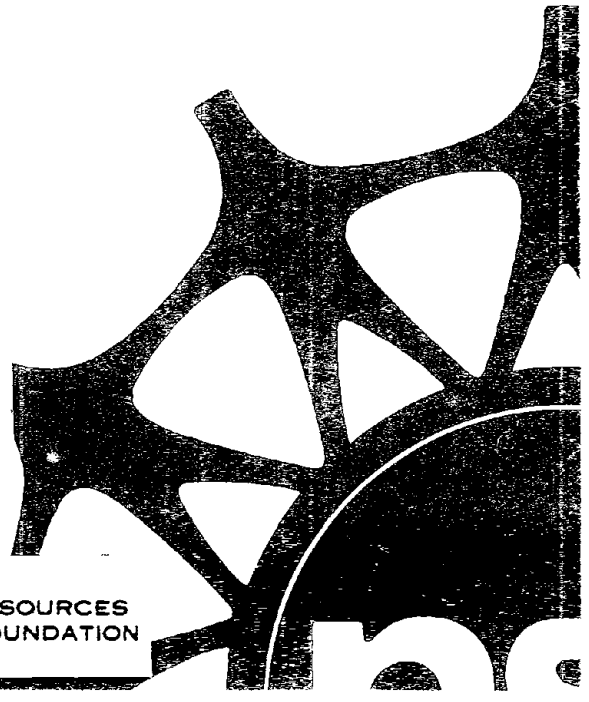
DIVISION OF PROBLEM-FOCUSED RESEARCH

SUMMARY OF AWARDS FISCAL YEAR 1979



NATIONAL SCIENCE FOUNDATION
Directorate for Engineering and
Applied Science
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Awards presented in each of the following areas of the Division of Problem-Focused Research are described: alternative biological sources of materials; chemical threats to man and the environment; community water management; earthquake hazards mitigation; human nutrition; and science and technology to aid the physically handicapped. The presentation format includes the title of the specific grant, the name and mailing address of the principal investigator, the institution conducting the research, and a summary of the project. Persons wishing to obtain information on project findings--including project reports, monographs, journal articles, technical reports, and other relevant materials--should write to the principal investigator at the grantee institution to determine what information is available and at what cost, if any, it may be obtained.

17. Document Analysis a. Descriptors

Hazards	Natural rubber	Contaminants	Biomass
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Physically handicapped	Technology	Toxins	
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INTRODUCTION TO THE DIVISION OF PROBLEM-FOCUSED RESEARCH (PRF)

NATIONAL SCIENCE FOUNDATION (NSF)

The goal of the Division of Problem-Focused Research (PFR) is to apply United States scientific and technological capabilities to selected problems of critical national importance in those instances where the absence of such application is clearly a barrier to problem clarification or resolution. Programs are structured around specific problems. The type and number of programs will change over time as new problems are selected and as ongoing programs are transferred or phased out. Each program supports a broad range of multidisciplinary basic and applied research as appropriate to the problem being addressed. Major attention is given to research utilization and participation of potential users of the practical results of the research supported. Problem-focused research is critical if discoveries in basic research are to be applied in clearly demonstrable, beneficial ways in the public interest.

The common objectives of the programs within the Division are to concentrate research on selected problem areas in order to:

- Facilitate the incorporation of science as a working tool for problem resolution in the public and private sectors;
- Provide support for problem-focused research that bridges from basic research discoveries to application; and,
- Enhance the capability and capacity of non-traditional research users to employ research results and methods.

PFR programs are organized by the development of a series of problem-related hypotheses and objectives which determine the nature of a problem, identify critical leverage points to be examined, and establish an end-point for the research. Each of the Problem-Focused Research programs has the following characteristics:

- It is an activity from which recognizable and generally measurable public benefits will accrue;
- It has wide geographical and social applicability;
- It requires the application of results from many scientific disciplines and professions;
- It intends to contribute to problem solution as well as to increase the depth or breadth of knowledge in any basic discipline; and,
- It provides results useful to the public and private sectors where disciplinary constraints, fragmentation, regulation or lack of market incentives inhibit research initiatives by others.

This *Summary* is organized by program. The PFR programs in FY 1979 were:

- Alternative Biological Sources of Materials
- Chemical Threats to Man and the Environment
- Community Water Management
- Earthquake Hazards Mitigation
- Human Nutrition
- Science and Technology to Aid the Physically Handicapped

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Deputy Division Director ..... Marvin E. Stephenson
Deputy Division Director for Social Sciences ..... James D. Cowhig
Staff Associate ..... Herman Harvey
Professional Assistant ..... Ramona M. Lauda
Administrative Assistant ..... Janice Apruzese

ALTERNATIVE BIOLOGICAL SOURCES OF MATERIALS

Program Managers ..... H.T. Huang
Oskar R. Zaborsky

CHEMICAL THREATS TO MAN AND THE ENVIRONMENT

Program Managers ..... Richard A. Carrigan
Farley Fisher

COMMUNITY WATER MANAGEMENT

Program Manager ..... Edward H. Bryan

EARTHQUAKE HAZARDS MITIGATION

Program Managers ..... William A. Anderson
Michael P. Gaus
William Hakala
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John B. Scalzi
Translator ..... Georgeann Vleck

HUMAN NUTRITION

Program Manager ..... William VanB. Robertson

SCIENCE AND TECHNOLOGY TO AID THE PHYSICALLY HANDICAPPED

Program Manager ..... Donald R. McNeal

DEFINITIONS

This publication contains brief summaries of the projects funded by PFR in Fiscal Year 1979. Projects selected for funding were subjected to peer review by the scientific community and by representative user groups to ensure their scientific merit and their relevance to program objectives. The Summary of Awards is organized by program. For each award, the problem area is described and an attempt to indicate how the research may help to solve the problem is made. An alphabetical listing of awards by Principal Investigator is included in Appendix A.

- 'Award' refers to financial support given in the form of a grant, contract, or other arrangement, depending upon the nature of the research work to be completed and the terms of performance.
- 'Effective Date' refers to the calendar date on which NSF funding of a research project becomes active.
- 'New' refers to an award which has received no prior support from NSF, regardless of whether the Principal Investigator has received support on previous occasions.
- 'Renewal' refers to follow-on support of a project which is currently supported.
- 'Supplement' refers to the addition of funds to an existing NSF-supported project without increasing the duration of NSF support.
- 'Principal Investigator' refers to the chief scientist or administrator who is responsible for coordinating the research plan and fiscal expenditures as an NSF-sponsored awardee.
- 'Institution' refers to any college, university, public or private laboratory, industry, or other organization, whether operating for profit or on a nonprofit basis, as well as State and local governments and Federal organizations.

Division-initiated funding actions excluded from this report are:

- Purchase Orders
- Funds for Personnel (Intergovernmental Personnel Act)
- International Travel Awards

ALTERNATIVE BIOLOGICAL SOURCES OF MATERIALS

The Alternative Biological Sources of Materials program deals with selected aspects of the problem of meeting the Nation's future needs for raw materials. By identifying or developing domestic biological sources of materials in the United States, this program hopes to alleviate our dependence on materials which can at present only be obtained from foreign sources. Program objectives include determining which biological sources constitute promising alternatives; developing biologically-based processes needed to convert the sources to useful materials; and, determining the socioeconomic, technical and environmental impacts of various proposed alternative biological systems on the country.

Three topics were selected for investigation in Fiscal Year 1979:

- Biological conversion of lignocellulosic materials to useful chemicals;
- Biological nitrogen fixation; and
- Production of rubber from the Guayule plant

The Regulation of Rubber Formation in Guayule (Parthenium argentatum) Plants; *Chauncey R. Benedict,* Texas A&M University, Department of Plant Sciences, College Station, TX 77843; $49,621 for 12 months beginning August 1, 1979.

Development of guayule *(Parthenium argentatum Gray)* as a domestic source of natural rubber is currently of considerable interest to the government. One of the characteristics of rubber accumulation in guayule is its cyclic nature. Rubber is not produced under the optimal growth conditions of summer, but is induced by exposure to low night temperatures of the fall and winter. The primary aim of this research is to identify the metabolic block to rubber synthesis and to characterize the biochemical control system operable in the cyclic synthesis of rubber. Success in this research will fill the gaps in our understanding of the regulation of rubber synthesis in non-lacticiferous rubber producing plants. Knowledge gained concerning the physiology and biochemistry of rubber synthesis in guayule will provide new leads to the enhancement of rubber yield under agronimic conditions.

Polysaccharide Production by Microalgae; *John R. Benemann,* Ecoenergetics Inc., 5619 Van Fleet Avenue, Berkeley, CA 94702; $24,696 for 6 months beginning October 1, 1979.

The mass cultivation of microalgae for production of fuels, protein, and wastewater treatment has received substantial attention. The technologies developed should have applications in the production of chemicals and polymers of industrial-commercial value.

This research addresses the production of polysaccharides from microalgal biomass produced on brackish waters. Microalgal polysaccharides of potential commercial interest will be identified, and their presence in sufficient quantities to allow commercial extraction will be demonstrated.

This research should lead to a process for developing microalgal polysaccharides as a new source of flocculants and emulsifiers of use in many practical applications, including tertiary oil recovery.

Mycorrhizae for Guayule and Jojoba Productivity; *H. Earl Bloss,* University of Arizona, Department of Plant Pathology, Tucson, AZ 85721; $30,674 for 12 months beginning March 15, 1979.

The development of guayule and jojoba as resource crops from marginal, semi-arid lands of the Southwestern United States is the focus of considerable governmental, scientific and commercial interest. Guayule is a potential domestic source of natural rubber while jojoba produces an oil similar to sperm whale oil. Research is underway to improve the productivity of both plants by breeding, selection, and appropriate horticultural and agronomic studies.

The use of mycorrhizal fungi to form symbiotic associations with plant roots offers another approach to improving the productivity of guayule and jojoba. Such associations are now practiced commercially with considerable success to increase crop yields. The mycorrhizae enhance the absorption by roots of key nutrients, e.g., phosphates and potassium. They would be particularly valuable for plants grown in marginal lands where heavy application of chemical fertilizers would be economically unattractive. Both guayule and jojoba in their native habitat have been shown to develop mycorrhizal associations. The objective of the research is to explore the use of induced mycorrhizal associations as a means to enhance the vigor and productivity of guayule and jojoba.

Two research tasks will be pursued. The first task will be to establish associations between guayule and jojoba and various strains of mycorrhizae. Young seedlings will be inoculated with mycorrhizal cultures, with and without plant growth hormones, and examined for evidence of symbiosis. The second task will be to select mycorrhizal associations capable of increasing the productivity of guayule and jojoba. Seedlings with healthy mycorrhizal associations will be transplanted to the field and their performance, in terms of survival rate and biomass production, evaluated. The most effective combinations will be tested further.

Enhancing Plant Productivity with Nitrogen-Fixing Bacteria; *Winston J. Brill,* University of Wisconsin-Madison, Department of Bacteriology, Madison, WI, 53706; $207,540 for 12 months beginning June 1, 1979.

The objective of this three year research project is to enhance plant productivity by coating the seeds of legumes with specific proteins which bind nitrogen-fixing bacteria to the roots of plants, and to construct and test by field application superior strains of such bacteria, both symbiotic and free-living, for use with legumes and cereals.

During this project's first two years, it was shown that specific protein-coated clover seeds gave no increased yield under field conditions. Use of superior mutants of *Rhizobium japonicum* led to yield improvement in tests conducted in areas where soybean had not been grown before, but not in areas previously exposed to soybean. This is presumably due to competition of indigenous *Rhizobium* populations. In this, the project's third year, coating of alfalfa and soybean seeds will be studied, and means to overcome the competition of indigenous organisms to super mutants in soybean will be developed and tested.

Bacterial Transformations of Lignin; *Ronald L. Crawford,* University of Minnesota, College of Biological Sciences, Minneapolis, MN 55455; $46,038 for 12 months beginning August 1,1979.

Lignin and cellulose are the two most abundant naturally-occurring organic materials on earth and represent potentially important industrial raw materials. In addition, disposal of lignocellulosic materials is becoming a major waste disposal problem. The objective of this project is to assess the effectiveness of bacteria for converting lignin in agricultural and forest-derived lignocellulosic materials to useful products. Specific objectives are to genetically modify lignin-degrading bacteria to produce catabolically blocked mutants, use the blocked mutants to map the catabolic pathways and produce novel lignin-containing compounds.

Water Use and Production Practices for Guayule; *Delmar D. Fangmeier;* University of Arizona, Department of Soils, Water and Engineering, Tucson, AZ 85721; $82,688 for 12 months beginning August 15, 1979.

This project involves three phases of guayule culture: establishment, growth and harvest; and evaluates the effectiveness of improved agronomic practices on the cultivation of guayule. Research concentrates on water requirement, stand establishment, herbicides usage, and harvest procedures.

Two field plots will be established in Arizona using both direct-seeding and transplantation. Direct-seeding studies will include various seed treatments and methods of seedbed preparation. Water will be delivered in measured quantities based on soil moisture content and plant needs. Both dryland and irrigated trials are included. Rubber yields will be monitored in plants from all treatments.

Enzymatic Transformations of Lignin; *Wolfgang G. Glasser,* Virginia Polytechnic Institute, Department of Chemistry, Blacksburg, VA 24061; $200,289 for 12 months beginning July 15, 1979.

Lignin constitutes a vast potential renewable resource base for producing chemicals and organic polymers, but its structural and chemical complexity has prevented effective utilization. Biotransformation of wood, including the lignin component, is accomplished naturally by microbes, and in this manner carbon is recycled. An alternative approach to conventional chemical processing of lignocellulosic materials is the use of enzymes or intact microorganisms.

The overall goal of this project is the development of enzymatic or microbial processes for the conversion of lignin to commercially valuable materials. Specifically, the objectives of this three-year project are to refine determinations of the chemical changes brought about in lignin by microorganisms in laboratory cultures or by cell-free lignin-transforming enzymes; to investigate the effect on lignin of enzymatically-generated reactive oxygen species; to explore alternatives to classical fermentation systems for lignin transformation; and to pursue actual utilization schemes for the microbially and enzymatically transformed lignins.

An Integrated Approach to the Conversion of Lignocellulose from Wood into Useful Chemicals; *Irving S. Goldstein,* North Carolina State University at Raleigh, Wood and Paper Science, Raleigh, NC 27607; $214,760 for 12 months beginning July 1, 1979.

This project studies the conversion of the wood components hemicellulose, cellulose, and lignin from low-quality southern hardwoods to useful chemicals in a systematic and integrated manner. Specific objectives include prehydrolysis of the hemicelluloses for optimum conversion to sugars, hydrolysis of cellulose to glucose with strong hydrochloric acid, conversion of lignin residues to low molecular weight phenoloc compounds, and preliminary process design of an integrated wood chemicals plant. Research focuses on the hydrogenation of lignin and a preliminary process design for the integrated system.

Workshop on Symbiotic Nitrogen Fixation in the Management of Temperate Forests; *John C. Gordon,* Oregon State University, Department of Forest Science, Corvallis, OR 97331; $25,315 for 12 months beginning December 1, 1978.

Nitrogen is the plant nutrient most frequently added to forest soils to increase productivity. Since the cost of nitrogen fertilizer has recently increased sharply, and future supplies may be limited, there is considerable interest in the alternative strategy of increasing the rate of fixation of nitrogen by forest plants.

The purpose of the workshop is to speed the adoption of this strategy by making recent fundamental research results more available to forestry researchers and managers, identifying research priorities and determining appropriate levels of effort, and aiding the formation of new groups of researchers to attack the problems of highest priority. The workshop will be held at Corvallis, Oregon on April 2-5, 1979. Invited

participants will discuss practical applications as well as the basic biology of nitrogen fixation in forest systems. The proceedings will be assembled into a state-of-the-art document on the role of symbiotic nitrogen fixation in temperate forest ecology and management.

Insecticidal Activity of Beauveria Bassiana; *Edward A. Grula,* Oklahoma State University, Department of Cell, Molecular and Developmental Biology, Stillwater, OK 74074; $0 for 12 months beginning September 1, 1979.

Experiments are being conducted to elucidate the mechanisms of infection of insect pests by the fungus *Beauveria bassiana.* This entomopathogenic fungus is used on crops in the USSR and in the People's Republic of China. Through the US/USSR Microbiology Program, a culture of *B. bassiana* has been brought to the US for study.

The specific objectives of this research are to elucidate the mechanism of penetration of the larval integument by growing hyphae, to determine the conditions for germination of fungal conidia, and to determine the growth requirements for the emergent hyphae on the surface of larvae.

Enzymatic Transformations of Lignin; *Philip L. Hall,* Virginia Polytechnic Institute, Department of Chemistry, Blacksburg, VA 24061; $40,625 for 12 months beginning November 7, 1978.

This award is a supplemental award to a current PFRA grant, and is for the purchase of a gas chromatograph and a high-pressure liquid chromatograph. Both instruments are critical analytical tools for determining the enzymatic degradation of lignin. Since the instruments are not available now for this project, the needed analytical services are secured externally. Other investigators and users have noted the analytical capabilities of the VPI group, especially their computer-assisted lignin analyses, and an increased need for better and faster determinations has arisen in order to respond to external requests for assistance. The supplement does not change the scope of the original project.

Chemical Stimulation of Rubber Synthesis in Guayule; *George P. Hanson,* California Arboretum Foundation, 301 North Baldwin Avenue, Arcadia, CA 91006; $65,825 for 12 months beginning May 1, 1979.

The objective of this project is to assess the feasibility of using chemical bioregulators to maximize yield and quality of rubber in guayule. During the past year, the stimulation of rubber synthesis by 2-(3, 4-dichlorophenoxy)-triethylamine has been confirmed by tests on 18-month old plants grown in the field. Several strains which respond well to chemical stimulation have been identified. Ten new potential bioregulators have been synthesized and are undergoing evaluation. The quality of the rubber produced under chemical stimulation was found to be unchanged and optimization of treatment parameters is in progress. These tasks, as well as determination of the composition of the resins, will be continued in this, the project's second year.

Breeding Improvement of Rubber Yield in Guayule; *George P. Hanson,* California Arboretum Foundation, 301 N. Baldwin Avenue, Arcadia, CA 91006; $144,056 for 12 months beginning April 1, 1979.

The objective of this project is to develop improved varieties of guayule to a point where guayule can be cultivated as a domestic source of natural rubber.

During the past two years, guayule seeds from the wild have been collected and germinated, crosses between exisitng varieties produced and planted, and horticultural procedures for transplanting seedlings developed and evaluated. Hybridization, selection and horticultural studies will continue, and improved varieties from preceding years will be identified and made available for agronomic evaluation.

