January 2012

CEE & UWRL Research In Action

Utah Water Research Laboratory

CEE & UWRL

Research in Action

Directors

Anderson, Loren R., Associate Dean of Engineering 750-2775

Bishop, A. Bruce, Dean of Engineering, Director, Engineering Experiment Station 750-2775

Bowles, David S., Associate Director, UWRL 750-3157

Dupont, R. Ryan, Assistant Director, UWRL 750-3227

Grenney, William J., Department Head, CEE Associate Director, UWRL 750-2932

Israelsen, C. Earl, Acting Director 750-3195

James, Douglas L., Director, UWRL, Associate Department Head, CEE 750-3168

Division Heads and/or Customer Liaisons

Anderson, Loren R., Geotechnical 750-2775

Jeppson, Roland W., Hydraulics 750-2943

Riley, J. Paul, Hydrology and Water Resources .. 750-2783

Sims, Ron C., Environmental Engineering 750-2926
or Michael J. McFarland 750-3196

Yener, Muzzaffer, Structures 750-2928

USU Foundation

Tullis, J. Paul 750-3164

Introduction

The Department of Civil and Environmental Engineering (CEE) and the Utah Water Research Laboratory (UWRL) have a symbiotic working relationship. The CEE Department provides the principal investigators with academic affiliation to the university while the UWRL provides faculty with a strong water research arena.

Both the CEE department and the UWRL have been involved in research and problem solving for government agencies and private industry.

Environmental Quality Facilities

The environmental quality laboratory (EQL) is divided among three laboratory sections: metals, organics, and nutrients and anions. Each of the sections is organized with a director (faculty or research scientist) and a section leader (research technician).

Internal quality control and standard operating procedures are followed in all analyses. The laboratory maintains performance certification with the U.S. EPA and the Utah Department of Health, Bureau of Laboratory Improvement.

The UWRL invests approximately $30,000 per year (not including equipment purchases) from state funds for laboratory facilities maintenance and operations management. This commitment assures the availability and continued operation of analytical capabilities as they are needed.

The UWRL's 11,000 sq. ft. EQL consists of chemistry, microbiology, and analytical instrumentation laboratories, constant temperature rooms, bioassay and research project areas, a refrigerated sample storage area, separate solvent and gas cylinder storage areas, and a loading dock.

We are evaluating the treatment of contaminated soils

Biological Hazardous Waste Management

Ronald C. Sims and Michael McFarland

We are evaluating aerobic composting to treat contaminated soil using white rot fungus *Phanerochaete chrysosporium*. The focus of our research is on treatment of soils impacted by industrial wastes, specifically those affected by wood preserving wastes used by petroleum agencies. The project is funded as part of the NIEHS Superfund program for cleaning up uncontrolled hazardous waste sites. (Sponsored by the NIEHS Superfund Research Program)

We will study the environment's ability to restore itself

Biotransformation Studies of Organic Chemicals

Ronald C. Sims and Michael J. McFarland

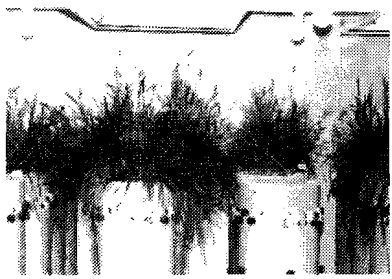
Using selected organic compounds associated with activities of the electric power industry, we will study biotransformation reactions and mechanisms. Results of the studies will be used to quantify rates of geochemical and microbial reactions involved in the release and transformation of the compounds in ground water and soils. Emphasis of the research will be on reactions that naturally convert organic compounds in the subsurface environment. We will conduct studies under both laboratory and field conditions. (Sponsored by the Electric Power Research Institute {EPRI})

Our models are used to determine the properties of organic substances

Environmental Contaminant Property Estimation
William J. Doucette, David K. Stevens, R. Ryan Dupont

