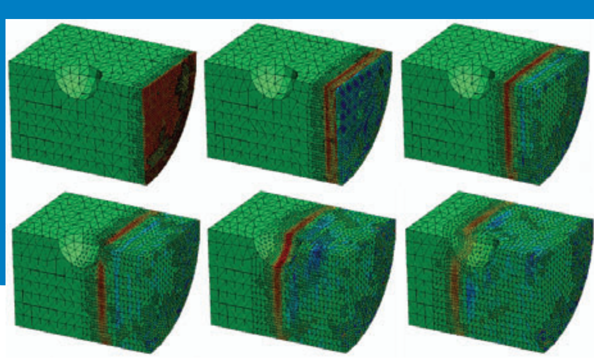
Ground Seismic Response and Effect on Structures

In collaboration with researchers in Japan, UCSD is conducting large-scale shake-table experiments 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.

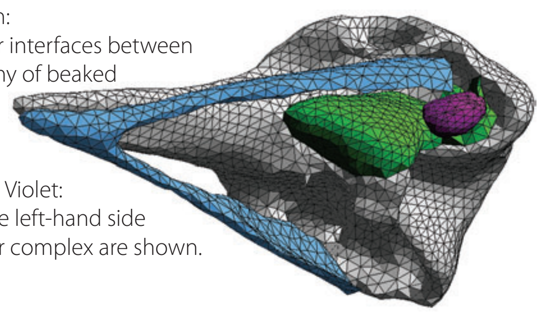


Computational Methods, Tools, and Simulations

UCSD structural researchers are conducting studies ranging from modeling of multi-body systems to adaptive finite element simulations of PDEs. Current efforts include models of mechanical processes in metals, composite panels, waveguides, and biological structures; adaptive approximation methods; computational geometry, including data analysis and approximation, mesh generation, and visualization; and high performance/parallel processing.



Snapshots of pressure from an adaptive finite element simulation of an elastic wave propagating in a cylindrical waveguide past a spherical void, using conforming hierarchical adaptive mesh refinement methods (CHARMS).



Bioacoustics Simulation:
Surface model of major interfaces between materials in the anatomy of beaked whales. Light gray: skull; steel blue: mandible; green: interface between air and tissue; Violet: ear bone. Note: only the left-hand side pterygoid sinus and ear complex are shown.

Powell Structural Research Laboratories

The Charles Lee Powell Structural Research Laboratories at UCSD are among the largest and most active full-scale structural testing facilities in the world. With 13 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
- Increase U.S. industry's worldwide competitiveness

Structural Systems Laboratory

With its 50 ft-tall reaction wall and 120 ft.-long strong floor, the Structural Systems Laboratory is equipped for full-scale testing of bridges, buildings, ships and aircraft. Pictured: The Powell Labs subjected a five-story building to a series of pseudodynamic earthquake simulations. The test validated five new framing systems with pre-compressed connections. This innovation paved the way for construction of high-rise buildings using precast concrete in highly volatile seismic zones in California.

Fiber Reinforced Composites Processing and Characterization Laboratories

The Fiber Reinforced Composites Manufacturing and Characterization Laboratories are among the leading university facilities nationwide for research in processing science, fabrication, and characterization of materials (with applications for high performance and low-cost large lightweight structures/systems). Processing and fabrication research is focused on autoclave (pictured), resin infusion (including vacuum assisted resin transfer molding VARTM), filament winding, UV-cure, and advanced contact molding derived processes. High performance composite structures are fabricated using prepreg materials in one of two large autoclaves. Researchers have extensive experience with a range of textile forms (e.g., carbon, glass, polyaramid, etc.), resins (e.g., epoxy, vinylester, polyurethanes, etc.), complex tooling and specialty processing, unique characterization techniques, and aspects related to fire-performance. Facilities include state-of-the-art equipment for characterization of the physical, chemical and mechanical properties from nanometer resolution to full structural component level. Extensive facilities also exist for characterization of environmental durability and for accelerated testing using mechanical, analytical, and chemical techniques (e.g., tailored test chambers and fixtures for long- and short-term durability including computer controlled freeze-thaw, humidity, UV chambers, accelerated testing, etc.). Research sponsors include Federal and State government agencies (NSF, NASA, Navy, Army), industry (aerospace, automotive, civil

Structural Components Laboratory

The Structural Components Laboratory includes a 10 X 16-ft shake table, a 65 ft-long reaction wall and strong floor, and three test bays. Pictured: Seismic test of a 40-ton electrical transformer with retrofitted bushings. During earthquakes porcelain bushings can break and/or the seals and gaskets within can fail, resulting in major power outages and oil leaks. The UCSD retrofit design should enable the bushings to perform more ruggedly during earthquakes.

Caltrans Seismic Response Modification Device Testing Laboratory (SRMD)

The SRMD is the world's largest six degree-of-freedom shake table for the dynamic testing of full-scale bearings, isolators and dampers. The SRMD is powered by computer-controlled hydraulic actuators that can apply up to 12 million pounds of force during earthquake simulations. Pictured: A test to evaluate the effectiveness of huge isolation bearings and dampers. In its earthquake retrofit strategy for the state's longest-span bridges, California is evaluating the use of these devices to absorb the shock of the earthquake and allow large displacements, preventing bridge collapse.

Faculty and Research

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

Scott A. Ashford
Geotechnical earthquake engineering, soil dynamics, foundation engineering, soil-structure interaction, slope stability, landfill linear design.

Joel P. Conte
Structural reliability and risk analysis, probabilistic design. Computational structural mechanics. Experimental structural dynamics, system identification, and structural health monitoring.

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

Gilbert A. Hegemier
Mechanics of composite materials with applications to aerospace and civil structures. Infrastructure renewal via composites, large-scale experiments on structures.

Vistasp M. Karbhari
Infrastructure renewal, mechanics of composites, manufacturing/processing science of polymers and composites, durability of polymers and composites, damage and crash energy management.

John B. Kosmatka
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
Finite element and meshless discretization methods applied to problems of structural and solid mechanics; mesh generation, shell modeling, adaptive nonlinear computations, dynamic crack growth, parallel algorithms, and optimal modeling for nonlinear dynamic problems.

Francesco Lanza di Scalea
Nondestructive evaluation, structural health monitoring, experimental mechanics.

J. Enrique Luco
Earthquake engineering, strong motion seismology, wave propagation in solids, dynamics, soil-structure interaction, foundations, active control of seismic control, of structures, effects of topography on earthquake ground motion.

Jose Restrepo
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
Bridge design, earthquake engineering, structural concrete and advanced composite design, large scale structural testing.

Michael Todd
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
Seismic behavior of steel structures, seismic design

Education

The UCSD Structural Engineering Department offers B.S., M.S., and Ph.D. programs in Structural Engineering. Rather than offering a broad civil program, the curricula provides students with a deep understanding of structural engineering and structural systems, with an emphasis on new materials, mechanics, analysis, and design. Students are prepared to work on structures across civil, aerospace, and marine industries. The program of study features strong components in laboratory experimentation, numerical computation, and engineering design. For admissions information, contact the Structural Engineering Student Affairs Office at: (858) 822-1421, or email

Structural Engineering

University of California, San Diego
9500 Gilman Drive, Dept 0085
La Jolla, CA 92093-0085
(858) 822-1420
http://structures.ucsd.edu