Enhancement of Biological Nitrogen Fixation by Genetic Manipulation of Rhizobium; *Donald R. Helinski,* University of California-San Diego, Department of Biology, La Jolla, CA 92093; $110,871 for 12 months beginning June 1, 1979.

This award provides incremental funding for the second year of a 4-year continuing grant. The objective of the project is to enhance the nitrogen fixing ability of the bacterium *Rhizobium meliloti,* which forms a symbiotic relationship with alfalfa, by manipulating the genes of the bacterium.

During the first year of the project a broad host range plasmid suitable for use with *R. meliloti* has been constructed, and conditions for high frequency conjugal mating between *E. coli* and *R. meliloti* were established. In the second year, a gene bank of *R. meliloti* in *E. coli* will be constructed and attempts will be made to clone nitrogen fixing genes. A test system will be set up to evaluate the effect of *R. meliloti* hybrid plasmids on symbiosis with alfalfa.

Low Temperature Thermoconversion of Biomass to Useful Chemicals by Lewis Acid Catalysts; *Victor R. Koch,* EIC Corporation, 55 Chapel Street, Newton, MA 02158; $22,024 for 6 months beginning October 1, 1979.

The high price and uncertain availability of hydrocarbon feedstocks makes biomass attractive as a source of useful organic chemicals. Biomass may be converted to alcohols, ketones and acide with high selectivity but at low rates; thermoconversion of biomass proceeds at high rates but with no selectivity. The goal of this project is to convert biomass into useful organic chemicals at reasonable cost. Specific objectives are to confirm the presence of pyrone by spectroscopic techniques and elemental analysis; identify the threshold temperature for pyrone formation with $AlCl_3$, determine useful temperature range for pyrone generation; and assess pyrone yield as a function of temperature and amount of $AlCl_3$ catalyst.

A multifaceted Approach to Enhancing Biological Nitrogen Fixation; *Marvin Lamborg,* Chas. F. Kettering Foundation Research Laboratory, 150 E. South College Street, Yellow Springs, OH 45387; $175,954 for 12 months beginning July 15, 1979.

This award supports the second year of a 3-year continuing project. The goal of the project is to increase the capacity for nitrogen fixation of several living organisms and of the enzyme involved in the process through physiological and chemical manipulations.

During the first year of the project conditions for optimal growth of five *Azolla* species were identified, the acetylene reduction activity of eleven strains of *Rhizobia* evaluated, and a procedure for isolation of large amounts of the molybdenum-iron cofactor of nitrogenase worked out. In the second year studies on *Azolla* and *Rhizobia* will be continued, and extensive measurements made on the spectral, electro-chemical and catalytic properties of the Fe-Mo cofactor to provide leads to improve the nitrogen fixing activity of these systems.

Enhancing Biological Production of Ammonia from Atmospheric Nitrogen and Soil Nitrate; *James M. Lyons,* University of California-Davis, College of Agricultural and Environmental Sciences, Davis, CA 95616; $91,021 for 12 months beginning June 15, 1979.

The four major objectives of this multidisciplinary project are to: (1) enhance nitrogen fixation in bacteria by genetic manipulation; (2) increase the efficiency of symbiotic nitrogen fixation in legumes; (3) evaluate the potential for supplying nitrogen to rice crops through the *Azolla/Anabaena* symbiotic system; and (4) increase the efficiency of conversion of nitrate to ammonia in soil bacteria and in crop plants.

During this, the project's second year, research will include: (1) the recognition that hydrogen uptake in *Rhizobia* is genetically controlled by a plasmid, (2) the identification of cyclic mononucleotides as regulators of nitrogen fixation by root nodule bacteria, (3) the

demonstration that superior mutants of *Rhizobia* can increase total productivity of soy plants, (4) continued optimization of Azolla propagation as a source of nitrogen for rice plants, and (5) the isolation of bacteria which convert nitrate to ammonia under anaerobic conditions. These studies will be continued, expanded and extended to field experiments where appropriate during the third year of the project.

New Polymers Based on Industrial Oils from Renewable Resources; *John A. Manson,* Lehigh University, Materials Research Center, Bethlehem, PA 18015; $64,625 for 12 months beginning May 15, 1979.

Organic chemicals and polymers, essential to the functioning of the U.S. society, are presently derived largely from petroleum. Alternative sources need to be examined. One possibility is the use of plant-derived materials for the production of the necessary chemicals, polymers, plastics, solvents, and intermediates. The goal of this research project is to investigate and develop prototype new polymers based on renewable agricultural resources, namely, industrial-type oils derived from non-edible oil-seeds. Emphasis be placed on oil-seeds from current or potential cultivars that are adaptable to growth in regions not suitable for other crops.

This research will evaluate the most appropriate natural oils in terms of versatility for chemical reactions, present and potential availability, and cost. Oils to be considered include drying oils such as tung, linseed and soybean, as well as oils from cultivars such as *Limnanthes* and *Lesquerella.* Emphasis is to be placed on oils that are primarily of industrial rather than nutritional interest. Rubber-like products will be synthesized from the natural oils selected, and their physical and chemical properties characterized. These natural oils will be compared with glassy and brittle polymers such as polystyrene to form interpenetrating polymer networks. The cost-effectiveness of these new materials will be characterized in a preliminary manner.

Nitrogen Fixation with Photosynthetic Marine Microorganisms; *Akira Mitsui,* University of Miami, Department of Biology and Living Resources, Miami, FL 33124; $117,983 for 12 months beginning January 19, 1979.

This project is to survey photosynthetic marine microorganisms for enhanced nitrogen fixation. The research plan for the three-year project consists of collecting microorganisms from tropical marine environments, isolating nitrogen-fixing species, assessing the production potential of isolates, and evaluating the use of these microbes as a source of food and fertilizer. Research for this period focuses on assessing the production potential of nitrogen-fixing isolates and the use of these microbes as a source of food for aquacultural purposes.

Production of Hydrogen by Marine Blue-Green Algae; *Akira Mitsui,* University of Miami, School of Marine and Atmospheric Science, Miami, FL 33124; $162,897 for 12 months beginning June 15, 1979.

The objectives of this research are to characterize promising species of marine blue-green algae which produce hydrogen gas, and to optimize this biological activity in the microbes by environmental (physiological) means. Research for this award period will focus on enhancing and stabilizing hydrogen production and developing small-scale reactor systems.

Development of Tissue Culture Systems for Guayule; *Toshio Murashige,* University of California-Riverside, Department of Botany and Plant Sciences, Riverside, CA 92521; $72,484 for 12 months beginning December 15, 1978.

Development of guayule *(Parthenium argentatum Gray)* as a domestic source of natural rubber is currently the focus of considerable governmental, scientific and commercial interest. Plant breeding research is perhaps the most important phase in the development of guayule as a commercial source of natural rubber.

This award is aimed at developing tissue culture

systems for guayule which can be used to enhance the efficiency of plant breeding programs. The proposed research will pursue three tasks.

Cell culture will develop a flexible breeding system including callus cultures, suspension cultures, and a method of attaining single cell clones. Plant regeneration will regenerate whole plants from cell cultures by appropriate manipulation of cultural conditions. Anther and pollen culture will achieve haploid cell cultures and regenerate them to homozygous plants.

Experimental Macro-Algal Mariculture; *Michael Neushul,* Neushul Mariculture Inc., 244 Vereda Galeria, Goleta, CA 93017; $335,207 for 24 months beginning July 1, 1979.

Organic chemicals and polymers are presently derived largely from petroleum. As fossil resources become scarcer, alternative organic resources and end-use products derived from these raw materials need to be examined. One possibility is to use marine plants for the production of essential chemicals, intermediates, and polymers.

The goal of this project is to cultivate selected species of marine algae suitable for deriving useful algal gums. In particular, the research will establish small-scale, near-shore, mariculture systems for the marine plants *Gelidium, Eucheuma* and *Macrocystis,* which produce agar, carrageenan, and algin. The research consists of preparing mariculture sites with anchored substrates, producing algal seed stock, propagating selected algae, seeding the substrates, applying required fertilizers, and obtaining essential growth and yield data. The optimum growth conditions for near-shore, marine plant farms capable of producing polymeric chemicals are to be determined.

Isolation of Lignocellulose-Transforming Microorganisms; *Dale M. Norris,* University of Wisconsin, Department of Entomology, Madison, WI 53706; $112,678 for 12 months beginning January 19, 1979.

Cellulose and lignin are the two most abundant naturally occurring organic materials on earth. They are presently used for a variety of purposes. These organic materials represent potentially important sources of industrial materials if efficient processes for converting them can be developed.

Such a possibility exists with biological systems based on lignocellulose-transforming microorganisms. The objectives of this three-year project are to isolate symbiotic lignocellulose-transforming microbes from wood-degrading insects and to characterize the transformations of lignin with the free-living microbes. Research for this period focuses on optimizing the culture conditions for the microbial transformations of lignin and investigating the animal feeding stimulant activity of the resultant products.

The Conversion of Agricultural By-Products to Sugars; *Peter J. Reilly,* Iowa State University of Science and Technology, Department of Chemical Engineering and Nuclear Engineering, Ames, IA 50010; $124,100 for 12 months beginning March 15, 1979.

This research assesses the feasibility of converting xylan (the predominant hemicellulose in grasses, cereal grains, and hardwoods) into xylose and other sugars. Specifically, the major objectives are to isolate and purify the xylanase enzymes involved in xylan hydrolysis; to characterize the individual enzymes in terms of the operational characteristics of stability, specificity, and kinetic properties; and to assess the feasibility of using an ultrafiltration enzyme reactor for converting corn cob and corn hull xylan to useful sugars.

Toxicological Studies on Guayule; *Eloy Rodriguez,* University of California-Irvine, Department of Ecology and Evolutionary Biology, Irvine, CA 92717; $53,329 for 12 months beginning February 15, 1979.

Development of guayule *(Parthenium argentatum Gray)* as a domestic source of natural rubber is currently the focus of considerable governmental, scientific and commercial interest. However, many Parthenium species have been shown to cause allergic skin reactions in humans. It is therefore prudent to ques-

tion whether guayule is a potential allergen before it is grown and processed on a large scale.

This project will test leaf and stem extracts of guayule, as well as refined fractions derived from them, by a standard skin sensitization test with guinea pigs. Fractions which induce a positive reaction will be analyzed further to isolate and identify the active components.

Natural Rubber From Guayule: Genetics, Cytogenetics and Breeding; *David D. Rubis,* University of Arizona, Department of Plant Sciences, Tucson, AZ 85721; $100,318 for 12 months beginning August 15, 1979.

This project involves research in genetics, cytogenetics and plant breeding of guayule *(Parthenium argentatum)* as a domestic source of natural rubber. The germplasm collection includes *P. incanum, P. confertum, P. hysterophorus, P. fruticosum, P. tomentosum* and *P. stromonium* as well as *P. argentatum.* Interspecific crosses will be made between guayule and each of the other species. Important characteristics such as cold tolerance and vigorous growth obtained from these crosses will be transferred to guayule by backcrossing.

The basic breeding behavior of guayule and related species will be studied in order to develop techniques of breeding for variety improvement. Polyhaploids (36 chromosomes) will be used in crosses to develop true breeding F_1 tetraploids. Effects of temperature, daylength and light intensity will be studied in order to make crosses all seasons of the year.

Chemicals from Western Hardwoods and Agricultural Residues; *Kyosti V. Sarkanen,* University of Washington, Department of Chemical Engineering, Seattle, WA 98195; $124,375 for 12 months beginning November 2, 1978 (AO1). $92,495 for 9 months beginning October 1, 1979 (AO3).

This research assesses the potential use of hardwoods and agricultural residues for the production of chemicals. Specific objectives are to: (a) characterize the essential properties of cellulose, hemicellulose, lignin and extractive components of red alder wood and wheat straw; (b) examine novel methods for converting red alder wood and wheat straw to fibrous products in combination with by-product recovery; and (c) convert the lignin and carbohydrate by-products to chemicals using microwave degradation. Research for this award period focuses on organic solvent separations of hardwood components and the characterizations of derived lignins.

Capturing the Sun through Bioconversion — Conference II; *Peter Schauffler,* Bio-Energy Council, Suite 204, 1337 Connecticut Avenue, N.W., Washington, DC 20036; $25,000 for 24 months beginning July 15, 1979.

This award provides additional support for the Bio-Energy '80 Conference to be held in Atlanta, Georgia, on April 21-24, 1980. Both the Department of Agriculture and the Department of Commerce (National Oceanic and Atmospheric Administration) are contributing supplemental support for the conduct of this conference. The conference focuses on biomass sources, conversion processes and products.

Investigation of Sagebrush as a Major Biological Source of Materials; *Fred Shafizadeh,* University of Montana, Department of Chemistry, Missoula, MT 59801; $83,521 for 24 months beginning September 15, 1979.

Sagebrush is a group of shrubby plants endemic to the semi-arid regions of the western United States. Sagebrush covers millions of acres of land in eleven states and produces several tons of biomass per acre per year. However, sagebrush is considered a weed, since it competes with grasses and other forage plants in its natural habitat.

The objective of this research is to investigate means for producing useful chemicals, industrial feedstocks, animal feed and other materials from sagebrush, and to determine the potential market for these products.

Regeneration, Selection and Evaluation of Plants from Protoplasts of Potato; *James F. Shepard,* Kansas State University, Department of Plant Pathology, Manhattan, KS 66506; $100,000 for 12 months beginning January 24, 1979.

The objective of this three-year continuing project is to develop the technology by which mutants of potato leaf protoplasts with certain desirable characteristics can be created, selected and regenerated into useful cultivars of potato.

During the first year of the project the efficiency of regeneration of plants from protoplasts has been raised from 20-30% to 70-80%. Protoplasts resistant to fungal toxins have been regenerated and grown in the field to yield plants which are resistant to early-blight disease. In the second year, emphasis will be on the generation of strains resistant to virus and fungal infections.

Jojoba Meal as a Livestock Feed; *Anthony J. Verbiscar,* Anver Biosceince Design, Inc., 160 E. Montecito Avenue, Sierra Madre, CA 91024; $128,371 for 12 months beginning December 1, 1979.

The objective of this research is to develop a practical low-cost procedure to detoxify jojoba meal so that it can be used as an ingredient in livestock feed. The research will complete evaluation of practical processes to detoxify jojoba meal, isolate and identify its two minor toxicants, prepare large quantities of detoxified meal, and demonstrate the efficacy of detoxified meal as feed for cattle, sheep and poultry.

It is expected that in about five years, as jojoba plantations mature and begin to bear fruit, a practical procedure to detoxify the meal so as to render it suitable for animal feed will become an important factor in determining the economic feasibility of this new agri-industry.

Herbicides for Weed Control in Guayule Plantations and Their Influence on Rubber Yields; *J. W. Whitworth,* New Mexico State University, Department of Agronomy, Las Cruces, NM 88003; $45,806 for 12 months beginning June 1, 1979.

Weed control is one of the most expensive operations in the growing of guayule. Stove oil and naptha substances effectively controlled small seedling grasses and susceptible broadleaved weeds, but the margin of selectivity on guayule was very narrow, and many weeds were resistant at any stage. Tentative solutions to these problems were indicated in preliminary testing of some newer herbicides. With increased availability of more plant material and guayule seeds, many of the more than 156 newer type herbicides, alone and in combination, will be investigated for season-long control of weeds. Preliminary screening in the greenhouse will establish the influence of various herbicides on growth and development of roots and foliage of guayule as well as on survival. The more promising herbicides will be field tested on both direct seeded and transplanted guayule. Since many of the herbicides have growth regulator activity, their positive or negative effect on the deposition and yield of rubber will be investigated along with total yield of shrub.

Bioconversion of Biomass Gasifier Product Gases to Organic Chemicals; *Donald L. Wise,* Dynatech Corporation, Biochemical Engineering, 99 Erie Street, Cambridge, MA 02139; $166,706 for 18 months beginning November 1, 1978.

The prevailing popular approach to the biological conversion of biomass to chemicals is to enzymatically hydrolyze the raw materials to sugars which are then fermented to a variety of useful chemical products. This award will investigate an alternative approach, which is to gasify the biomass and then convert the resulting gases (CO, CO_2, and H_2) to organic chemicals by anaerobic fermentation. The proposed research will pursue four tasks.

Microbial cultures which convert CO, CO_2, and H_2 to useful chemicals will be selected and isolated. These cultures will be identified and characterized. The

range of products formed under varying environmental conditions will be determined. Results will be validated in laboratory scale fermentors. The end result of this research will be an understanding of the necessary operational parameters for determining ultimate commercial utilization of this bioconversion process for efficient use of renewable biomass.

Development of Superior Cultivars of Jojoba; *Demetrios M. Yermanos,* University of California-Riverside, Department of Plant Sciences, Riverside, CA 92521; $102,545 for 12 months beginning October 1, 1979.

The objective of this project is to develop superior cultivars of jojoba, a potential crop for the arid lands of Southwestern U.S. and northern Mexico.

During the first year of this project, seeds with high oil content were selected through a non-destructive nuclear magnetic resonance procedure, planted in breeding nurseries, cytological studies initiated, and whole plants regenerated from stem terminal explants. In the second year these studies will be continued to develop and identify new cultivars with agronomically superior qualities.

Biological Systems for Lignocellulose Conversion; *J. G. Zeikus,* University of Wisconsin-Madison, Department of Bacteriology, Madison, WI 53706; $98,690 for 12 months beginning August 15, 1979.

Cellulose and lignin are abundant renewable resources. Biological conversion of these substrates to chemicals and materials is attractive because of low conventional energy requirements, high efficiency, and environmental acceptability.

The objective of this project is to convert cellulose and lignin to useful materials by biological means and to define the rate limiting steps. The organisms to be used are *Phanerochaete chrysosporium* and *Clostridium thermocellum.* Specifically, *p. chrysosporium* is to be used to optimize delignification of wood and the production of useful low molecular weight aromatic chemicals. *C. thermocellum* cellulase is to be used to optimize saccharification of delignified wood to readily utilizable sugars such as glucose. Conversion of cellulosic matter to high yields of ethanol or acetic acid is to be evaluated in mono- and co-culture fermentations with *C. thermocellum.*

CHEMICAL THREATS TO MAN AND THE ENVIRONMENT

The Chemical Threats to Man and the Environment program element supports research to increase our scientific knowledge of man-made contaminants and naturally occurring toxicants and to make this knowledge available to appropriate users. Because of their numbers and the complexity of their interactions with the environment, most of the many thousands of chemicals that are released to the environment in an industrialized society cannot receive detailed attention. The scientific community, industry, and the Federal and State agencies need a broadened base of scientific knowledge to help identify the problem chemicals from among these thousands. Such knowledge forms the necessary basis for considering regulatory questions, or better yet, for managing potential contaminant effects without resort to regulation. The ultimate goal of this program of research is to harmonize the protection of environmental quality with society's requirement for essential chemical products.