This project will develop a microcomputer-based model to estimate physical-chemical properties of an organic compound and then predict its environmental fate, using the structure of the chemical and site characteristics. The system, utilizing Quantitative Structure Activity Relationships (QSARs), will estimate the following essential properties for modeling environmental transport and behavior: aqueous solubility (S), octanol/water partition coefficient (K_{ow}), vapor pressure (P_v), organic carbon normalized soil/water sorption coefficient (K_{oc}), and Henry's Law constants (H). (Sponsored by U.S. Air Force Office of Scientific Research)

Prairie grasses may remediate contaminated soil



Use of Plants for Stimulating PAH Degradation in Soil
Ronald C. Sims, James Herrick, Wayne Aprill

We are evaluating the use of deep-rooted prairie grasses to stimulate degradation and detoxification of toxic and recalcitrant organic chemicals at low soil concentrations. We expect to stimulate degradation through several proposed mechanisms, including: (1) increase in cometabolic potential through use of root exudates by microorganisms; (2) increase in contact between microbes associated with roots and toxic organic compounds associated with a contaminated soil; and (3) improvement of physical and chemical soil properties that affect the growth and activity of microorganisms. (Sponsored by Union Carbide Corporation)

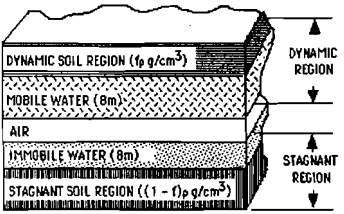
We are studying the potential of metal migration into the aquifer

Photographic Developer Waste Discharge Site Soils

Darwin L. Sorensen, Joan E. McLean

Silver, cadmium, chromium and lead from photographic emulsions and equipment cleaning processes were discharged onto soils at a northern Utah industrial complex. Presently, we are determining the potential for these metals to migrate from the discharge areas to the uppermost aquifer at the four contaminated sites. We are determining the concentrations of total, exchangeable, and carbonate associated metal. These data in combination with estimates of hydraulic leaching potential will be used to assess the potential for metals mobility. (Sponsored by Thiokol Corporation)

Our model evaluates the fate of hazardous substances



Vadose Zone Interactive Processes (VIP) Model

David K. Stevens, William J. Grenney, and Ronald C. Sims

The VIP model, an expansion of the RITZ model developed at the Robert S. Kerr Environmental Research Laboratory, provides a mathematical description of a land treatment system. It simulates vadose zone processes including volatilization, degradation, adsorption/desorption, advection, and dispersion. The model also takes into account site-specific parameters such as application rate and frequency, site temperature, degradation, and soil-water partition coefficients for chemicals as a function of soil depth. (Sponsored by the U.S. EPA)

Our integrated computer system will be used for analyzing environmental resources

Environmental Resources Analysis System

Thom Hardy

We will develop an integrated computer system for analyzing environmental resources. The system will incorporate decision support modules for project scoping, study design, evaluation personnel, resource significance, and evaluation elements. The analytical components will include models used to examine environmental resources in terrestrial, riparian, wetland, and aquatic habitats at the species, population, and community levels. It will provide tools for physical processes such as stream flow hydraulics, hydrology, and sediment transport. (Sponsored by the U.S. Army Corps of Engineers Waterways Experiment Station)

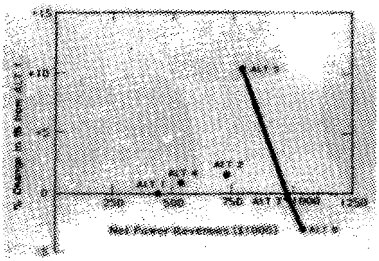
Our allocation model will be used to minimize impact on fisheries habitat in the Virgin River

Optimal Water Resource Allocations within the Virgin River

Thom Hardy

We will examine the multi-objective allocation problem associated with existing and proposed minimum instream flows for protecting endangered and threatened fish species in the main stem of the Virgin River. We will develop predictive models to assess optimal flow regimes which will maximize water storage, hydropower revenues, and municipal and agricultural water delivery schedules while minimizing impacts associated with altered flow regimes on the native fishes. The project will also involve field verification and validation of model predictions by evaluating the population responses of the fish community. (Sponsored by the Washington County Water Conservancy District, U.S. Fish and Wildlife Service, and Utah Division of Wildlife Resources)

Natural systems models for protecting fisheries habitat



Quantification of Instream Flows for Fisheries Habitat within the Snake River Basin

Thom Hardy

We are developing an integrated hydraulic modeling data base for over 1000 quantification sites on Idaho Forest Service lands. The system will be used in claiming federal reserved water rights as part of the Snake River Adjudication. A database system will be developed and implemented for existing hydraulic field data. These data will be used to calibrate hydraulic and fish habitat models for predicting historical, existing, and proposed flow regimes within each river. The data will provide a basis for quantifying reserved instream flows to protect or enhance fisheries habitat. (Sponsored by the U.S. Forest Service)

Hydraulics Facilities

The 50,000 square foot hydraulics laboratory contains a variety of flumes, channels, pumps, pipelines, equipment, and instrumentation for conducting hydraulics and fluid mechanics research, model studies, calibration, and testing. Flow is supplied to the models from a constant head tank, directly from the Logan River and Reservoir or from the pumps. Flow from the river and reservoir is supplied by gravity at rates up to 180 cfs through a 48-inch pipe to a flume that is eight feet wide, six feet deep, and 600-feet long.

Calibration facilities include a towing channel, weighing tanks, volumetric tanks, and a submerged jet tank. These can be used to test and calibrate instruments for velocity of discharge measurements. Each of the two weighing tanks is capable of weight measurements up to 30,000 pounds with an accuracy of plus or minus five pounds.

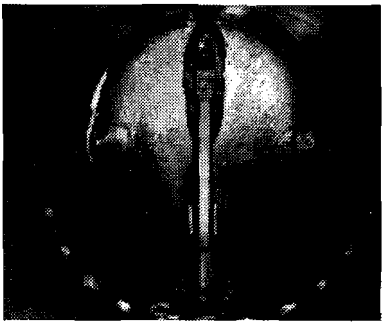
Piping configurations and valve setups of 100 feet long by 50 feet wide can be easily accommodated inside the laboratory. The upper section of the laboratory has a ceiling height of 20 feet while the height of the lower section exceeds 40 feet.

Rainfall Simulator. Since its construction in 1973, the rainfall simulator has been extensively tested and used in research. The rainfall simulator is a drip-type device in which individual raindrops are formed by water emitting from the ends of small-diameter brass needles. These needles form a horizontal plane to let water drip vertically toward a tilting flume which contains soil-filled test plots. It is possible to vary the flow in on-off positions with 31 increments, producing "rain" at rates of 1 to 31 inches per hour.

Tilting Test Flume. The test flume can be tilted hydraulically to any slope up to 43° from horizontal. The rainfall simulator is positioned over the flume so that the rain falls directly onto the soil in the test plots.

Sunlight Simulator. The sunlight simulator, consisting of incandescent and fluorescent lamps, provides the radiant energy needed for good plant growth.

Through cavitation research we identify and reduce cavitation problems

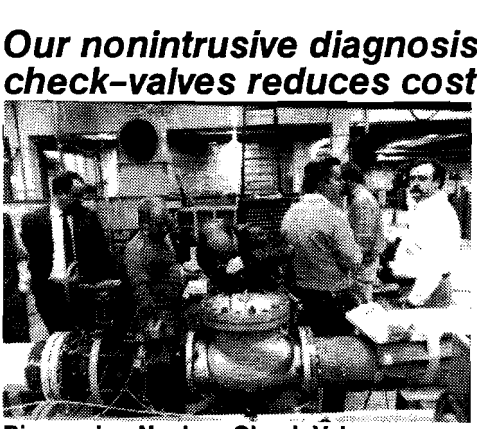


Cavitation Research

J. Paul Tullis, William J. Rahmeyer, Steven L. Barfuss

Valves, pumps, turbines, and hydraulic structures frequently experience severe structural damage because of cavitation. Through research at the UWRL, we investigate the problem of cavitation. (Sponsored by various engineering firms)