This program was discontinued on October 1, 1979.

Research on a Rapid and Simple Detection Method for Asbestos; *Fred R. Albright,* Lancaster Laboratories, Inc., 2425 New Holland Pike, Lancaster, PA 17601; $21,210 for 6 months beginning October 1, 1979.

Occupationally related diseases are of great concern in our industrial society. Data on cancer and respiratory diseases suggest asbestos as a causative agent. This project addresses the need for a reliable, simple method of detecting asbestos fibers in the environment.

Current analytical methods for asbestos possess inherent limitations, including lengthy analysis time, sophisticated and expensive instrumentation, inability to resolve or confirm the identity of fibers, and deficient analytical sensitivity. This research project studies the surface-chemical reactivity to fluorescent binding agents of several types of asbestos. Goals are to achieve a novel means of enhancing the detection of asbestos through greater specificity in identifying fibrils among non-asbestiform residues, and to reduce analysis time and expense.

A Water Pollution Monitoring Laser System; *Silverio P. Almeida,* Virginia Polytechnic Institute, Department of Physics, Blacksburg, VA 24061; $103,607 for 12 months beginning March 1, 1979.

An important indicator of the quality of a water body is its population of diatom species. Diatom species can be identified and counted manually using a microscope, but this technique is subjective, expensive for large numbers of samples, and too slow for detection of rapidly changing conditions. The object of this research is to develop and test a system for the automatic assay of various diatom species in water samples.

Diatoms are observed under a microscope with illumination from the coherent light of a low-power laser. The microscope produces a real, magnified, coherent image of the specimen. The image plane is followed by two successive Fourier transform (FT) planes. In the first FT plane, low and high frequency spatial filters are used as preprocessing filters to enhance image quality. The enhanced signal is reimaged to the second FT plane, which contains a matched spatial filter used for specimen identification. On-line computer processing evaluates the match between the specimen and spatial filter. Work will be directed to the optimization and testing of the system for its capability to perform on-line operation under simulated and real biomonitoring conditions in which mixed populations of diatoms are present.

Field Studies of Biologically Produced Atmospheric Sulfur Compounds; *Alan R. Bandy,* Drexel University, Department of Chemistry, Philadelphia, PA 19104; $127,052 for 12 months beginning March 6, 1979.

Worldwide emissions of volatile sulfur compounds of biogenic origin are commonly believed to exceed the total flux of sulfur dioxide released to the atmosphere as a result of human activities. Unlike anthropogenic sources, which emit mostly sulfur dioxide, biogenic sources are believed to contribute hydrogen sulfide, dimenthyl sulfide, and minor amounts of other sulfur compounds. Like sulfur dioxide, the latter sulfur carriers seem likely to oxidize in the air to form sulfuric acid or other particulate sulfates. These sulfate forms are believed to be hazardous to human health.

This project questions whether the biogenic emissions believed to be dominant on the global scale are also significant for the production of airborne sulfate particulates in regions affected by anthropogenic sources of sulfur dioxide such as coal- or oil-burning plants. The research will be done by gas-chromatographic analysis of estuarine waters and the overlaying air in a pristine area (Wallops Island, Virginia). Samples will be analyzed for hydrogen sulfide, sulfur dioxide, methyl mercaptan, dimethyl sulfide, carbon disulfide, and carbonyl sulfide. Meteorological observations will be made as aids to the identification of sources. Surface emission rates will be estimated by model calculations based on wind velocities and air analyses at different elevations.

Investigation of Water-Borne Cancer Hazards Associated With the Buffalo River Environment; *John J. Black,* Health Research, Inc., 666 Elm Street, Buffalo, NY 14263; $170,000 for 30 months beginning May 1, 1979.

Preliminary studies of the Buffalo River and adjacent Black Rock Ship Canal and the Niagara River have indicated a complex mixture of contaminant organic chemicals in bottom sediments. Several species of bottom feeding fishes collected from these areas exhibit specific neoplasms that appear to result from chronic exposure to the contaminated sediments. The sediments contain carcinogens/-mutagens as evidenced by positive Ames test results and high pressure liquid chromatography studies, lending strong support to this hypothesis.

This hypothesis will be directly tested by exposing the appropriate species of fish to a concentrated extract (organic solvent) derived from a composite bottom sediment sample. The objective of these experiments will be to produce tissue lesions identical to those observed in the feral fish populations. Fish to be studied include sheepshead (drum), white sucker, and brown bullhead. In addition to the carcinogenesis testing in fish, data concerning the levels of aromatic hydrocarbon contaminants in fish and bottom sediments collected from this aquatic ecosystem will also be sought.

Natural and Fertilizer-Induced Emissions of Nitrous Oxide from Soils; *John M. Bremner,* Iowa State University of Science and Technology, Department of Agronomy, Ames, IA 50010; $110,195 for 12 months beginning February 15, 1979.

Recent research has suggested that increased use of nitrogen fertilizers to aid food production may increase release of nitrous oxide from soils to the atmosphere and may thereby promote destruction of the stratospheric ozone layer. The primary purpose of this project is to obtain information needed to assess this risk and to study the processes responsible for emission of nitrous oxide from soils.

Emissions of nitrous oxide from unfertilized and fertilized soils will be measured in field and laboratory studies, and factors affecting release of nitrous oxide from soils through denitrification and nitrification of fertilizer nitrogen will be investigated. The soils selected for study will include diverse types, and measurements of nitrous oxide emissions will be performed under a wide variety of field conditions. Nitrous oxide will be determined by a gas chromatographic procedure that involves use of an ultrasonic detector and permits use of the xenon in air as an internal standard. The work will include a critical evaluation of methods available for nitrous oxide analysis of air and for field measurements of nitrous oxide emissions from soils. The mechanism of nitrous oxide production during nitrification of

ammonium and ammonium-yielding fertilizers in soils will be studied, and an attempt will be made to determine if nitrous oxide is an obligatory intermediate in reduction of nitrate to nitrogen by soil microorganisms.

Quantitative Electron Microprobe Analysis of Individual Airborne Particles; *Peter R. Buseck,* Airzona State University, Department of Chemistry and Geology, Tempe, AZ 85281; $148,868 for 14 months beginning April 1, 1979.

The goal of the research is to determine the chemical composition of individual submicron airborne particles, and to relate this composition to sources and to the chemical and physical transformation processes these particles undergo. The research is designed to: refine correction procedures developed by this group for the analysis of single particles by X-ray analysis by energy-dispersive and wavelength-dispersive methods using the electron microprobe; characterize by composition, size, and morphology the respirable particles from Phoenix ambient aerosol samples; characterize the aerosols from two major copper smelters; identify area emission sources by comparison of individual particle analysis from ambient and source samples; investigate the nature and extent of particle coating and agglomeration; and explore the capabilities of the scanning transmission electron microscope for submicron particle analysis.

Microbial Biodegradation of Synthetic Environmental Pollutants; *Ananda M. Chakrabarty,* University of Illinois at the Medical Center, Chicago, IL 60680; $151,718 for 24 months beginning August 1, 1979.

The release of synthetic halogenated hydrocarbons in the form of refrigerants, dielectric fluids, flame retardants, herbicides and pesticides to the environment has resulted in death and disability to many biological organisms. It appears that the ability of microorganisms to detoxify pollutants is restricted because of the absence of appropriate genetic competence for their complete biodegradation in a single culture. Yet, characterization of facultative anaerobes from the Hudson River sediments points to the evolution of PCB bioconversion competence in the form of plasmids in members of the family *Enterobacteriaceae.* Similarly, examinaton of soil microflora has demonstrated the occurence of a 2, 4-D plasmid in *Alcaligenes paradoxus.*

This project seeks to isolate and characterize various microorganisms, from soil and river sediments as acrobic and facultative anaerobic cultures, and to examine the evolution of degradative competence against synthetic chlorinated hydrocarbons and various herbicides and pesticides. The evolution of a 2, 4-D plasmid in a soil bacterium species makes it likely that similar pathways for the partial or complete biodegradation of other chlorinated hydrocarbons may be evolving in various microorganisms. A study of the molecular mechanisms involved in the emergence of such biodegrative functions should be extremely useful in constructing multiplasmis strains that may develop capabilities for rapid and complete degradation of hazardous environmental pollutants.

Studies on the Metabolism of Ochratoxin A and Citrinin; *Fun Sun Chu,* University of Wisconsin-Madison, Food Research Institute, Madison, WI 53706; $135,437 for 36 months beginning March 15, 1979.

Ochratoxins and citrinin are a group of nephrotoxic dihydroisocoumarins produced by a number of fungi in the genera *Aspergillus* and *Penicillium.* The metabolism of this series of toxins in animals will be studied. The objectives of this research are to elucidate the mechanism of the toxic effect of these mycotoxins through metabolic studies in animals, and to determine whether such mycotoxins and their metabolites accumulate in meat, milk, organs and tissues of food-producing animals which have consumed mycotoxin-contaminated feed.

Radioactive mycotoxins will be fed to rats, chickens, goats and monkeys. The kinetics of accumulation of toxin and its metabolites in urine, serum, milk and different organs will be determined. Major metabolites will be purified by different

chromatographic methods. Toxicity of the new metabolites will be determined by chicken embryo, day-old chicks, and Ames' tests. Kinetics of metabolism and binding of toxin and/or metabolites with cellular macromolecules and organelles of liver and kidney will be compared using young and adult rats and also chickens of resistant and susceptible species. In addition, the kinetics of metabolism of the toxin by liver (and kidney) microsomes or homogenates of different animal species will be compared *in vitro*. For elucidation of the mode of action of ochratoxins, correlations among the kinetics of metabolism, the degree of binding, and the toxicity (LD_{50}) of the mycotoxin(s) of these experiments will be determined.

Soils as a Source or Sink of Atmospheric Nitrous Oxide; *John M. Duxbury,* Cornell University, Department of Agronomy, Ithaca, NY 14850; $114,145 for 12 months beginning August 15, 1979.

Nitrous oxide has a role in the stratospheric ozone cycle. Nitrous oxide is produced in soil during the normal nitrogen cycle, and it may be that modern agricultural methods sharply increase nitrous oxide production, thereby upsetting the natural balance. This project is designed to test this hypothesis by measuring nitrous oxide fluxes across the soil-atmosphere interface and the fluxes of nitrous oxide and nitrate nitrogen in drainage water at selected agricultural and non-agricultural sites, and by determining the conditions under which soils act as a source or a sink of atmospheric nitrous oxide. The sites to be studied include mineral soils in central New York State and organic soils in western New York State and southern Florida. Both fallow and cropped land with various fertilization treatments will be studied. Field work will be supplemented by laboratory studies to characterize the phenomena observed.

The Chemistry of N-Nitroso Compounds and Their Occurrence in the Environment; *David H. Fine,* New England Institute for Life Sciences Inc., Department of Chemistry Research, Waltham, MA 02154; $199,474 for 12 months beginning September 1, 1979.

Over the last three years new findings of nitrosamine occurrences have indicated that human exposure to these carcinogens may be far more widespread than was suspected. Earlier inquiries into the possible formation of nitrosamines from pesticidal chemicals in soils led to the discovery that some amine-containing herbicide formulations were contaminated with nitrosamines. Further research showed that nitrosamines occur in other products formulated with amines, such as industrial cutting fluids and cosmetics. We need a better knowledge of the general chemistry of nitrosamine formation in the total human environment, including industrial and consumer products to which humans are exposed.

Awareness of widespread occurrences of nitrosamines may have been delayed because of earlier misconceptions about nitrosamine chemistry (e.g., that only secondary amines are readily nitrosated, that nitrosation can be expected only in acid media, or that a nitrite is a necessary precursor). This project will determine the conditions under which nitrosamines can form, identify nitrosating agents, and determine the detailed chemical pathways and mechanisms of nitrosamine formation. Particular emphasis will be given to formation mechanisms in neutral and alkaline solutions, to the nitrosation susceptibility of different amine substrates, to organic nitro and nitroso compounds as nitrosating agents, and to the role of nitrogen oxide gases.

Effects of Pollutants on Gills of Freshwater Fishes; *Paul O. Fromm,* Michigan State University, Department of Physiology, East Lansing, MI 48824; $46,383 for 12 months beginning July 1, 1979.

Gills represent that tissue or organ of fishes which is maximally exposed to water-borne pollutants. Continuous ventilatory activity insures that the concentration of any toxicant present in the aquatic environment is maintained at the respiratory surface. This study of the action of pollutants on fish gills will

provide valuable information relative to the impact of man's activities on the aquatic environment. The project will investigate the isolated perfused gill preparation as a model for the study of the effect of pollutants on fish.

The overall project will consist of three main divisions: experimental investigation of the permeability properties (flux of water) across isolated perfused gills and the effect of pollutants on same; a study of the salt transport capabilities in gills exposed to pollutants; and biotransformation of pollutants by gills during transit of materials from the ventilate to the blood vascular space.

Mycotoxins: A Potential Human Health Hazard; *Anil C. Ghosh,* SISA Incorporated, 767B Concord Avenue, Cambridge, MA 02138; $188,640 for 24 months beginning July 15, 1979.

This research on problems in the field of mycotoxins includes: development of rapid methods for the detection and estimation of toxins elaborated by the mold *Penicillium islandicum* Sopp; detailed studies on microbial production, structural elucidation, and biological activity of simatoxin and lumiluteoskyrin, two new metabolites of *P. islandicum;* and microbial production, identification, and biological studies of toxins produced by selected species of penicillia.

All the fungi selected for these studies are common contaminants of various foodstuffs. The availability of practical detection methods for the toxins elaborated by these molds will facilitate an assessment of the overall extent of the hazard of these mycotoxins to human health.

Vapor Deposited Silver Halides for Thin Layer Chromatography; *Gershon M. Goldberg,* Ionomet Company, Inc., 1660 Soldiers Field Road, Brighton, MA 02135; $24,980 for 6 months beginning October 1, 1979.

This project relates to improvements in the technique of thin-layer chromatography, (TLC); specifically, the preparation of a thin-film medium that will provide a rapid, economical, sensitive means to separate (from air, water, and soil samples) and quantitate chemical species having possible health or environmental consequences. The approach is to prepare, by vapor deposition continuous thin films of silver halides; to determine the optimum surface structure required for maximum separating effectiveness; and to tabulate the types of chemical structures that can be separated by them. The unique properties of these films may allow the preparation of a reverse phase system and offer the amplification factor of photographic development as a potential means for increased sensitivity of detection. It is anticipated that the complexing ability of silver ton combined with the faster and more complete separations claimed for other thin-film (as opposed to thin-layer) media will provide a high-performance TLC material competitive with the more equipment-intensive high-performance liquid chromatography and gas chromatography techniques.

Sources, Transformations, and Chemical Nature of Atmospheric Pollutants; *Glen E. Gordon,* University of Maryland-College Park, Department of Chemistry, College Park, MD 20742; $51,364 for 12 months beginning December 1, 1978.

This is a continuation of NSF research on the trace elements in size-graded particulates emitted by power plants, refuse and sludge incinerators, automotive traffic, airports, copper smelters, steel mills, and cement plants. The objective is to identify sources of toxic elements in the atmosphere and to measure the relative contributions of natural and individual man-made sources to the particulates of urban atmospheres.

This grant extends the study to a more complete characterization of copper smelters, a cement plant, and a steel mill, and to the aircraft sampling of two or three other non-ferrous smelters (zinc, lead, or nickel). This extension will add size-graded particulate analyses of in-plant materials to determine the role of fractionation processes governing the composition of the stack emissions. The resulting expanded data base will be used to refine the existing model for estimating source contributions to urban air particulates.

Aerosol Characterization in Real Time; *Robert K. Gould,* Aerochem Research Labs, Inc., P.O. Box 12, Princeton, NJ 08540; $99,937 for 12 months beginning May 1, 1979.

This research project is aimed at developing an atmospheric aerosol analysis technique capable of operating in either a continuous mode or as an individual particle analyzer. The instrumentation to be designed will provide information on particle mass and composition. To accomplish these measurements, an aerosol beam will be separated from the gaseous constituents and rapidly vaporized in a high-temperature cell. A pressure sensor will be used to estimate particle mass. Mass spectrometric techniques will be used to measure particle composition. The developed techniques are expected to be capable of measuring several aerosol properties. The research effort to be pursued will include an evaluation of the advantages and limitations of the developed techniques as they apply to specific areas of atmospheric aerosol science.

One area of expected application is the measurement of particle composition (averaged over all particles) without the need for concentration by integrated collection techniques. Another area of interest concerns the ability to measure concentrations of a given compound (or a few compounds) on a particle-by-particle basis.

Separation of Radium-226 and Thorium-230 from Uranium Ore; *John W. Hawley,* Hazen Research Inc., 4601 Indiana Street, Golden, CO 80401; $24,600 for 6 months beginning October 1, 1979.

The purpose of this research is to test the possibility of separating radium-226 and thorium-230 from uranium mill tailings at the time of leaching the uranium ore with sulfuric acid. The approach is to determine experimentally whether radium-226 and thorium-230 can be complexed to such a degree that precipitation of the sulfates can be prevented during uranium leaching. The complexing agents suggested for testing include orthophosphates and condensed phosphates such as pyrophosphate, Trimetaphosphate, and hexametaphosphate.

Annual Conferences on Trace Substances in Environmental Health; *Delbert D. Hemphill,* University of Missouri Columbia, Department of Horticulture, Columbia, MO 65201; $24,425 for 12 months beginning June 15, 1979.

The purpose of the Thirteenth Annual Conference on Trace Substances in Environmental Health is to explore the biological, ecological and health significance of organic and inorganic substances that may be present in "trace" amounts in the environment.

These conferences form part of an overall interdisciplinary approach necessary to understand the complexity of environmental and ecological problems and methods for their control. Areas of emphasis for the Thirteenth Conference include: Epidemiology of Trace Substances, Environmental Pollution, Environmental Geochemistry and Health, Analytical Methodology, and Metabolic and Health Effects of Chemical Substances.