Our nonintrusive diagnosis of check-valves reduces costs

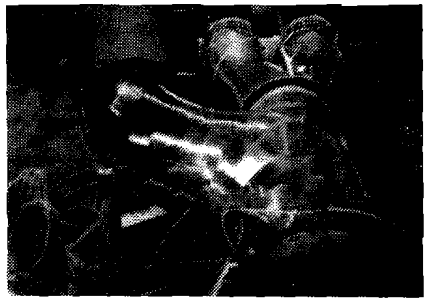


Diagnosing Nuclear Check Valves

J. Paul Tullis, William J. Rahmeyer, Steven L. Barfuss

Check valves have moving parts that wear out with time. In nuclear power plants it is very important to diagnose the condition of the check valves before they fail so that proper repairs can be made. Usually, this requires shutting down the plant so the valves may be physically opened to inspect their internal parts. Presently, we are investigating various nonintrusive diagnostic techniques to find out if we can evaluate the internal parts of the valve without actually opening it. For the EPRI project we tested 11 different types and sizes of check valves, up to 24-inch in diameter. (Sponsored by the Electric Power Research Institute)

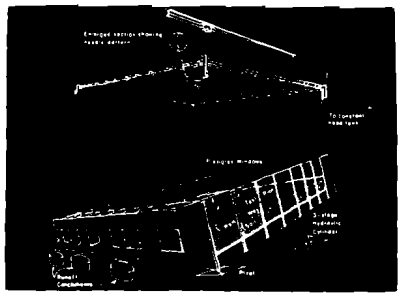
Model studies of hydraulic structures improve system performance while markedly reducing costs



Model Studies of Hydraulic Structures
J. Paul Tullis, William J. Rahmeyer, Steven L. Barfuss

In the design of most hydraulic structures, the use of a model study is important to verify or improve the hydraulic performance and the economics of the system. We contract with various companies to perform hydraulic model studies of dam spillways, outlet tunnels, energy dissipators, hydropower installations, pumping plants, etc. Improved performance of the system and the savings in cost far exceed the cost of the model study. (Sponsored by various engineering firms)

In our testing facilities, we evaluate erosion control products



Erosion Control Product Testing
C. Earl Israelsen, Gilberto E. Urroz

Our rainmaker is the only one of its kind in the world. It simulates the effects that various rain intensities would have upon erosion-control products, particularly on sloping land.

In our test flume, we evaluate products that will be used in channels where there is a high velocity of water flow (such as drainage channels and spillways). Through these tests we are able to evaluate materials that can be used in place of the more expensive rip rap and concrete lining. (Sponsored by various product manufacturers)

We are studying phosphate and nitrogen groundwater inputs to the Deer Creek Reservoir

Studies to Determine Phosphates and Nitrogen Groundwater Inputs to Deer Creek Reservoir

Roland W. Jeppson

Deer Creek Reservoir supplies approximately 65 percent of Salt Lake County's water. To maintain water quality and limit eutrophication, "best management practices" for surface waters have been implemented. Thus, the quality of surface streams flowing into the reservoir has significantly improved. However, recent data on phosphorus and nitrogen in ground water inflows are several times larger than predicted. Cleaning surface inflows by spreading treated sewage on land, retaining dairy wastes in lagoons, etc., may have merely delayed the arrival time of harmful chemicals which may be transmitted through groundwater recharge. (Sponsored by the Bureau of Water Pollution Control, Division of Environmental Health, State of Utah)

Our IOWE promotes national and international water education

The International Office for Water Education (IOWE) was organized in 1983. The major purpose of the IOWE is to promote water education through: development of comprehensive water education curricula; provision of effective in-service training for curricula users; promotion and implementation of adult water education programs; production and marketing of water education materials; provision of special services to individuals or groups that have water-related interests and needs; and development of a coordination and information resource center for state, national, and international water education programs and needs.