Cytogenetic Effects of Mutagens and Mitotic Poisons on Mammalian Cells; *T. C. Hsu,* University of Texas, M.D. Anderson Hospital and Tumor Institute, Galveston, TX 77550; $86,703 for 12 months beginning January 19, 1979.

There is an urgent need for quick, inexpensive and reliable tests for screening chemicals for adverse health effects. Conventional tests in laboratory animals are accepted as applicable to the human experience, but there are not adequate resources, trained personnel or time to test the 30,000 or more commercial chemicals in use in the United States annually. New, rapid techniques are needed for screening chemicals for their potential to cause mutations so that those with the highest potential can be extensively tested and their risk assessed so that intelligent regulatory decisions can be made concerning their

use. Several test systems using bacteria are in wide use, but the simplicity of the bacterial mechanisms obscures possible effects to humans.

This project uses mammalian cells as test systems. A protocol has been developed for the rapid screening of water-soluble chemicals for their ability to cause chromosome breaks or to interfere with mitosis in mammalian cells in cell culture and *in vitro*. Modifications necessary for water-insoluble compounds will be made. In addition, attempts will be made to refine a technique for visualizing premature condensed chromosomes so that background abnormality rates can be estimated. An investigation will also be initiated to assess the feasibility of using male mammalian meiosis as a test system for environmental mutagens. And finally, investigations will be made using selected chemicals which cause "dominant lethals" in the Chinese hamster to ascertain the mechanism of this process.

Analysis of Organic, Elemental and Carbonate Carbon in Atmospheric Aerosols; *James J. Huntzicker,* Oregon Graduate Center, Environmental Technology, 19600 N. W. Walker Road, Beaverton, OR 97005; $36,203 for 12 months beginning August 1, 1979.

This is a detailed investigation of the ability of the Oregon Graduate Center carbon analyzer to separate and measure the organic, elemental, and carbonate fractions of carbonaceous aerosols. The sample, collected on a glass or quartz fiber filter, is heated to 850° to volatilize organic carbon. The volatile carbon is swept through a bed of an oxidizing agent, after which carbon dioxide is catalytically converted to methane and measured in a flame ionization detector. Following removal of the volatilizable carbon, any remaining carbon is oxidized to carbon dioxide and the analysis completed as before. Provision is made for an acid treatment step to measure carbonate carbon.

The objective of this project is to optimize the discrimination between elemental carbon and organic carbon. Interferences by non-carbonaceous materials will be assessed. The method will be compared with solvent extraction methods and with a wet chemical-thermogravimetric method.

Analytical Instrumentation for the Determination of Formaldehyde in the Ambient Atmosphere; *Gregory L. Kok,* Harvey Mudd College, Department of Chemistry, Claremont, CA 91711; $30,351 for 16 months beginning February 15, 1979.

Formaldehyde is present at trace levels (approximately ten parts per billion) in polluted urban atmospheres. Improved analytical data on ambient levels of formaldehyde are necessary to verify photochemical smog models and to provide more information on the spatial and temporal distribution of this irritant gas in the atmosphere.

Current analytical techniques for measuring formaldehyde lack sufficient sensitivity for reliable work at ambient levels. This research is designed to develop a new method based on the chemiluminescent reaction of gallic acid with formaldehyde.

The research plan is divided into three parts. A liquid-phase chemiluminescent system for formaldehyde analysis will be set up and optimized. The system will be tested with ambient air samples. Atmospheric formaldehyde levels will be measured and compared with those obtained by state-of-the-art methodologies, including the chromotropic acid method.

Characterization and Transformations of Aquatic Organics and Complexes; *Walter J. Maier,* University of Minnesota, Department of Civil and Mineral Engineering, Minneapolis, MN 55455; $135,932 for 18 months beginning August 1, 1979.

This research will provide information on the relationship between natural (background) constituents and trace pollutants in water. Such information is needed to formulate realistic pollution abatement strategies. An effort to identify and characterize the physical-chemical properties of natural constituents in the upper Mississippi River has been undertaken. Previous studies focused on the development of analytical methodologies including techniques for isolating, concentrating, and identifying specific

compounds; characterizing functional groups; and measuring physical-chemical parameters of isolates for both organic material and trace metals in river water.

The project extends and applies these techniques. Natural organics will be fractionated by polarity on macroreticular resins, characterized, and correlated with seasonal changes and variations in sources of organic matter in the river. Specific organic compounds in the aquatic organic pool of river water will be characterized; these include hydrocarbon and organic compounds containing nitrogen, sulfur, and chlorine. Organometallic complexes from aquatic systems will be isolated and characterized and their stability constants measured.

Improved Sensitivity of Laser Absorption Techniques for Atmospheric Pollutant Monitoring; *Arlan Mantz,* Laser Analytics Inc., 25 Wiggins Avenue, Lexington, MA 02173; $76,018 for 12 months beginning May 15, 1979.

The objective of this research is to improve the sensitivity of remotely monitoring atmospheric pollutant gases by absorption from a laser beam. The goals are to minimize laser source noise and the effects of atmospheric turbulence, both of which diminish the sensitivity of long-path monitoring by laser absorption techniques. The main emphasis of the work will be to complete the development and evaluation of the prototype environmental monitor system suitable for industrial plant site applications. This will include the refinement of a digital rationing technique for eliminating atmospheric turbulence effects.

Oxidation Processes in Soil; *Theodore Mill,* SRI International, Department of Physical and Organic Chemistry, Menlo Park, CA 94025; $175,375 for 6 months beginning May 1, 1979.

To understand the behavior of chemicals in the environment, we must understand chemical conversions such as chemical (abiotic) oxidations in soil systems.

This study has two major objectives: to identify and quantify important oxidants such as peroxy radicals and singlet oxygen formed on sunlight irradiation of soils, and to identify the structural features in soils (clays, humic acids, and metal oxides) that most strongly affect the production of photochemical oxidants. These oxidants will be identified by using the product composition in the oxidation of selected chemical probes. Kinetic analyses of these oxidations should provide a basis for estimating average concentrations. Radical or oxidant traps may also be used. Model soils made up from known proportions of purified clays and metal oxides will be used to develop an improved understanding of the role of these materials, as well as humic acids, in generating or scavenging oxy radicals, singlet oxygen, and other oxidants.

Evaluation of Effects of Acid Mine Drainage on Microbial Community Structure and Function in a Freshwater Lake; *Aaron L. Mills,* University of Virginia, Department of Environmental Sciences, Charlottesville, VA 22903; $94,926 for 24 months beginning August 1, 1979.

This project will investigate the effects of drainage from pyrite mines into Lake Anna, Virginia. Emphasis will be placed on the effects of low pH, high heavy-metal concentration runoff on the structure and function of microbial communities in the most contaminated arm of the lake. The hypothesis is that both the microbial communities and the processes they control have been severely altered.

Functional parameters such as heterotrophic potential, substrate decomposition, carbon dioxide uptake by phytoplankton, nitrification, denitrification, and sulfur oxidation will be measured. Stations for sampling have been selected to investigate the extent of the effects of contaminated drainage into the reservoir. A series of experiments involving metal uptake by bacteria, phytoplankton, and deritus is planned to determine the amount of metal made available for passage into higher trophic levels of aquatic food chains.

SO_2 Oxidation Rate on Well-Characterized Surfaces — A Laboratory Study; *Volker A. Mohnen,* SUNY State University at Albany, Atmospheric Sciences Research Center, Albany, NY 12222; $100,035 for 12 months beginning August 1, 1979.

The first phase of the research will study the oxidation rates of SO_2 on two well-characterized surfaces that can serve as paradigms for the wide range of surface types on typical stack particles. These surfaces are polycrystalline V_2O_5 (representing the metal oxides) and carbon on pyrolytic graphite (representing carbonaceous particles). Oxidation on V_2O_5 is hypothesized to occur in two stages: oxygen absorption at reduced vandadium sites, and then oxidation of SO_2 by an Eley-Rideal mechanism. Oxidation on carbon surfaces is hypothesized to occur in two similar phases. This research will determine whether the proposed reaction schemes are valid, and will deduce the rate-controlling step. Methods of analysis include mass spectrometry, molecular beam and auger spectroscopy.

The second phase of the research will involve the study of sulfate concentrations from in-stack coal and oil flyash samples. Measurements will be made of total sulfate per unit weight, surface vanadium content, and surface areas per unit weight for each type of ash. Determinations will be made of the degree to which sulfate concentration from SO_2 oxidation is related to the total surface area and to the vanadium concentration of the ash. These studies will elucidate the relative importance of vandium and the carbonaceous surfaces of flyash as oxidizing agents for SO_2. Analysis will include use of $BaCl_2$ precipitating agent, ion liquid chromatography, BET surface analysis, and electron microscopy and energy dispersive X-ray microanalysis.

A Field Study of Biogenic Sulfur Gas Releases from Inland Surface Waters; *David F. Natusch,* Colorado State University, Department of Chemistry, Fort Collins, CO 80523; $77,727 for 12 months beginning August 1, 1979.

This project will determine whether marshes and other surface waters contribute to local atmospheric loads of particulate sulfate. This study will determine the atmospheric concentration and stable sulfur isotope ratios of sulfides, sulfur dioxide, and particulate sulfur species at several sites to aid in determining how much of the sulfate in the atmosphere at these sites is derived from upwind anthropogenic SO_2 sources and how much is derived from local biogenic S sources. Local meteorological data, backwards air mass trajectories, trace metal concentrations and ammonium and nitrate concentrations in the particulate fraction will also be analyzed.

Poroplastic Personnel Vapor Monitoring Badges; *Arthur S. Obermayer,* Moleculon Research Corp., 139 Main Street, Cambridge, MA 02142; $106,822 for 12 months beginning January 22, 1979.

Toxic vapors in the occupational environment pose a significant threat to workers. There is a need for a toxic vapor personnel monitoring badge for individual use which is convenient, rapid and specific in its response, easy to interpret, reliable, inexpensive, and capable of alerting a worker to a hazard at the time of exposure. Colorimetric vapor-sensing badges represent a practical response to this need. This project employs transparent, liquid-impregnated poroplastic film which combines in one component the ability to acquire vapor, to conduct a colorimetric reaction, and to display the resulting color. A previous NSF-supported project showed the feasibility of detecting phosgene and formaldehyde with film impregnated with suitable reagents. This extension of that project will allow for feasibility testing with seven additional vapors and for the design of a prototype badge for routine use.

Pentachlorophenol and Pentachlorophenol Degradation Product Persistence in Lake Sediment; *Richard H. Pierce Jr.,* Florida Institute of Technology, Department of Oceanography/Ocean Engineering, Melbourne, FL 32901; $43,350 for 24 months beginning January 1, 1979.

The primary objective of the proposed investigation is to determine the persistence of pentachlorophenol (PCP) and PCP-degradation products in the sediment of a lake contaminated as the result of an industrial accident. In addition, the rate of PCP degradation and the rate of accumulation of toxic degradation products will be observed in the natural environment.

Sediment cores will be collected from a heavily polluted lake. Each core will be cut into sections and each section will be analyzed separately to study the sediment profile to a depth of 20 cm. Simultaneously, surface sediment will be obtained for the analysis of benthic organisms and trace toxic organic substances which are known to result from pentachlorophenol. The compounds will be recovered by solvent extraction and analyzed by gas chromatography with electron capture detectors. Verification of representative samples will be obtained by mass spectrometry.

The significance of this study is that it involves a basic question regarding the fate of toxic organic substances in the natural environment which must be resolved to evaluate possible threats to man and the environment. The question being: does the chemical (PCP) rapidly degrade in the natural environment, as suggested by controlled laboratory experiments, or does it persist due to some factor not represented in the laboratory study, as was indicated by monitoring the PCP concentration in the contaminated lake sediment over a period of several months?

Atmospheric Transformations and Mutagenic Activity of Primary and Secondary Air Pollutants; *James N. Pitts,* University of California-Riverside, Statewide Air Pollution Research Center, Riverside, CA 92521; $249,949 for 12 months beginning February 5, 1979.

Polluted urban air is the product of a diverse mixture of man-made contaminants that react chemically with one another and with naturally-occurring atmospheric constituents to form secondary pollutants that include visibility-degrading aerosols, gaseous bioirritants, and various substances having unspecified effects on human health. These smog-forming chemical processes have a definite time-course and therefore determine the quality of a moving body of air at locations remote from the original pollutant sources. The diversity of chemical species emitted by sources, and the complexity of the chemical and photochemical processes involved, complicate the work of pollution control authorities, who cannot defend regulatory decisions without credible scientific evidence connecting demonstrable effects with identifiable sources subject to regulation.

The research objectives are to: (1) refine an existing kinetic model of smog photochemistry by including aromatic hydrocarbons (toluene, xylenes, trimethylbenzenes) and carbonyl compounds (aldehydes and ketones); (2) isolate and chemically characterize mutagens in ambient airborne particulate matter; (3) assess reproducibility of the Ames test in its application to the quantitative determination of the mutagenicity of ambient particulate matter; (4) determine the chemical transformation of amines, nitrosamines, and their photooxidation products in simulated polluted atmospheres; and (5) investigate unknown causes by which smog chambers perturb experiments in pollutant photochemistry. Experimental techniques include simulated photochemical smog formation, infrared spectroscopy, chemical analysis, gas and liquid chromatography, mass spectroscopy, and bacterial assays for mutagenic activity.

Personal Dosimeter for Anesthetic Gases; *Eugene P. Scheide,* Environmetrics-St. Louis, 2833 Lawton Promenade, St. Louis, MO 63103; $24,973 for 6 months beginning October 1, 1979.

Epidemiologic studies of medical personnel assigned to operating rooms have shown that women employees and wives of male employees are subject to increased spontaneous abortions, birth defects in their children, and cancer compared to medical personnel who do not work in operating rooms. An estimated 214,000 medical and dental workers are chronically exposed to these gases. Exposure to toxic gases in the

work environment must be monitored in order to protect employee health. The objective of this research is to develop a simple and inexpensive method of measuring time-weighted average concentrations of breathing zone samples of waste anesthetic gases in hospital operating rooms. Researchers envision a personal dosimeter similar to a radiation film badge that can be worn on the coat lapel. The air contaminants being sampled diffuse into the dosimeter and are absorbed onto a collection element. Later analysis of this substrate gives the time-weighted average concentration of the contaminant being monitored. This research program will address all of the parameters that affect the performance of this personal dosimeter.

The Detection of Pyrrolizidine Alkaloids and Their Metabolites; *Henry J. Segall,* University of California-Davis, Department of Physiological Sciences, Davis, CA 95616; $86,015 for 12 months beginning June 1, 1979.

Pyrrolizidine alkaloids are toxic compounds found in plants worldwide. These toxins may contaminate human and animal food sources. Analytical methodologies are being developed to identify these alkaloids and their metabolites in plants and in the milk of cows which consume the plants. Analytical tools being employed include high pressure liquid chromatography and gas chromatography/mass spectroscopy. Plants to be examined include *Senecio vulgaris, Senecio jacobaea, Seneca longilobus* and *Amsinckia intermedia.*

Chemical Threats to Man's Nervous System; *Peter S. Spencer,* Yeshiva University, Albert Einstein College of Medicine, New York, NY 10033; $131,741 for 12 months beginning January 1, 1979.

The purpose of this project is to respond to the need for the development of sensitive biological assay systems to screen new and existing manufactured chemicals for neurotoxic properties. It is based on a triple classification of neurotoxic chemicals according to their site of tissue damage: nerve and cell body (neuronopathy), the axonal process (axonopathy), and the myelin sheath or myelin-producing cell (myelinopathy). Representative chemicals from each neurotoxic group will be studied to determine their effects on tissue components of the nervous system of mammals. For this purpose, light and electron microscope examination of the central and peripheral nervous tissues of animals and organotypic tissue cultures exposed to the chosen neurotoxins will be used to determine the timing and sequence of tissue damage.

By focusing on the earliest phases of neurotoxic insult in each of the three classes of disease, it will be possible to design sensitive animal and tissue culture assays to screen existing and newly-identified chemicals for possible neurotoxic properties. This will provide the mechanisms to screen out from the present and future inventory of manufactured chemicals those substances which are hazardous to the brain and nervous system.

Development of Screening Methods for Developmental Abnormalities; *Raymond L. Teplitz,* City of Hope National Medical Center, Department of Developmental Biology, Duarte, CA; $89,999 for 12 months beginning July 1, 1979.

The objective of this project is to detect developmental abnormalities in developing *Drosophila* (fruit fly) embryos and to assess the usefulness of such observations for screening chemicals relative to their ability to produce birth defects in humans and mammals. Procedures will be developed for detecting teratogens by adding them to cultures of *Drosophila* cells and determining which responses of cell differentiation and tissue formation are the best indicators of teratogenicity.

An array of known teratogens and nonteratogens will be tested *in vitro* in order to determine if the cells discriminate between these classes and also to catalogue the effects of these compounds on the cells. Procedures will be developed for testing metabolic products of ingested compounds for ability to induce developmental anomalies; this will be done by feeding compounds to rodents and then assaying their serum

in vitro for effects on developing embryos. Procedures will be developed for testing compounds for teratogenicity in intact *Drosophila.* Correlations will be drawn among data for the effects of compounds *in vitro,* for their teratogenic effects in intact *Drosophila,* and for their known teratogenic effects in mammals.

It is anticipated that the procedure developed will serve as a screen to detect teratogens that are dangerous to humans and ecosystems, and the data collected will contribute to our understanding of the role of teratogenesis in ecosystems and our understanding of basic biochemical and developmental aspects of teratogenesis.

Pollutant Flow Through the Marine Food Wed; *David R. Young,* Southern California Coastal Water Research, Division of Biology, El Segunda, CA 90245; $602,662 for 24 months beginning August 1, 1979.

Public apprehension about the build-up of pollutants in sea food is based on the assumption that food-chain concentrations of organic and inorganic pollutants, which have been demonstrated in certain terrestrial and freshwater systems, also applies to open coastal marine ecosystems. Recent pollutant studies doubt this assumption; in fact, models of an unstructured marine food web have been proposed.

The purpose of this research is to determine whether or not coastal marine ecosystems are indeed structured with respect to pollutants by carefully analyzing concentrations of pollutants and pollutant analogues in tissues of marine organisms and comparing these data with trophic level assignments determined from food habits studies. Food webs from a diversity of ocean environments will be sampled, including at sites adjacent to well-documented sources of pollutants. Concentrations of volatile and non-volatile trace elements, chlorinated hydrocarbons and the pollutant-analogue, cesium, will be determined.

If the results confirm a lack of structure in marine food webs with respect to pollutants, the result will be a major change in the thinking of marine biologists and concern about pollutants will have to be addressed individually.

COMMUNITY WATER MANAGEMENT

The Community Water Management program originated in the former Regional Environmental Systems (1971-1975) and Regional Environmental Management (1976-1978) progams of the National Science Foundation. These programs dealt with water-related issues such as land use, urban water resources, residuals, and risk management. Research supported by this program focuses on management of threats to community water which affect public health, safety and the environment. The Community Water Management program supports research to identify and assess alternative and innovative concepts for dealing with community water and wastewater-related problems.

The program addresses the principal problems associated with urban water management by considering water a limited resource from which communities must satisfy a variety of competing residential, industrial and environmental needs. Community water systems are regarded as dynamic systems subject to perturbations, such as seasonable water demands and changing water quality, which create stress on normal or preferred use patterns. Research supported by this program is directed toward evaluating new and existing concepts of water resources management, toward improving processes by which knowledge relating to the management of threats to community water is translated into public policy, and toward analyzing and developing legal and institutional mechanisms for more effective management of community water resources.

This program was discontinued on October 1, 1979.

Chromium Recovery from Tannery Industry Wastes; *Francis C. Brown,* EIC Corporation, 55 Chapel Street, Newton, MA 12158; $24,931 for 6 months beginning October 1, 1979.

The objective of this project is to determine whether there is a technically feasible and economically attractive process for recovering chromium from tannery industry solid wastes. A survey of the industry is being conducted to identify representative plants and waste disposal sites. Samples of currently produced and historically deposited wastes are being collected from these sites and analyzed to determine their chemical composition and their response to chemical and physical methods for processing to recover chromium. The chemical and physical properties of sludge residues following chromium removal and disposal methods for these residues are being evaluated. The data from these tasks will be used to produce a preliminary technical and financial assessment of commercial scale chromium recovery from tannery wastes.

Utilization of Wetlands for Wastewater Management; *Ronald Capalaces,* Forum Inc., 6512 Jay Miller Drive, Falls Church, VA 22041; $59,384 for 8 months beginning May 1, 1979.

The objective of this project is to produce a concept for a documentary film presentation of results of research currently underway on utilization of wetlands for management of community wastewater. This film is planned to provide information and guidance to communities considering the potential utilization of wetlands as an alternative to conventional methods for advanced treatment of their wastewater. The treatment concept draws upon NSF-supported research in progress at the University of

Michigan, Williams and Works, Inc. (Grand Rapids, MI), the University of Florida; Boyle Engineering Corporation (Orlando, FL), and the State of Florida.

Removal of Silica from Cooling Water by Activated Alumina; *D. B. Clayton,* D. B. Clayton and Associates, 10919 Braes Forest, Houston, TX 77071; $25,000 6 months beginning October 1, 1979.

The objective of this research is to characterize the adsorptive ability of activated alumina for silica as it may be applied to removal for potential reuse of silica from industrial cooling tower water blowdown. Bench-scale experiments will be conducted to identify and evaluate the engineering design parameters necessary to indicate the feasibility of the concept and to provide information for the next phase, which is expected to involve pilot plant experimentation.

The Entrapment Concentration and Recovery of Heavy Metals From High-Yield Exhausts by Use of Stabilized Soil Adsorption Beds; *Richard R. Dedolph,* Gravi-Mechanics Company, 22 W510 71st Street, Naperville, IL 60540; $24,970 for 6 months beginning October 1, 1979.

The objective of this project is to assess the potential for using the adsorptive and ion-exchange capacity of minerals, soils, peat and sludge for the concentration and recovery of heavy metals from industrial exhaust streams. After dispersal of the absorbing medium on a suitable substrate, the absorbant/exchange capacity of the medium is being determined by subjecting it to the exhaust fumes containing lead and zinc. The effects on metal entrapment efficiency of flow-rate, temperature, heavy-metal concentration and moisture-content of the absorbing medium are being evaluated.

Process Integration for Optimum Management of Municipal Wastewater Treatment Sludges; *Richard I. Dick,* Cornell University, Department of Environmental Engineering, Ithaca, NY 14850; $77,800 for 12 months beginning July 1, 1979.

This research will determine the influence of design and operating variables in wastewater and sludge processing on physical properties of municipal wastewater treatment plant sludges with emphasis on thickening and dewatering. Studies include determination of the effects of sludge residence time in treatment processes on settling and dewatering properties and changes in these physical properties as a consequence of both aerobic and anaerobic stabilization. The role of disinfection with emphasis on its potential integration into systems for appropriate management of sludges is being investigated. The determination of the effects of using energized electrons for disinfection of sludges on their physical characteristics is being conducted in cooperation with research in progress at the Massachusetts Institute of Technology.

Utilization of Wetlands for Wastewater Management; *Clayton Edwards,* Image Associates, 1611 Connecticut Avenue, N.W., Washington, D.C. 20009; $3,000 for 2 months beginning May 21, 1979.

The objective of this project is to produce a treatment concept for a documentary film presentation of results of research currently underway on utilization of wetlands for management of community wastewater. This film is planned to provide information and guidance to communities considering the potential utilization of wetlands as an alternative to conventional methods for advanced treatment of their wastewater. The treatment concept draws upon NSF-supported research at the University of Michigan; at Williams and Works, Inc. (Grand Rapids, MI); the University of Florida; Boyle Engineering Corporation (Orlando, FL); and the State of Florida.

Water Management in New England: A Method for Investigating Short-Run Operational and Long-Range Investment Strategies; *Harris Gold,* Water Purification Associates, 238 Main Street, Cambridge, MA 02142; $130,102 for 12 months beginning September 1, 1979.

This project is developing and evaluating a method for optimizing operational and long-range investment strategies for water management in New England. A stochastic, dynamic programming method for analyzing potential water shortages is being designed which will be linked to a formulation for optimizing the expansion of water system capacity with respect to size and time. The intent is to combine both short- and long-term considerations to reconcile demand for and supply of water.

The integrated method being developed is being evaluated in New England at the local, regional and river-basin levels in comparison with current strategies. Specific tasks include delineation of technological and institutional mechanisms for matching supply with demand, formulation and testing of an optimization method for choosing the levels of demand-reduction and supply-increase in light of uncertain future supplies, tests of the use of developed methods on specific cases, and comparisons with policies that would result from standard water resource planning methods. Direct transfer of methodologies developed in this study will occur as a consequence of specific case studies conducted in this project, workshop seminars and a manual of practice which is planned as a final product.

Benefits and Problems of Refuse-Sludge Composting; *Clarence G. Golueke,* CAL Recovery Systems Inc., 160 Broadway, Suite 200, Richmond, CA 94804; $19,599 for 6 months beginning October 1, 1979.

The objective of this project is to determine whether the light fraction of mixed municipal solid waste can be utilized as a bulking agent in composting of sludges produced during treatment of community wastewater: A standard rototiller and high-speed shredder are being adapted for development of a prototype mixer for the sludge and solid waste. The design principles for equipment to process these mixtures and the dilution effect of this concept on heavy metal content of sludges are being investigated.

Agricultural utilization of Sludges From Treatment of Community Wastewater; *Roger Haag,* Rickel Manufacturing Corp., Box 626, Salina, KS 67401; $25,000 for 6 months beginning October 1, 1979.

The objective of this project is to evaluate the technical and economic feasibility, of a method for placement of ammonia and phosphoric acid into agricultural soil simultaneously with sludges derived from the treatment of community wastewater. This concept is being evaluated in field-plot scale tests on a 10-acre site near Salina, Kansas using sludges obtained from the Salina municipal wastewater treatment plant.

Stabilization of Community Wastewater Sludges By Soil Invertebrates; *Roy C. Hartenstein,* S.U.N.Y., College of Environmental Science and Forestry, Environmental and Forest Biology, Syracuse, NY 13210; $90,000 for 12 months beginning June 1, 1979.

This research will determine the feasibility of utilizing earthworms for stabilization of community wastewater treatment plant sludges prior to their application to agricultural land for use as a soil conditioner. Substances contained in anaerobically digested sludges which exert a toxicity effect on soil invertebrates will be identified. The optimum conditions for amelioration of the toxicity effect are being identified and characterized. The nutritional needs of several earthworm species are being studied as they may be affected by temperature, moisture and oxidation-reduction potential. Caloric and space needs for otptimum conversion of sludges into biomass and humus as well as the functional role of minerals in soil on conversion of sludges into castings are being investigated. The effects of chemical precipitants on the conversion process are also being characterized.

Wetland Utilization for Management of Community Wastewater; *Robert H. Kadlec,* University of Michigan, Department of Chemical Engineering, Ann Arbor, MI 48109; $152,275 for 12 months beginning May 1, 1979.

This research will evaluate the use of a peat marsh wetland in the Houghton Lake Wildlife Area for advanced treatment of domestic wastewater. A 600 acre site designed to accept 180 million gallons per year of effluent data is being monitored to provide for verification and potential readjustment of eco-system models constructed and validated under a prior NSF grant.

Observations will be made to determine the effect of wastewater effluent application on hydrologic, nutrient, soil, microbial, algal, vegetation and animal compartment of the ecosystem. Water quality parameters are being determined at the treatment plant and in the wetland to assess renovation efficiency. Ecosystem uptake of phosphorus and nitrogen is being investigated to determine mechanisms of nutrient removal. Impacts on public use of wetland, potential benefits from increased wetland productivity, and preservation of the quality of receiving waters are also being determined. Cooperating agencies include the State of Michigan Department of Natural Resources, the U.S. Environmental Protection Agency, the Houghton Lake Sewer Authority and the consulting engineering firm of Williams and Works, Inc. of Grand Rapid, Michigan.

Application of Ultrasonics and Electrostatics in Wastewater Treatment and Disinfection; *Paul S. Kernion,* Sonic-Clean Inc., 2427th Street, New Orleans, LA 70184; $25,000 for 6 months beginning October 1, 1979.

This research will investigate the potential use of an ultrasonic, electrostatic process for the advanced treatment of wastewater to permit its reuse for industrial and agricultural purposes. The work involves assessment of physical and chemical factors such as solids concentration, pH, and frequency of vibration on the efficiency of treatment. The capability to provide disinfection with regard to bacteria and parasites is also being investigated.

Disinfection of Community Wastewater Sludges By Use of High Energy Electrons; *John G. Trump,* Massachusetts Institute of Technology, Department of Electrical Engineering and Computer Science, Cambridge, MA 02139; $90,000 for 12 months beginning July 1, 1979.

This award supports the completion of studies to evaluate the technical and economic feasibilities of using high-energy electrons to disinfect sludges produced during treatment of municipal wastewater. The objective of this study is to analyze results obtained from operation of the 50 kilowatt, 850,000 volt electron accelerator at the Deer Island Wastewater Treatment Plant of the Metropolitan District Commission (Boston) to complete codification of the design, operational, and maintenance characteristics of the electron-beam disinfection system.

Microbiological studies include further characterization of an inhibitory effect on regrowth of *Salmonella* and *Shigella* species in disinfected sludges which has been observed and tentatively attributed to competitive growth of gram positive bacteria. Potential control of regrowth by deliberate use of lactic acid bacyteria is being investigated. A conference planned for Spring of 1980 will concentrate on the design, operation, and maintenance of equipment for disinfection based upon use of ionizing radiation and its integration with other sludge processing concepts.

Prediction and Control of Heavy Metals and Toxic Organic Materials in Sludges; *Leon W. Weinberger,* Environmental Quality Systems, 1160 Rockville Pike, Suite 202, Rockville, MD 20852; $123,234 for 12 months beginning September 1, 1979.

The objective of this research is to project the future composition of community wastewater treatment plant sludges with regard to their content of heavy metals and toxic organic substances based upon the implementation of current and likely future pollution abatement regulations. The results of these projec-

tions will provide the basis for the formulation, development and evaluation of strategies for control of potentially toxic and hazardous substances in sludges. Existing data are being collected and reviewed to provide a baseline of present composition of sludges from communities differing in size and mix of domestic, commercial and industrial components. Current and anticipated future regulations are being analyzed to predict their impact on sludge composition. The effects of alternative treatment and control strageties are being assessed for their potential role in changing the amounts of inorganic compounds of heavy metals and organic substances of similar significance that are contained in community wastewaters and which become fixed and concentrated in their wastewater treatment plant sludges.

EARTHQUAKE HAZARDS MITIGATION

At least 70 million Americans in 39 states reside in areas described by seismologists as regions of major or moderate seismic risk. Communities which experience earthquakes are affected through direct loss of life, personal injury and property damage, losses and costs incurred in the operation of relief and rehabilitation programs, loss of income due to business disruption, and disaster-caused psychological problems.

NSF's Earthquake Hazards Mitigation (EHM) program for Fiscal Year 1979 is based on Option B of a report prepared at the request of the President's Science Advisor in 1976. The report, entitled *Earthquake Prediction and Hazard Mitigation Options for USGS and NSF Programs* presents options for development of combined NSF/USGS (U.S. Geological Survey) programs. Option B was selected for implementation by the Executive Branch. The goal of the joint NSF/USGS earthquake prediction and hazard mitigation activity is to reduce casualties, damage, and social and economic disruption from earthquakes. The social, economic and political actions that must be taken to attain this goal are based on technological capabilities that require development through research. Primary research objectives include:

- Earthquake Prediction: to develop the capability to predict the time, place, magnitude and effects of earthquakes so that more effective preparedness actions can be undertaken;
- Earthquake Modification and Control: to develop techniques that allow the control or alteration of seismic phenomena
- Land Use: to develop procedures for assessing seismic risk and evaluating earthquake hazards so that appropriate construction and land use plans can be implemented;
- Design Improvement: to develop improved, economically feasible design and construction methods for building earthquake-resistant structures of all types, and for upgrading existing structures; and,
- Social and Behavioral Response: to develop an understanding of the factors that influence public utilization of earthquake mitigation measures.

Earthquake engineering and research for utilization are the responsibilities of NSF's Earthquake Hazards Mitigation program. The Geophysics programs of NSF and the USGS are responsible for fundamental earthquake studies. Earthquake prediction, induced seismicity, and hazards assessment are the responsibilities of USGS. NSF and USGS programs are carefully coordinated through formal and informal mechanisms to achieve the goals set forth in the Report to the President.

The Earthquake Hazards Mitigation program for Fiscal Year 1979 was comprised of three subelements:

- Siting
- Design
- Policy

SITING

Earthquake damage to a structure can be caused by fault slip, by the failure of the founding soils or rocks, or by heavy ground shaking transmitted to the structure through its surrounding soil and rock media. When soils are strongly shaken, they may amplify the bedrock motion and modify the characteristics of the motion imparted to the supported structure. Soils may also fail through a variety of mechanisms such as settlement, loss of bearing capacity, embankment or slope instability, and soil liquefaction. In some cases the earthquake may also trigger secondary geophysical hazards such as tsunamis (tidal waves), rock and land slides, or flash flooding from damaged dams.

The Siting subelement of the Earthquake Hazards Mitigation program provides research support for the elucidation of the physical basis for earthquake energy generation and the transmission and propagation of the generated shock waves through various geologic and soil conditions. The Siting research area is also concerned with the impact of earthquake ground motion on structures and the development of criteria and guidelines for the mitigation of potential impacts on the built environment.

Earthquake-Induced Longitudinal Vibration of Earth Dams; *Ahmed Abdel-Ghaffar,* University of Illinois-Chicago Circle, Department of Materials Engineering, Chicago, IL 60680; $29,929 for 12 months beginning January 1, 1979.

This research will analyze the longitudinal vibrational behavior of earth dams during earthquakes. This project includes development of a simplified method, using an analytical elastic model, for evaluating dynamic characteristics of earth dams in a direction parallel to the dam axis, and for estimating earthquake-induced strains and stresses in that direction. Both shear and compressional (axial) deformations will be considered. In addition, results of full-scale dynamic tests, both ambient and forced, and observations of some existing dams will be utilized to confirm and improve the method of analysis.

A rational procedure will be developed to estimate dynamic strains and corresponding elastic moduli and damping factors for earth dams from their hysteretic responses to real earthquakes utilizing the hysteresis loops from the crest as well as the base records of earth dams. This will lead to a study of the nonlinear behavior in terms of the variation of stiffness and damping properties with the strain levels of different loops. Finally, the data so obtained will be compared with those previously available from laboratory investigations.

Engineering Monographs on Earthquake Criteria and Structural Design; *M. S. Agbabian,* Earthquake Engineering Research Institute, 2620 Telegraph Avenue, Berkeley, CA 94704; $140,000 for 18 months beginning June 1, 1979.

One of the most important aspects of earthquake engineering research is the dissemination and application of the results to those individuals and organizations who have the need-to-know in order to make knowledgeable decisions pertaining to the mitigation of the earthquake hazard.

The objective of this project is to encapsulate the practical knowledge of earthquake engineering into reference volumes for use by engineers, building officials, and governmental agencies interested in the

mitigation of earthquake hazards, the safety of citizens, and the protection of property.

This series of monographs will serve as a ready reference on the major topics of concern in seismic design. The monograph volumes to be developed are: Seismicity and earthquake hazard analysis, dynamics of structures, interpreting strong motion accelerograms, understanding soil behavior, soil-structure interaction, seismic design spectra, design criteria and seismic design procedures. The monographs will be prepared by national experts, each in his own field, and will be reviewed by an advisory committee of equally qualified stature. This project is a natural sequel to the series of lectures presented by authors at regional seminars under the direction of the Earthquake Engineering Research Institute.

A New Approach to the Prediction of Earthquake Strong Motion; *Keiiti Aki,* Massachusetts Institute of Technology, Department of Earth and Planetary Science, Cambridge, MA 02139; $119,166 for 16 months beginning March 8, 1979.

Scientific evidence has shown that no part of the United States is immune to earthquake threat. For safety of structures, the determination of the expected earthquake ground motion at any given site is essential. For areas where historic earthquake data are available, design ground motion data can usually be constructed without much difficulty. For areas where little or no historic earthquake data exist, the problem of predicting site ground motion and establishing design bases for earthquake-resistant structures remains unsolved.

The objective of this project is to predict earthquake strong motions where no historical data exists. The research will develop means for predicting earthquake strong motion for given seismic regions on the basis of the laws of physics, using information on the physical properties of earthquake faults. This project will test the validity of the "Barrier Model," a new versatile earthquake model which is characterized by five site parameters: fault length, width, maximum slip, rupture velocity, and barrier interval. The Barrier Model will be tested using data on earthquakes in California, the Central United States, Hawaii, and Japan.