We provide short courses on computer-assisted floodplain hydrology

Computer-Assisted Floodplain Hydrology and Hydraulics

Daniel H. Hoggan

In two short courses emphasizing the HEC-1 and HEC-2 software systems, we have taught computer assisted floodplain hydrology and hydraulics. HEC-1 is used for floodplain and watershed hydrology computations, and HEC-2 is used for water surface profile computations. The courses provide in-depth training in the hydrologic techniques and principles and the hydraulic engineering techniques used in floodplain and watershed hydrology. (Sponsored by the UWRL, CEE Department, and the USU Conference and Institute Division)

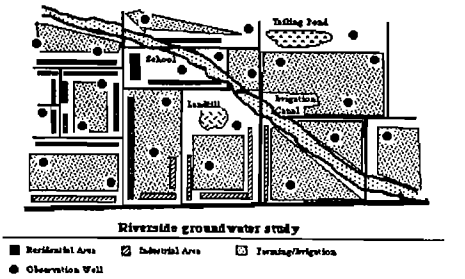
We are developing a numerical model within the framework of a geographic information system

Distributed Hydrologic Modeling using Digital Topographic and Geographic Data

David G. Tarboton

A research program in distributed hydrologic modeling is being initiated in which a numerical model will be developed within the framework of a geographic information system. The aim is to rely less on conceptual parameterization of hydrologic processes by incorporating more physical, spatially distributed data. Aside from the practical modeling, research will focus on understanding the spatial variability and scaling of hydrologic properties, particularly those relevant to runoff generation. This focus is important for proper integration of processes up to basin or general circulation model scale grids. (Sponsored by USU)

Our regression schemes will assess non-point source pollution

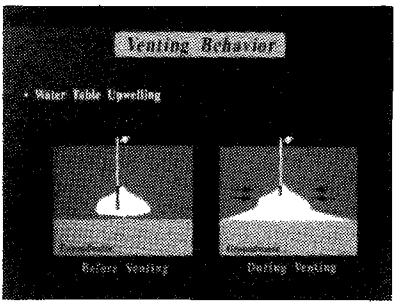


Non-point Source Ground Water Contamination

Upmanu Lall

Non-point source pollution is a widespread cause of poor ground water quality in Riverside, Utah. Robust nonparametric regression schemes are being developed to assess the extent and rates of non-point source pollution. These schemes will allow the use of contaminant concentration observations to: characterize the variability of ground water contaminant concentration over a study site, and describe the change in concentration across the site over time. The techniques developed should lead to a general foundation for the analysis of space-time random fields. (Sponsored by USGS)

Our expert system assists in the analysis of soil vapor extraction systems



Hyperventing: Expert System for Soil Vacuum Extraction

Marian W. Kemblowski

An expert system is being developed to assist in the analysis and design of soil vapor extraction systems for subsurface contamination of hydrocarbons. The system will take advantage of the menu-driven environment of Hypercard. In addition, a data base is being developed within the framework of the system which includes relevant hydrogeologic and chemical data, menu-driven computation software for relevant process simulation, a decision tree, and a graphical depiction of the behavior of important parameters in the venting system.

Risk assessment methodologies are being developed for national and international application

Risk Benefit Assessment
David S. Bowles

Research is being conducted to develop risk assessment methodologies, including dam safety improvements, hazardous waste site remedial action, and nuclear plant siting and design, for application nationally and internationally. Current research involves 1) risk/benefit assessment of flood mitigation alternatives for the Great Salt Lake; 2) assessment, such as liquefactions potential mapping, of various geological hazards; 3) development of risk assessment approaches for dam systems; 4) development of software for performing dam safety evaluation; and 5) development of a comprehensive framework for hazardous waste risk assessment. (Sponsored by the UWRL)

We developed a model to aid in water demand/supply planning

Wasatch Front Water Demand/Supply Planning Model
A. Bruce Bishop, Trevor Hughes, Herb Fullerton