Seismic Behavior and Design of Urban Area Tunnel Linings; *Subhash C. Anand,* Clemson University, Department of Civil Engineering, Clemson, SC 29631; $29,966 for 12 months beginning January 1, 1979.

This research will attempt to develop a better understanding of the dynamic load transfer mechanism in tunnel linings subjected to earthquake forces. In particular, load distributions around tunnel linings due to seismic effects on a series of concentrated (or line) loads at the ground surface (or somewhere in between tunnel linings and the ground surface), will be calculated. The results of this study will indicate whether column or wall foundations can be automatically supported directly above the existing or proposed tunnels in seismically active areas.

The research will be carried out by performing finite element studies of soil-tunnel lining interaction models. Static analyses will be performed initially for the overburden and column or footing loads. The models will then be subjected to earthquake motions; from the response additional loads on the tunnel linings will be obtained. The superposition should yield total loads from which safe design loads will be determined. Recommendations will be made to agencies concerned with the development of seismic codes.

Methods and Costs of Maintaining Hospital Functions in Earthquakes; *Christoph E. Arnold,* Building Systems Development, Inc., 120 Broadway, San Francisco, CA 94111; $187,304 for 18 months beginning August 15, 1979.

Earthquakes pose a major threat to the populous states of the Pacific Coast. Of major concern is the survival of critical facilities which will be immediately necessary for rescue, relief and recovery activities. Since there were two serious hospital failures during the San Fernando Earthquake of 1971 high priority has been placed on providing for the structural and functional survival of hospitals so that the hospitals might be fully operational.

While considerable attention has been paid to the

issue of structural survival (the California Hospital Code, the Veterans Administration Seismic Reenforcement Program), relatively little study has been directed to the issues of non-structural damage control and its relationship to hospital functionality. Hospitals have intricate electrical, mechanical, and life support systems. The interaction of these systems during extreme shaking and the impact of non-structural failure on hospital function are not well understood. This research will develop measures for the reduction of non-structural damage in new and existing hospitals and assess the costs involved in alternative damage control strategies.

Analysis of Lifelines Subjected to Earthquakes; *Richard E. Barlow,* University of California-Berkeley, Operations Research Center, Berkeley, CA 94720; $86,256 for 12 months beginning June 1, 1979.

This research is addressed to the development of a systematic procedure for assessing the reliability of lifeline systems subjected to strong motion earthquakes. Emphasis will be on a methodology for review of an existing lifeline system. Common features and differences of systems will be mathematically modeled to permit the systematic refinement of details based on experience. The behavior of the elements of the lifeline system will be studied from a structural engineering viewpoint. The resulting methodology will be applied to an actual lifeline system in California.

Underground Lifelines in a Seismic Environment; *Melvin L. Baron,* Weidlinger Associates, 110 East 59th Street, New York, NY 10022; $417,829 for 12 months beginning May 1, 1979.

This research deals with the analysis and design of water distribution and transmission systems for earthquake effects. The aim is to develop rational and practical design procedures which can be used by utilities, governmental agencies and manufacturers in their design activities. Such procedures will involve various aspects of current technology, such as earthquake data, pipe damage statistics, analysis and design procedures, joint types, pipe materials, etc. The research will concentrate on underground water distribution lifelines. Specific research tasks include: studies of incoherent seismic motions, development of pipeline failure/damage criteria, experimental test planning, design decision analysis (to be performed by Columbia University as a project subcontractor), and preparation of design guidelines. Results will be made available in the form of a practical design methodology, including design curves, tables and formulas.

Dynamic Analysis of Earthquake Shaking Deformations for Large Caverns in Jointed Rock; *Theodore B. Belytschko,* Northwestern University, Department of Civil Engineering, Evanston, IL 60201; $175,900 for 24 months beginning January 15, 1979.

This research concentrates on the development of analytical procedures to predict the response and stability of rock caverns to earthquake shaking. Computer programs to be developed will be able to account for rock mass inhomogeneities in the form of continuous joints or shear zones, irregular geometry of both the opening and intact rock blocks, and seismic excitation. As an integral part of this effort, procedures and guidelines for modelling jointed media in the vicinity of an excavation will be investigated. Rational procedures for devising prototypical joint configurations will be developed exercising the model and calibrating it with recorded experience.

The anticipated outcome will be not only a computational tool but also guidelines for engineering analysis. Even though this project focuses primarily on earthquake response, the results will have application in other fields of study such as feasibility studies for underground nuclear reactors, underground storage of oil and radioactive waste in seismically active areas, and hazard assessment studies for lifeline systems.

Optimal Design of Earthquake Strong-Motion Networks; *Jack R. Banjamin,* Jack R. Benjamin Associates Inc., 260 Sheridan Avenue, Palo Alto, CA 94306; $34,886 for 12 months beginning October 1, 1979.

The seismic Engineering Branch (SEB) of the United States Geological Survey (USGS) is responsible for locating and maintaining strong-motion networks. Because of the possibility of a greatly expanded strong-motion program in the near future and the need to consider all possible uses of the data, it is important that a systematic methodology for locating instruments be established. The goal of this project is to provide a decision-making tool to those responsible for strong-motion instrumentation programs.

The research will lead to: (1) Development of a practical decision-making methodology including consideration of network configuration, number and type of instruments, network pattern with respect to tectonic, geologic, seismologic, and structural engineering requirements as well as various cost factors and derived benefits; (2) Application of the methodology for the central and eastern United States, where major gaps in scientific and engineering knowledge exist and where the potential for critical losses also exists; and, (3) Recommendations for coordination between USGS national network programs, State and local agencies, and university projects.

Partial Support of the Committee on Seismology; *Joseph W. Berg,* National Academy of Sciences, 2101 Constitution Avenue, N.W., Washington, DC 20418; $20,000 for 24 months beginning October 1, 1979.

This award provides partial support for the activities of the Committee on Seismology of the Assembly of Mathematical and Physical Sciences, National Research Council. These activities will consist of completion of a report on earthquake problems related to the siting of critical facilities; completion of a report on national, regional, and local seismograph networks; four regular business meetings of the Committee on Seismology; preparation of other reports by the Committee and its Panels; and initiation, if warranted, of additional studies on topics of importance both to the scientific community and to the general public.

Flexible Sub-Surface Building-Foundation Interfaces for Aseismic Design; *John M. Biggs,* Massachusetts Institute of Technology, Department of Civil Engineering, Cambridge, MA 02139; $114,927 for 12 months beginning September 1, 1979.

Flexible building-foundation interfaces have the potential to reduce seismic forces, thereby improving the earthquake-resistance of buildings. This project will conduct a feasibility study of a below-ground flexible interface which appears to have several advantages over conventional construction. The research will concentrate on the possible use of sleeved-pile foundations to reduce the seismic effect of the superimposed structure. Researchers will analyse the dynamic behavior of such systems, including soil-structure interaction effects, to establish optimal system parameters and to evaluate potential benefits for building protection. Conceptual design studies will also be made. The final result will be a set of conclusions with regard to the feasibility of the concept, potential benefits to be derived, and the range of possible applications.

Scientific and Technical Information Exchange in Earthquake Research Between the United States and the People's Republic of China; *John A. Blume,* Earthquake Engineering Research Institute, 2620 Telegraph Avenue, Berkeley, CA 94704; $34,940 for 6 months beginning August 1, 1979.

The Earthquake Engineering Research Institue will host earthquake researchers from the People's Republic of China (PRC) in a tour of the United States. The purpose of the tour is to expedite the signing of an Implementing Accord between the two countries, an act that will formally establish a U.S.-PRC cooperative program in earthquake research. The tour will consist of visits to U.S. research facilities, public utilities and design and consultation firms and Chinese participation in the 2nd U.S. National Con-

ference on Earthquake Engineering. During the three-week tour, the visiting Chinese group members will discuss earthquake research and exchange information about Chinese earthquake studies with U.S. researchers. Discussions will be directed toward identifying mutual research needs and priorities.

Taiwan Large-Scale Strong-Motion Array Project; *Bruce A. Bolt,* University of California-Berkeley, Seismographic Station, Berkeley, CA 94720; $336,477 for 24 months beginning July 15, 1979.

Lack of a comprehensive set of strong ground-motion data from major earthquakes has handicapped earthquake engineering research. To remedy this situation, dense strong-motion arrays have been recommended for highly seismic locations around the world, including a site in Taiwan. This project will establish a moderate array in Taiwan for both source mechanism and wave propagation studies. The array will be subjected to a two-phase operation: a mobile array deployed in northwestern Taiwan followed by a permanent deployment at a site in southwestern Taiwan, depending on the records obtained and analysis conducted during the first phase study. The project will be implemented as cooperative research between the U.S. and Taiwan. The U.S. will provide the recording instruments and Taiwan will provide the technical staff and local support for the installation, operation and maintenance of the array and data collection and processing over the life of the array.

The National Program on Strong-Motion Instrumentation; *A. G. Brady,* U.S. Geological Survey, 12201 Sunrise Valley Drive, Reston, VA 22092; $993,880 for 12 months beginning May 1, 1979.

This project is a continuation of the NSF-supported Seismic Engineering Program on strong-motion instrumentation and data management. The objectives of the program are to maintain and operate the national strong-motion network, to record strong ground motions and the response of representative types of structures during potentially damaging earthquakes, and to disseminate this data and information about the sites and structures to external users in earthquake engineering research and design practice.

The program is organized around two principal projects: data management and network operations, and two secondary projects: network design and data analysis. The data management project is to develop an information retrieval system to provide users with immediate access to all available data and records. The network operation project is to carry out a gradual upgrading of existing instrumentation and a redistribution of those instruments. Under network design, the effort will be to participate in studies of optimum network procedures and to provide assistance to other agencies in the planning of their networks. Under the data analysis project, analytical studies related to the strong-motion and routine processing and analysis of relevant data will be conducted. The results obtained are presented in the publication entitled, "Seismic Engineering Program Reports" which summarizes preliminary data and information obtained each quarter; in strong-motion data reports that present more detailed data processing and analysis; and through technical reports and papers presented or published in appropriate meetings and publications.

Objective and Subjective Seismic Safety Considerations; *Colin B. Brown,* University of Washington, Department of Civil Engineering, Seattle, WA 98195; $47,625 for 12 months beginning July 15, 1979.

In the design and safety evaluation of structures for seismic effects, structural response and capacity are assumed to be random, thus permitting the construction of probability distributions. To date, subjective features such as numerical errors in design and construction and general omissions and simplifications have not been properly addressed nor included in a formal design process. This project addresses the problem of rationally including both objective and subjective considerations in seismic safety evaluations.

Objective information will be treated as statistical moments and limits. Unbiased distributions will be obtained by maximizing entropy in the manner of

Jaynes. Subjective information in the form of linguistic statements will be accommodated within the mathematical theory of fuzzy sets. This ensures a measure and a calculus for such statements.

Numerical and Experimental Study of Earthquake Strong Motion; *James N. Brune,* University of California-San Diago, Department of Geophysics and Planetary Physics, La Jolla, CA 92093; $144,875 for 12 months beginning June 15, 1979.

This project will study the characterization of earthquake ground motion in terms of fault proximity, fault type, and intervening earth structure by numerical computations and laboratory experiments. Results from spontaneous shear ruptures in foam rubber have provided new information on rupture mechanics and the focusing of wave energy in the direction of rupture.

A three-dimensional finite element method for modeling crack-induced waves has accurately reproduced analytical results for a growing circular crack and simulated surface motions in laboratory experiments. New results obtained using computer methods concerning surface contours of maximum particle velocity during an earthquake, response spectra as a function of distance and direction from a strike-slip earthquake, and seismic amplification curves for a three-dimensional sedimentary deposit will be used in this research.

The project is intended to further calibrate the computer methods for modeling actual earthquakes, to simulate ground motion under a variety of conditions, and to produce rules for characterizing ground motion which are suited to the needs of design engineers.

Design Method for Predicting Footing Settlement from Earthquake Effect; *Ching S. Chang,* University of Massachusetts-Amherst Campus, Department of Civil Engineering, Amherst, MA 01003; $29,317 for 12 months beginning January 1, 1979.

The purpose of this study is to develop an analytical model to evaluate footing settlement caused by earthquake induced pore pressure dissipation. This research will involve laboratory tests of soil samples under a general anisotropic cyclic stress state. Characteristics of dynamic pore pressure generation, dissipation, and soil deformation will be studied. With the understanding of these characteristics, an analytical model will be developed to evaluate the deformation of soil under footings, considering the coupled effect of stress and flow during pore pressure dissipation.

Effects of Grain-size Distribution on Dynamic Properties and Liquefaction Potential of Granular Soils; *Nien Yin Chang,* University of Colorado at Denver, Department of Civil and Urban Engineering, Denver, CO 80202; $29,960 for 12 months beginning January 1, 1979.

The effects of grain-size distribution upon dynamic properties and liquefaction potential, while known to be significant, have not been studied systematically. The objective of this research is to investigate the effects of grain-size distribution on the dynamic properties (dynamic shear modulus and damping ratio) and liquefaction potential of granular soils. Granular soils with constituents ranging from fine silts to gravels will be tested. Both resonant column and cyclic triaxial tests will be conducted. The former test will yeild the dynamic properties at small shear strains (10^{-6} to 5×10^{-3}). The cyclic triaxial test will be used to determine the liquefaction potential of granular soils. Since materials with a wide spectrum of grain size will be tested, both small and large diameter resonant column and cyclic triaxial test cells will be used. The dynamic properties and liquefaction potential of granular soils are known to depend strongly on the void ratio, effective mean stress and relative density.

Earthquake-Induced Landslides; *Wai-Fah Chen,* Purdue University, School of Civil Engineering, Lafayette, IN 47907; $194,289 for 24 months beginning January 1, 1979.

The objective of this research is to devise means for assessing the danger of slope failures and landslides under static and dynamic loading conditions. The research is directed toward a better understanding of the close interaction between soil properties and the instability and subsequent slope failures that result from seismic disturbances. Initially, emphasis will be on the critical assessment of existing soil constitutive models from the viewpoint of experimental and theoretical considerations as well as the application of these models in numerical calculations solving specific benchmark problems. On the basis of this assessment, improved constitutive models will be developed. The improved models will be used to re-interpret and reevaluate available data from laboratory tests as well as to recalculate specific benchmark problems to verify the adequacy of the improved models for general use in earthquake-induced landslide calculations.

Centrifuge Facility for Research in Geotechnical Engineering; *James A. Cheney,* University of California-Davis, Department of Civil Engineering, Davis, CA 95616; $16,583 for 12 months beginning August 15, 1979.

This supplement to a prior award supports an interchange between geotechnical engineering dynamicists and mechanical design engineer groups. The purpose is to develop a sharper definition of the loadings which can be imposed on a building (including multiaxial loadings).

US/Taiwan Cooperative Research in Earthquake Engineering; *Anil K. Chopra,* University of California-Berkeley, College of Engineering, Berkeley, CA 94720; $67,269 for 24 months beginning September 1, 1979.

This research will develop analytical procedures to determine dynamic stiffness or impedance coefficients for embedded foundations. The approach is based on a hybrid model wherein the near-field (the soil region near the foundation) is idealized as a finite element system and the far-field is treated as a continuum. System identification techniques will be used to represent the effects of the far-field on the near-field.

The hybrid model will be used to study the dynamic response of structures supported on embedded foundations. Parametric studies will be used to evaluate the effects of structure — soil interaction on earthquake response of embedded structures; to identify the conditions under which these effects are significant; and, to identify the conditions under which such effects can be ignored.

Earthquake Behavior of Techi Dam; *Ray W. Clough,* University of California-Berkeley, Department of Civil Engineering, Berkeley, CA 94720; $140,173 for 24 months beginning January 15, 1979.

Numerical methods, particularly finite element procedures, for seismic response analyses of arch dams have been well developed. However, many assumptions inherent in the analyses have not been verified by experiments, and uncertainties remain in the results even after refined analyses. The objective of this project is to conduct U.S.-Republic of China cooperative research to obtain seismic response information from the Techi Dam in Taiwan. The Techi Dam, a modern, thin shell concrete arch structure located in the region of significant seismicity, offers a unique opportunity to obtain data on the actual seismic behavior of an arch dam. The project will install additional instrumentation in the dam, calculate and measure the dam vibration properties, refine the mathematical model through numerical analysis, observations and correlaton study, evaluate the seismic response, and perform table tests of scaled dam models.

The project will demonstrate the effectiveness of current response analysis procedures and will provide improved techniques for treating reservoir and foundation interaction, as well as better understanding of expected failure mechanism.

Probabilistic Earthquake Hazard and Risk Assessments; *Lloys S. Cluff,* Woodward-Clyde Consultants, Three Embarcadero Center, Suite 700, San Francisco, CA 94111; $59,615 for 18 months beginning June 1, 1979.

Existing deterministic criteria for defining "active" (or "capable") faults do not consider the degee of fault activity, which involves such parameters as rate of slip, amount of slip, recurrence interval, and earthquake magnitude. As a result, faults with low slip rates, small amounts of slip, and long recurrence intervals are considered on an equal basis with faults having high slip rates, large amounts of slip, and short recurrence intervals. A framework must be established that will allow the degree of fault activity to be taken into consideration in quantifying seismic hazards[1] and in assessing seismic risk.

This study will involve an analysis of fault activity parameters using published and unpublished worldwide data. The result of this analysis will be a refined scheme for classifying degree of fault activity that compares and characterizes different degrees of fault activity in different tectonic environments. Using this classification scheme as a basis, a formula for probabilistic earthquake hazard and risk assessments will be provided.

Engineering Ground Motion Prediction Procedures; *C. Allen Cornell,* Massachusetts Institute of Technology, Department of Civil Engineering, Cambridge, MA 02139; $292,810 for 24 months beginning July 15, 1979.

This project will develop new engineering procedures for making ground-motion predictions by incorporating recent advances in theoretical ground-motion studies, analyses of strong-motion data, and probabilistic and statistical methodologies for engineering risk applications.

Theoretical models will be used to develop ground-motion parameter dependence relationships and to study the biases in parameter estimates. Specific research tasks are: inference analysis of geophysical ground motion models to determine parameters of first-order importance and to establish the general dependence relationship between the ground motion and these parameters; to perform regression analysis for improved analytic methods for ground motion predictions; use of representative ground-motion samples to study the biases in the estimations;' Bayesian statistical analysis to quantify the uncertainty in prediction resulting from finite sample sizes; and development of a new probabilistic seismic hazard analysis methodology for engineering applications.