The use of colored transparent electronic maps, geographic information systems (GIS), is being tested for its ability to spatially disaggregate water demand into many more categories than previously feasible. A model has been developed in which all assumptions are both visible and easily changeable by the user. In addition, a database for demand projections, including very disaggregated population estimates of both single and multiple family dwellings, has been developed. (Sponsored by the Utah Division of Water Resources)

We use modern computerized instrumentation systems to evaluate the performance of various soil-structure systems

Performance of Mechanically Stabilized Retaining Walls

Loren R. Anderson

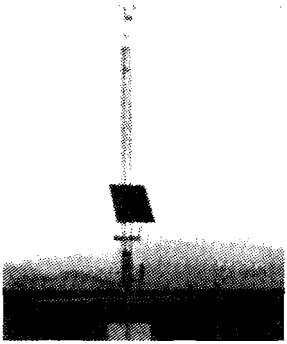
The Geotechnical Engineering Division has worked with two companies in private industry in evaluating the performance of Mechanically Stabilized Retaining Walls. Based on the evaluation of full sized test walls and on laboratory pullout tests, design methodologies for two different retaining wall systems have been developed. Modern computerized instrumentation systems were used to collect and analyze data in evaluating the performance of the full size test walls. The Geotechnical Engineering Division worked closely with the developers of these new wall systems. As a result, efficient and economically feasible systems were developed and are now in common use. (Sponsored by Hilfiker Company/Syro Steel Company)

We are improving laboratory testing procedures for evaluating freeze-thaw durability

Durability Testing of High-Strength Concrete
Derle Thorpe, Muzz Yener

This research will improve laboratory testing procedures for evaluating freeze-thaw durability and understanding the parameters that influence the durability of concretes containing high-range water-reducing (HRWR) admixtures. The objectives of this research have been to: 1) investigate the significance of various concrete properties, such as air-void characteristics and the durability of high strength concretes (compressive strength greater than 4,000 psi) that contain HRWR admixtures; and, 2) compare and assess the variability of durability factors calculated from various methods of testing concrete for freezing and thawing durability. (Sponsored by the National Cooperative Highway Research Program)

Our knowledge-based expert system is for transportation applications



Interfacing an Expert System with Remote Sensing for Transportation Applications
William J. Grenney, J. Paul Riley

The objective of this research is to improve the multi-million dollar annual effort for snow and ice removal from highways. Remote sensing equipment is being provided by Surface Systems, Inc., to monitor local meteorological conditions at a site on Highway 89 in Sardine Canyon. Researchers at Utah State University are developing a computer-based expert system to evaluate the real-time data and provide decision support for efficiently maintaining winter highway safety. The Civil and Environmental Engineering Department is leading the development of knowledge-based expert systems for transportation applications. (Sponsored by the Mountain-Plains Consortium/Utah Department of Transportation/SSI)

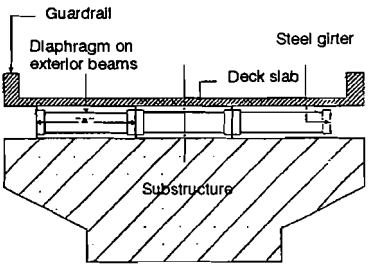
We are developing an expert system to aid in the design of earthquake-resistant buildings

Knowledge-Based Expert System for Earthquake-Resistant Building Design

Muzz Yener

We are developing an expert system for earthquake-resistant building design. The system will provide preliminary structural design of high-rise buildings in strong earthquake areas. It will advise what type of a structural system should be chosen, suggest an appropriate analysis method, provide information based upon a complex dynamic analysis procedure, and/or explain to users why some particular input is needed and how a particular solution was derived. The expert system and the analysis procedure will allow optimized design and realistic time-history response prediction of building structures under earthquake loading. (Sponsored by the Structural Engineering and Mechanics Division/Civil and Environmental Engineering)