Response of Submerged Shells to Seismic Waves; *Subhendu K. Datta,* University of Colorado, Department of Mechanical Engineering, Boulder, CO 80309; $30,000 for 12 months beginning January 1, 1979.

This research will investigate the dynamic response of circular cylindrical and spherical shells submerged in a semi-infinite, linearly elastic medium due to incident seismic waves. Particular attention will be focused on the three-dimensional response of these structures to obliquely incident and Rayleigh waves. The objective is to assess the relative importance of various parameters (the physical properties of the shell and the medium; the depth-to-radius ratio of the shell; the wavelength of the disturbance; the angle of incidence of the incident wave) influencing the critical response of the shell. The study covers three stages. In the first stage, attention will be focused on the two-dimensional motion of a circular cylindrical shell. This will be followed by an analysis of the three-dimensional motion. In the last stage, the three-dimensional motion of a spherical shell will be studied. The mathematical techniques to be used for these analyses are a method of matched asymptotic expansions and a method of successive reflections.

A Model Study of Pile Bearing Capacity in Liquefiable Sand Deposits Under Earthquake Loading; *Pedro A. DeAlba,* University of New Hampshire, Durham, Department of Civil Engineering, Durham, NH 03824; $29,660 for 12 months beginning January 1, 1979.

A model study will be conducted of pile settlement and bearing capacity in saturated sand subjected to earthquake loading. Liquefaction will be induced in sand samples six inches high and 22 inches in diameter

by means of a simple-shear type apparatus. The technique is one by which one or more piles can be inserted into a sample already subjected to confining pressure, thus producing stress conditions similar to those existing around a driven pile in the field. The testing program will investigate the behavior of single piles and four-pile groups for different sand densities and confining pressures, including both freshly-deposited samples and samples previously subjected to minor earthquake loadings. Pile settlement and intergranular pore pressure developed during loading would be monitored continuously for each test and the results presented in the form of normalized plots applicable to field situations.

Duration Characteristics of Horizontal Components of Strong Motion Earthquake Records; *Ricardo Dobry,* Rensselaer Polytechnic Institute, Department of Civil Engineering, Troy, NY 12181; $233,037 for 24 months beginning September 15, 1979.

A key aspect in the reduction earthquake hazards is the characterization of strong ground motions. The overall intensity of the motion has been generally characterized by a single number which is identified with the level of shaking. Theoretical studies and field evidence indicate that the duration of the motion is also important.

Two parameters for the overall characterization of rock ground motions will be used. Characterizations will include variation with time of the level of shaking and of the principal axes of ground motion. Determination of the frequency content and a study of the peak vector acceleration will also be undertaken. This detailed characterization of the records will be correlated with the different seismic waves arriving at the site with relevant seismological factors. Finally, a study will also be performed for the individual horizontal components of the records.

A Symbol Processor for Earth Dam Seismic Response with a Nonlinear-Inelastic Soil Model; *John O. Dow,* University of Colorado, Department of Civil/Environmental/Architectural Engineering, Boulder, CO 80309; $28,160 for 12 months beginning January 1, 1979.

Research objectives are to improve the nonlinear, inelastic soil model in the seismic response analysis of earth dams and to incorporate all developments into a currently used, finite element earth dam seismic response program. The developments will include the significant nonlinear effects caused by large shear deformations by modeling the soil with a step-wise linear representation. Recently developed symbol processing techniques will be utilized in the development of finite element and overall system matrices to replace approximate numerical algorithms with exact operations, formulate expressions which are too complex or time-consuming to be performed by hand, and generate closed-form solutions by executing numerical algorithms in symbolic form.

The research will provide an analysis procedure for seismic stability and liquefaction potential in embankment dams, static analysis of nonlinear, inelastic systems, dynamic analysis of other large systems such as buildings and bridges.

Maximizing the Learning from Destructive Earthquakes; *C. M. Duke,* Earthquake Engineering Research Institute, Department of Engineering, Berkeley, CA 94704; $50,005 for 12 months beginning July 1, 1979.

The previous "Learning from Earthquakes" Project of the Earthquake Engineering Research Institute has produced Planning, Field Guides and Earthquake Response Procedures. The project's implementation effort has included national governmental and private organizations and several state and local areas in the United States. Coordination plans for cooperating organizations have been developed at the national and California levels. Post-inspection team members and others have used the Field Guides following nine foriegn and United States earthquakes since 1973, and the important new lessons learned have been disseminated to concerned organizations and individuals. This award will maintain the implementation effort at an acceptable level; revise, publish, and distribute the Guides and Response Procedures; and expand programs to train investigators and to improve the dissemination of lessons learned.

Post Event Investigations to Maximize Learning From Destructive Natural Disasters; *Edward Epremian,* National Academy of Sciences, Committee on Natural Disasters, Civil Engineering, Washington, D.C. 20418; $85,000 for 12 months beginning September 1, 1979.

This project will make possible the collection of perishable information after natural disasters (such as earthquakes) which cause sudden, widespread destruction and disruption of the economic and social structure of an area. Such a disaster is, in effect, a full-scale test of facilities designed and built to a variety of codes and standards.

Because rescue activities may involve large physical movement of debris and damaged facilities and because clean-up operations may start quite quickly after the disaster, it is necessary to have professional teams visit the site immediately to capture information which documents and explains failures and/or satisfactory performance of facilities. The National Academy of Engineering and National Academy of Science are in a unique position to organize and dispatch interdisciplinary teams to collect and publish perishable information which can provide a basis for in-depth studies at a later time. Such an arrangement will, in particular, maximize information from disasters occurring in foreign countries.

1979 Multiprotection Design Institute; August 6 through August 17, 1979; DCPA Staff College; Battle Creek, Michigan; *George T. Goforth,* Department of Defense, Department of Defense/Defense Civil Preparedness Agency, Washington, D.C. 20301; $25,000 for 6 months beginning August 1, 1979.

This award provides support for the 1979 Multiprotection Design Institute. One-week short courses in Earthquake Engineering and Ground Motion, Fire Safety in Building Design, Designing of Buildings Against Wind, and Energy Conservation Design in Buildings will be held for architectural and engineering faculty of accredited colleges and universities who are actively engaged in dealing with natural hazard mitigation problems.

The purpose of the Institute is to stimulate insights into the nature and complexities of mitigation of natural hazards resulting from earthquakes, fire, and wind. This purpose can be achieved by an informal type of institute consisting of scheduled lectures and discussions by leading experts bringing to the Institute results from the forefronts of research.

Seismological Investigation of Strong Ground Motion: The San Fernando Earthquake; *Donald V. Helmberger,* California Institute of Technology, Department of Geological and Planet Science, Pasadena, CA 91104; $61,080 for 12 months beginning February 1, 1979.

Many researchers consider the wealth of near- and far-field data obtained from the San Fernando earthquake to be the single most important data set for understanding the dynamics of earthquakes to date. However, the event was a complicated one, involving complex rupturing situated in a complex geological environment. In 1976, funds were provided for the support of a 24-month California Institute of Technology project involving theoretical and observational investigations of the physical significance of the strong ground motion generated by the San Fernando earthquake. This project will continue the numerical modeling of the ground motions of the earthquake. The results of this research, in conjunction with recent progress in the deterministic models of other earthquakes, should greatly improve our ability to predict strong ground motions in many situations.

Generate Mathematical Models of Slide Induced Waves; *R. S. Hickman,* University of California-Santa Barbara, Department of Mechanical and Environmental Engineering, Santa Barbara, CA 93106; $29,320 for 12 months beginning January 1, 1979.

The generation of tsunamis by earthquakes is well-known and has received much attention. This research is aimed at understanding local large amplitude tsunami-like waves caused by landslides into the

ocean. The first task will be to generate a marker in the cell numerical solution to the hydrodynamic equations. Two computer models will be developed. One model will be a simple two-dimensional analysis. The second will be cylindrically symmetric. Solutions for time-dependent boundary movement (simulating a landslide or landfall) will be used to compare results to existing data. Representative calculations of waves generated in lakes will be made to obtain estimates for comparisons to known earthquake-landslide produced waves. Extension of the calculations to include three-dimensional and topological details of the ocean floor will be started if the two-dimensional calculations produce reasonable results. Ultimately, the three-dimensional analysis will be used to assess potential hazards to shore facilities located near potential slide areas.

Seismic Response of Structures and Strong-Motion Instrumentation; *George W. Housner,* California Institute of Technology, Department of Engineering and Applied Science, Pasadena, CA 91104; $404,552 for 12 months beginning May 1, 1979.

A three-year program of research in earthquake engineering at the California Institute of Technology will be undertaken. The program includes the analysis of recorded earthquake motions of structures; dynamic testing of structures; the analysis of vibrations in the strongly nonlinear range where damage is occurring; the development of a portable digital accelerograph network; operation and upgrading of existing strong-motion instrument networks of the program; and analysis of earthquake data to improve seismic design criteria.

National Information Service for Earthquake Engineering; *George W. Housner,* California Institute of Technology, Department of Civil Engineering/Applied Mechanics, Pasadena, CA 91104; $90,493 for 12 months beginning July 1, 1979.

This award supports the Center for the National Information Service for Earthquake Engineering at the California Institute of Technology. This service is part of the joint program with the University of California at Berkeley.

The Center provides a data base for information on earthquake engineering topics through the library services, copies of reports, copies of accelerograms, digitized card decks, and magnetic tapes. The Earthquake Engineering Research Library and the Strong Motion Records Data Bank form the nucleus of the activity. The Service Center provides engineering information to users throughout the country, such as engineering and architectural consulting firms, industrial firms, local, state and Federal agencies, and other professional organizations.

In Situ Soil Dynamic Testing and Analysis to Determine Soil Constitutive Properties; *Paul Ibanez,* ANCO Engineers, Inc., 1700 Colorado Avenue, Santa Monica, CA 90404; $121,187 for 15 months beginning July 1, 1979.

The purpose of this research is to develop a coupled *in situ* dynamic testing/nonlinear modeling technique for determining the *in situ* dynamic properties of soils. Such an approach to site soils modeling and earthquake engineering could supplement and possibly supplant laboratory test techniques which of necessity involve disturbed soil samples, and which require substantial engineering judgment to interpret.

A major component of this research is the experimentally validated transfer of technology in nonlinear soil modeling and multi-dimensional nonlinear wave propagation computer methods from the defense community into the civilian sector. The research consists of execution of a series of insitu dynamic tests at a previously studied site; use of advanced numerical techniques and nonlinear constitutive laws to model the experiments; sensitivity studies to establish a sensitivity matrix; and the use of this sensitivity matrix in parameter identification studies to establish the optimal nonlinear constitutive soil model, taking into consideration both model and experimental uncertainties. A better knowledge of subsurface *in situ* properties will lead to greater confidence in the seismic safety of such structures as dams and power plants.

Prediction of Dynamic Material Properties from their Static Shear Behavior; *Edward Kavazanjian,* Stanford University, Department of Civil Engineering, Stanford, CA 94305; $30,000 for 12 months beginning January 1, 1979.

The primary objective of this research is to establish procedures for predicting the behavior of soil subjected to uniform cyclic shear loads from the results of static shear tests. A second objective is to establish correlations between soil index properties used to describe the results of static tests and the parameters required to describe material behavior.

Evaluation of the parameters required to describe the behavior of soil in dynamic response analysis involves sophisticated and expensive laboratory cyclic shear tests. The ability to predict the results of these cyclic tests from static shear tests on the basis of "general" stress-strain laws would greatly simplify the evaluation of these parameters. Furthermore, it would facilitate the use of existing empirical correlations between soil index properties and hyperbolic static stress-strain parameters in estimating the value of dynamic parameters for use in preliminary analysis.

Statistical Investigation of Engineering Seismology; *Leon Knopoff;* University of California-Los Angeles, Institute of Geophysics and Planetary Physics, Los Angeles, CA 90024; $100,523 for 16 months beginning March 1, 1979.

This project addresses two significant problems of engineering seismology: seismic risk estimation and the theory of earthquake sources. These two problems are interrelated and interdependent. The methods of analysis in the study of these problems are statistical investigations of seismicity and physical models of earthquake faults.

The project will be based on recently developed stochastic models of earthquake occurrence and previous theoretical results. This research will develop basic procedures for seismic risk estimation in a given region, investigate periodicities of seismicity by statistical means, improve the established stochastic dependence between seismicity and source complexity, and refine and test the developed synthetic seismicity program.

The goals of this research are to develop an improved model and numerical methods, based on physics and statistics, for estimating regional earthquake risk, and to quantify the risk for engineering applications.

Development of a Computer Code for the Response of Submerged Structures to Seismic Excitations; *Denny R. Ko,* Dynamics Technology Inc., 22939 Hawthorne Boulevard, Suite 200, Torrance, CA 90503; $125,719 for 12 months beginning July 1, 1979.

This research addresses the problems of designing submerged structures, such as oil storage tanks, to resist the combined loadings of earthquake and wave forces. Studies include the dynamic responses of submerged tanks subjected to seismic action. A general finite element solution procedure has been formulated and a general computer program for use in tank response analysis will be developed for use by design engineers and other researchers. Also included will be studies of internal wave sloshing effects inside submerged tanks under horizontal and vertical ground excitations; studies of the coupling between interior and exterior fluids; and the formulation of tank-coupled system solution procedures.

Dynamic Properties of Clays under General Three-Dimensional Stresses; *Hon-Yim Ko,* University of Colorado, Department of Civil Engineering, Boulder, CO 80309; $140,845 for 24 months beginning April 15, 1979.

This research addresses the problems of designing submerged structures such as oil storage tanks to resist the combined loadings of earthquake and wave forces. Studies include the dynamic responses of submerged tanks subjected to seismic action. A general finite element solution procedure has been formulated and a general computer program for use in tank response analysis will be developed. Also includ-

ed will be studies of wave sloshing effects inside submerged tanks under horizontal and vertical ground excitations; studies of the coupling between interior and exterior fluids; and the formulation of tank-coupled system solution procedures.

Earthquake Engineering Applications of Nonstationary Autoregressive Models; *Frank Kozin,* Polytechnic Institute of New York, Department of Electrical Engineering, Brooklyn, NY 11201; $168,217 for 24 months beginning December 1, 1978.

Nonstationary random characteristics are manifested in the magnitude variations as well as the frequency variations of strong motion acceleration records. To date, strong motion seismic data have not generally been treated as a statistical time series using available estimation and modeling techniques. Recently, an autoregressive model was developed which satisfactorily accounts for the nonstationary random characteristics of seismic disturbance.

This research project is directed at applications of this model to seismic problems, earthquake engineering problems, and general inverse problems of modeling from nonstationary time series. Problems such as simulated seismic occurrences, determination of subsurface information by coefficient estimation, and spectral characteristics of earthquake input and response of structures will be investigated. In addition, statistical questions such as how well does the model fit the data and physical questions such as how well does the model describe the physical phenomena will be addressed.

Fluctuating Pressures on Tall Buildings; *Bernard M. Leadon,* University of Florida, Department of Engineering Sciences, Gainesville, FL 32611; $77,311 for 12 months beginning October 1, 1979.

This research will obtain full-scale dynamic wind measurements and compare these with predictions of theories for the interaction between turbulent winds and obstacles; examine the relation between small-scale wind tunnel studies and full-scale structures to estimate the dynamic response of structures under lateral loadings of low frequency; and estimate the convective film heat transfer coefficient for smooth surfaces in curtain walls.

Specific studies to be made are: fluctuating pressure measurements, glass light deflections, and lateral displacement of the structure of the Independent Life Tower (I.L.T.) in Jacksonville; wind tunnel tests of a ¼-scale model of curtain wall section with mullions; wind tunnel tests of models of the I.L.T. (at Colorado State University); and, comparison of results with a theory of the interaction of turbulence with obstacles in the flow.

Structural Response Under Random Wind Loading; *Y.K. Lin,* University of Illinois-Urbana, Department of Aeronautical, Astronautical Engineering, Urbana, IL 61801; $9,000 for 3 months beginning June 1, 1979.

Strong-motion earthquake and strong gusty winds are dynamic natural hazards to man-made structures. Large deflections, over-stresses, and structural instability can take place under certain unfavorable loading conditions. The conventional treatment of such problems is often based on simple equivalent static forces and on deterministic modeling of complex dynamic loading and response processes. More sophisticated analysis is required to improve our understanding of the behavior of structures subjected to the random forces generated by winds or earthquakes.

In the project which this award supplements, analytical studies established the mathematical theory for structural response to random gusty winds and applied stochastic stability concepts to solve the wind-induced structural instability problems. This amendment will provide additional staff time and support to investigate the feasibility of modifying the methodology developed for wind conditions in earthquake applications. The emphasis of the study will be on the treatment of nonstationary parametric excitations on the effects of interaction of vertical and horizontal ground motions to the response of structures.

Numerical Modeling of Tsunamis; *Philip L. F. Liu,* Cornell University, Department of Environmental Engineering, Ithaca, NY 14850; $51,420 for 12 months beginning December 15, 1978.

Tsunamis are ocean waves generated primarily by undersea earthquakes of shallow focus depth during which vertical dislocations of the sea floor occur. Tsunamis present a major hazard to life and property when they strike the shorline of exposed areas. To minimize such loss, it is essential to develop an accurate and efficient computation method describing the generation, propagation, and amplification of tsunamis.

The project is primarily devoted to the problem of tsunami wave generation. Its objective is to establish a more sophisticated numerical model of tsunami generation which includes both non-linear and dispersion effects. The Boundary Integral Equation Method (BIEM), which can solve free surface flow problems more efficiently and economically than either finite difference or finite element methods, will be formulated, investigated and applied to tsunamis problems.

Response of Three-Dimensional Structure to Non-Vertically Incident Seismic Waves; *Juan E. Luco,* University of California-San Diego, Department of Applied Mechanics and Engineering Science, La Jolla, CA 92093; $141,295 for 24 months beginning April 15, 1979.

As part of a continuing study of the dynamic interaction between structures and the soil, a systematic analysis of the dynamic response of structures subjected to non-vertically incident seismic waves will be undertaken. In this study, a structure will be represented by an elastic three-dimensional model (symmetric or non-symmetric), the foundation will be modelled as a rigid mat (flat or embedded), and the soil will be represented by a viscoelastic half-space (uniform or layered). The seismic excitation will be modelled as plane non-vertically incident P, SV, Rayleigh, SH and Love Waves. Particular emphasis will be given to the evaluation of additional torsional and rocking components of motion induced by non-vertically incident waves.