We are predicting the design and response of bridge structures



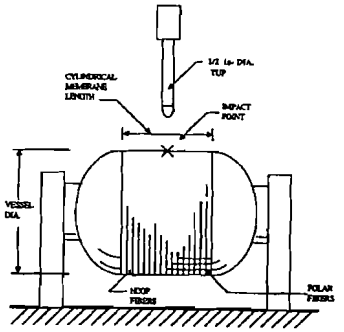
Cross-section of the bridge

Bridge Structures Optimum Design and Dynamic Response

Muzz Yener

We are developing a multi-level optimum design scheme for highway bridge systems. The structural response analysis of the scheme takes into account the dynamic interaction between the bridge and traversing vehicles under general traffic conditions. We use close idealization of the bridge and vehicles to predict the behavior of the structural system. Bridge response analysis is performed through the application of finite element analysis with numerical time integration methods. The design variables that will be used in the optimization scheme are the member sizes and geometric layout. Commonly used design constraints such as stress, displacement, and side constraints are considered as well as the terrain geometry within the boundaries of the bridge. The optimum design procedure is carried out through a multilevel optimization technique. (Sponsored by the Mountain-Plains Consortium/Utah Department of Transportation)

Computer model predicts progressive failure of composite structures



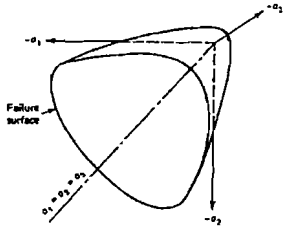
Typical bottle impact test setup (external hoop design)

Constitutive Modeling and Structural Response

Muzz Yener

We are developing a multi-purpose finite element program which is capable of predicting the progressive failure of composite structures subjected to static, dynamic, and thermal loadings, as well as solving instability and damage assessment problems. We have implemented the currently developed constitutive models and failure criteria into our nonlinear explicit finite element code, DACSIL, and have analyzed several benchmark problems. (Sponsored by Mineral Lease/Thiokol Corporation)

Our computer model provides implicit-explicit analysis of concrete structures



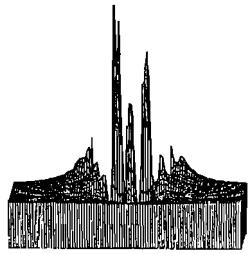
Schematic Representation of the Failure Surface of Concrete

Implicit-Explicit Finite Element Modeling

Muzz Yener

We are developing a finite-element-based, implicit-explicit predictive analysis technique that is primarily applicable to reinforced concrete structures which are subjected to dynamic and/or static loading. The study encompasses material and structural modeling. Our nonlinear finite element program is capable of progressive analysis, and it takes into account material and geometrical nonlinearities. Two post-fracture analysis schemes have been developed and implemented into the computer program. (Sponsored by the Structural Engineering & Mechanics Division/Civil & Environmental Engineering)

Our numerical procedure provides analysis of particulate-filled materials



Shelley's seven-inclusion problem

Microstructural Propellant Constitutive Theory

Muzz Yener

By using an analytical/numerical iterative procedure, we determined stress and strain concentrations in a three-dimensional matrix material that contained many densely packed spherical inclusions. Since this complex problem is solved in an "exact" manner, the solution procedure and results should be of utmost importance to mathematicians, physical and material scientists, engineers, and theoretical and applied mechanists. Our objective has been to devise an iterative procedure using orthogonal eigenfunction expansions of the Navier equation about each spherical particle in the pack. (Sponsored by Thiokol Corporation/U.S. Air Force)

We have developed a computer program for an undersea crossing

Finite element mesh of the circular liner and the ground mass

Progressive Finite Element Analysis of Underwater Tunnels

Muzz Yener

For the deep, circular, partially-lined underwater tunnel that has been proposed for the Strait of Gibraltar, we performed a finite element analysis, taking into account the behavior at the interface between the liner and the surrounding ground mass. To accomplish this objective, we implemented a thin-layer interface element into the finite element-based computer program. The loading condition used is a consequence of the consideration of a partially lined tunnel. This consideration results in the arching action phenomenon. The analysis results of a circular concrete tunnel compared favorably with those obtained in tests. (Sponsored by the Government of Morocco)