This work is motivated by recent studies that tend to invalidate conventional assumptions with regard to vertically incident seismic waves, and by our need to incorporate the additional rocking and torsional components of motion in the earthquake-resistant design of structures. To solve the complete soil-structure interaction problem with non-vertically incident seismic excitation, a sub-structuring procedure is proposed. The procedure is based on the use of carefully developed solutions for simpler sub-problems.

Site and Source Effects on Design Earthquake Motions; *Ajit K. Mal,* University of California-Los Angeles, Department of Mechanics and Structures, Los Angeles, CA 90024; $160,000 for 24 months beginning May 1, 1979.

The objective of the research is to investigate the effects of source and site on design earthground ground motions. A representation theorem which relates the Fourier Transform of the ground motion directly to the displacement discontinuity across a fault will be used to study the effect of the source on the ground motions. A semi-empirical linear system theory and an improved version of the Haskell-Thomson Algorithm will be used to study the effect of the site on ground motion. Field modeling of sites and field experiments will be conducted to verify the analytical procedures that are developed.

Workshop on Wind Characterization for Dynamic Analysis of Structures; *Kishor C. Mehta,* Texas Tech University, Department of Civil Engineering, Lubbock, TX 79409; $15,195 for 12 months beginning August 15, 1979.

This award provides partial support for a two-day workshop on the geographical distribution of wind climate. Objectives of the workshop are to examine available wind data for its applicability to design practice, to review statistical methods for converting raw wind data into usable forms, to establish current state-of-knowledge in wind climate data collection and recording procedures to recommend guidelines for future data collection, and to promote dialogue between meteorologists and wind engineers.

Many organizations and agencies collect wind data but its usefulness is flawed by lack of continuity, lack of uniformity in collection and recording procedures, and lack of availability. This workshop, involving meteorologists and engineers who are concerned with design for wind climates, will promote better use of collected data and improvement in collection of future data. The resulting information will have direct application in the design of high cost and critical facilities subjected to wind and earthquake loadings.

Vulnerability of Transportation and Water Systems to Seismic Hazards; *Irving J. Oppenheim,* Carnegie Mellon University, Department of Civil Engineering, Pittsburgh, PA 15213; $105,120 for 12 months beginning March 15, 1979.

Lifeline engineering is the evaluation of the dependence of urban regions on their service systems. The essential features of lifelines are their geographical extent and their redundancies (or lack thereof).

Lifeline models will be developed which will permit the preparation of inverse iso-seismal maps for given lifelines: zones within which a shock of given magnitude will cause lifeline failure. The integrated value of earthquake frequency over the areas contained within the inverse iso-seismals (or the "damage areas") is a direct measure of seismic risk. This problem is particularly significant for areas in the east-central part of the United States.

Lifeline models and earthquake risk calculations will be generated for selected major eastern and western cities. The techniques will be presented in a manner facilitating their use by other analysts. The results of the analyses of the selected cities will serve to illustrate the increased seismic risk encountered in a lifeline analysis (as opposed to an *in-situ* structural analysis) and the increased relative risk for east-central areas.

Analytical Modeling of Buried Pipeline Response to Static Earthquake Displacement; *Thomas D. O'Rourke,* Cornell University, Department of Civil/Environmental Engineering, Ithaca, NY 14850; $28,970 for 12 months beginning January 1, 1979.

The research will develop an analytical model for buried pipeline response to static earthquake displacement. The model will use the finite element method because of its special capabilities for simulating various aspects of the soil-pipeline system, such as individual lengths of pipe, couplings, slip surfaces, and soil. The model will be used for a parameter study of pipeline response to fault movement. The parameters under study will include the geometry of earthquake movement, angle of intersection between pipeline and fault, pipe material, type and spacing of couplings, soil strength parameters, and the relative stiffness between the pipeline and surrounding soil. Field observations of various pipelines that have been subjected to fault displacements will be summarized and used to evaluate the results of the model. In addition, the model will be used to judge relative improvements in pipeline behavior as a function of changes in the line construction.

National Information Service for Earthquake Engineering; *Joseph Penzien,* University of California-Berkeley, Earthquake Engineering Research Center, Berkeley, CA 94720; $318,485 for 12 months beginning April 1, 1979.

The National Information Service in Earthquake Engineering (NISEE) has become the national focus for information on earthquake engineering data, projects and research reports. NISEE provides for the transfer of earthquake and other hazards information generated through research to the public users. This award will enable NISEE to collect and assess information from many different sources in order to provide a single, efficient source for researchers in the field who wish to obtain information from a comprehensive collection. The project will be geared to meet the needs of both academic researchers and design engineers at the national level. NISEE's computer program distribution service now has many programs, each fully developed and suitable for use in professional engineering offices. New programs will be added to the library and made available for distribution as they are developed. The Earthquake

Engineering Research Library will maintain collections of reports (both published and unpublished), site visit records, data acquired from various seismic regions, and provide an abstracting service and a technical journal directed to the needs of earthquake engineers.

The United States-Japan Cooperative Research Program on Large-Scale Structural Systems: A Planning Study; *Joseph Penzien,* University of California-Berkeley, Department of Civil Engineering, Richmond, CA 94720; $8,570 for 6 months beginning March 1, 1979.

Traditionally, concepts for design of structures to resist earthquake forces have evolved from post-inspections of earthquake damage and laboratory simulations. As beneficial as these concepts are, many factors cannot be evaluated by inspection or small scale tests.

The results of small-scale tests could be verified by full-size structural tests to evaluate the time behavior in a structural system. A program to extend the tests to full size structures to determine the parameters which can not be evaluated otherwise would be desirable and beneficial to the engineering profession.

This project will undertake a planning study for development of an effective research program of maximum benefit to both the United States and Japan on large-scale tests of structural systems. A task committee to be established under the U.S.-Japan Panel on Wind and Seismic Effects, U.S.-Japan Panel on Wind and Seismic Effects, U.S.-Japan Natural Resources Program, will be responsible for making detailed plans and recommendations on such a program.

Development of Field Techniques to Measure Damping Values for Near-Surface Rocks and Soils; *Bruce B. Redpath,* John A Blume and Associates, Research and Technical Development, 130 Jessie Street, San Francisco, CA 94105; $183,241 for 18 months beginning August 1, 1979.

Research efforts in the fields of soil-structure interaction and site response to earthquake loading have produced advanced numerical models that require the damping characteristics of the subsurface materials as input. Developments in engineering geophysics have not kept pace with progress in calculational approaches to solving earthquake response problems.

In order to develop practical field techniques to acquire the needed dynamic properties of site materials, geophysical investigations will be conducted to measure the attenuation of shear and compressional seismic waves. Down-hole and cross-hole surveys of velocities and attenuation rates will be carried out in 200-ft holes at two sites; one, in sedimentary rock; the other, in alluvial deposits. The observed attenuation characteristics (Q), corrected for geometrical spreading and any changes of acoustic impedance in the ray paths, will be used to determine values for the near-surface materials.

Two methods of data analysis will be applied. One will determine Q indirectly by calculating spectral ratios of both compressional and shear pulses to determine the magnitude and frequency dependence of the attenuation coefficient in the exponential term of the propagation equation. The other method will test a relationship in which the rise-time of a seismic pulse is proportional to its travel time and in which the constant of proportionality is Q^{-1}. The end product of the proposed research will be practical recommendations for field procedures and data analysis to measure Q-values in near-surface materials.

An Evaluation of Laboratory Testing Techniques in Soil Dynamics; *Adel S. Saada,* Case Western Reserve University, Department of Civil Engineering, Cleveland, OH 44106; $136,274 for 24 months beginning July 1, 1979.

Laboratory testing plays an important role in determining the parameters needed in the design of earthquake-resistant structures, offshore platforms, machine foundations and others. High quality, appropriate tests are necessary to simulate field conditions and to provide the design parameters. The two types of tests that have been traditionally used to determine dynamic soil properties at large strains are the simple shear test and the standard triaxial test. This research will study differences among the various

tests used in obtaining the dynamic properties of soils. Particular emphasis will be placed on the cyclic triaxial test, the simple shear test and the thin, long hollow cylinder test. This phase of the investigation will concentrate on clay while the second phase will study sandy soils.

Development of an in Situ Liquefaction Evaluation System; *Dwight A. Sangrey,* Cornell University, School of Civil and Environmental Engineering, Ithaca, NY 14850; $145,575 for 24 months beginning June 15, 1979.

An *in situ* liquefaction evaluation system based on effective stress methods and the prediction of excess pore pressure due to cyclic loading will be developed. Previous research has shown that excess pore pressure resulting from undrained cyclic loading of various soils can be related to several fundamental soil properties, including volumetric compressibility. Emphasis will be on measuring these properties in situ so that strength reduction or liquefaction potential of soils can be predicted for cyclic loading.

The research is divided into three phases. The first phase will be a theoretical analysis of the existing effective stress model to obtain a practical design for an *in situ* testing device. The equipment will be built and tested to confirm that it does measure the desired soil properties. Finally, appropriate user oriented manuals will be prepared.

Improving Earthquake Resistance of Power Transmission Substations; *Anshel J. Schiff,* Purdue University, Department of Mechanical Engineering, Lafayette, IN 47907; $94,029 for 12 months beginning June 1, 1979.

The objective of this project is to improve the earthquake safety of electrical power systems and facilities. Performance of power systems during past earthquakes shows that one weak link in these systems is substations. This project focuses attention specifically on earthquake problems associated with power substations and emphasizes the implementation of the research results for improved seismic design of power systems.

Three major research tasks will be conducted. A draft seismic design guide for power system transmission facilities emphasizing substations will be developed, a unified design procedure for power system analysis under seismic, ice, wind and short circuit loads will be developed, and the seismic reliability of circuit breakers, including examination of transformer failures during the Sendai, Japan (June 12, 1978) earthquake, will be evaluated.

The research will establish improved analysis and design capabilities which can be easily adopted by utilities to improve their earthquake safety practices. Close interactions with utilities and with professional society power lifeline committees will be maintained to guide the research and to assure its utilization.

Dynamic Properties of a Cohesive Soil; *M. G. Sharma,* Pennsylvania State University, Department of Science and Medicine, University Park, PA 16802; $30,000 for 12 months beginning January 1, 1979.

The purpose of this investigation is to study the dynamic mechanical behavior of a cohesive soil and to develop dynamic constitutive relations that reflect the elastic-viscoplastic responses of the soil. To achieve these objectives, dynamic tests involving the uniaxial compressive sinusoidal loading (super-imposed on a static loading) for frequencies ranging from 1 to 1000 hertz, and uniaxial compressive stress-strain tests for deformation rates ranging from 0.01 to 20 in./min., will be performed. Sinusoidal experimental results will be reduced to obtain dynamic stiffness and damping coefficients for various frequencies of loading. In the stress-strain tests, the load will be monotonically increased up to a predetermined load level and then gradually decreased until it becomes zero. During loading and unloading cycles in the experiments a particular deformation rate will be maintained. The experiment will be repeated for several magnitudes of permanent (plastic) strain, and the recoverable (elastic and viscoelastic) strain will be ascertained for each deformation rate and stress magnitude. The results from these tests will be interpreted to develop one-dimensional viscoplastic constitutive relations for the soil, including a yield function that is rate dependent

and the elastic constants to represent the elastic response. Finally, attempts will be made to perform an analysis of a rigid footing on a viscoplastic medium to demonstrate the applicability of the developed constitutive relationship.

Probability Distribution of Extreme Wind Speeds; *Emil Simiu,* National Bureau of Standards, Center for Building Technology, Gaithersburg, MD 20234; $68,286 for 12 months beginning May 15, 1979.

Improved code provisions for the design of structures for wind loads are a prerequisite for achieving more rational and economical designs. To develop such provisions, improvements are necessary in the practical application of the probabilistic approach to the definition of design wind speeds.

Although this approach has already been used in the American National Standard ANSI A58.1-1972, important questions regarding its practical use are still unsolved. The first question is whether the type of extreme value probability distribution that best fits series of maximum annual wind speeds in Gumbel (as is assumed in the National Building Code of Canada and in all probabilistically-based European Codes) or Frechet (as assumed in ANSI A58.1). Second, the magnitude of the sampling errors needs to be estimated. Third, estimates are required of the errors associated with quality of the data. Fourth, the question needs to be examined of the extent to which short-term data (e.g., three years of record) can provide useful information on long-term wind extremes. Fifth, the important question of modeling the pobability of occurrence of hurricane winds needs careful examination. Sixth, the question needs to be investigated of the mean recurrence intervals that must be specified for design purposes if consistent levels of safety for structures subjected to wind loads are to be achieved. This research aims at elucidating these questions by using climatological data, as well as results and tools from such disciplines as probability theory, statistics, micrometeorology, climatology and reliability theory.

Seismic Stability Evaluation of Earth Structures; *Mahendra P. Singh,* Virginia Polytechnic Institute, Department of Engineering Science/Mechanics, Blacksburg, VA 24061; $30,000 for 12 months beginning January 1, 1979.

The main objective of the proposed research is to develop a simple and efficient analytical approach which can use seismic inputs defined in terms of response spectra curves for calculation of seismic stability of materially nonlinear earth structures like slopes, embankments, dams and foundations. To achieve this, a stochastic approach has been formulated which will be refined further and validated by a comprehensive numerical simulation study. In the simulation study, models of horizontally layered soil media and an earth dam will be analyzed by the stochastic approach and by a nonlinear approach. An ensemble of time histories which are statistically equivalent to the stochastic input used in the proposed approach will be used as seismic inputs in the nonlinear analysis. A comparison of various response quantities obtained by the two different approaches will provide a necessary corroboration for validation of the proposed approach. A comparison of the results with results obtained by a currently used equivalent linear approach will also be made.

Earthquake Induced Soil-Structure-Water Interaction for Gravity-Type Ocean Structures; *Lars Skjelbreia,* Sincc Engineering Associates, 2111 West Crescent Avenue, Suite A, Anaheim, CA 92801; $198,360 for 24 months beginning July 1, 1979.

Ocean structures present special problems for engineers because of the loading conditions associated with wave forces and earthquake excitations. This research addresses two important problems for such ocean structures: the soil-structure interaction problem and the earthquake-induced hydrodynamic response problem.

Research is undertaken in this project to evaluate the potential of foundation failure for a gravity-type structure under seismic action by investigating per-

manent ground deformation due to cyclic loadings, and determine the hydrodynamic forces acting on the structures as a result of seismic action and evaluate the potential of structural damage. A computer program will be developed to determine the response and to assess the safety of the foundation. Small-scale laboratory experiments will be conducted by California State University, Fullerton, to complement the analytic work.

Dynamic Behavior of Cohesive Soils; *Frank Somogyi,* Wayne State University, Department of Civil Engineering, Detroit, MI 48202; $30,000 for 12 months beginning January 1, 1979.

This research involves a critical evaluation of the Menard pressuremeter as an instrument for determining the behavior of cohesive soils under cyclic pressuremeter moduli as well as limit pressures before and after cyclic loading. The effects of both range and number of cyclic loadings will be assessed. In addition, various isotropically and anisotropically consolidated triaxial tests will be performed in order to determine possible correlations between in-situ and laboratory measured soil parameters.

Predicting Response Spectra in Eastern United States from Known Displacement Spectra Densities; *Ronald L. Street,* University of Kentucky, Department of Geology, Lexington, KY 40506; $130,642 for 36 months beginning May 1, 1979.

A serious problem exists in the establishment of proper earthquake design criteria for structures in the Eastern United States (EUS) because of the lack of strong-motion records of EUS earthquakes. Current methods, based on gross assumptions about earthquake intensity, peak acceleration, and about the attenuation characteristics of ground motions in EUS appear insufficient and need improvement. To remedy this situation, researchers must enhance the strong-motion instrument program in EUS to capture future data; they must conduct research to improve physical geological understanding of the EUS earthquakes; and they must develop improved methods for characterizing the EUS earthquake motions and for defining the EUS design earthquake parameters.

This project is to conduct a comprehensive study to improve the characterization and the modeling of ground motions due to EUS earthquakes.

This project will develop alternative methods for predicting peak ground-motion parameters in EUS by using existing instrument records of EUS earthquakes to characterize the spectral content and duration of the motion, and define the design earthquake motions. A broad sample of EUS earthquake records will be analyzed and their magnitudes, seismic moments, and spectral characteristics will be determined. The duration of strong-motion due to EUS earthquakes as a function of magnitude, corner frequency, and epicentral distance will be determined. An EUS ground-motion model will be developed.

Risk Methodologies in Geotechnical Design of Offshore Structures; *Wilson H. Tang,* University of Illinois-Urbana, Department of Civil Engineering, Urbana, IL 61801; $97,637 for 30 months beginning June 1, 1979.

The design and construction of offshore structures must take into account the complex problems of interaction of wave forces, earthquake loads, and soil-structure response. Since failures are costly because of large investments and possible environmental losses, the reliability of offshore structures is of concern not only to producers but to regulatory agencies.

This research will identify failure events associated with foundation performance of offshore structures; construct risk event trees; and develop a procedure to evaluate failure probabilities. Because there are few case histories available on the performance of offshore structures, those case histories which do exist will play a large role in the design of future structures. (See also Wu, T.H.)

An Improved Computational Strategy for the Nonlinear Analysis of Structures Subjected to Earthquake and Wind Loads; *Theodore G. Toridis,* George Washington University, Department of Engineering and Applied Science, Washington, DC 20052; $69,646 for 12 months beginning September 1, 1979.

This project will develop an effective computational strategy for the nonlinear dynamic analysis of large structures subjected to wind and earthquake loadings. Such a strategy would maximize the quality of results and minimize the total effort (and cost) required to produce them (including the effort in spatial and temporal discretization, handling of algebraic equations and computer implementation).

The following will be investigated: the use of mixed formulation (with displacement and stresses chosen as fundamental unknowns) in conjunction with modified multistep integration schemes (based on first-order equation formulation); and, use of adaptive techniques to automatically control the time step, the order of integration algorithm, and the finite element mesh size based on a preselected set of criteria.

Earthquake Engineering Investigation of Strong Ground Motion; *Mihajlo D. Trifunac,* University of Southern California, Department of Civil Engineering, Los Angeles, CA 90007; $199,696 for 24 months beginning April 15, 1979.

The research includes comprehensive theoretical and observational studies of strong earthquake ground motion. The purpose of these studies is to develop more detailed, more realistic, and less uncertain methods for characterization and prediction of strong earthquake ground motion for use in the design of earthquake-resistant structures.

Comprehensive studies will be conducted on earthquake generation, wave propagation and empirical description of the resulting motions in the following six subject areas: 1) Detailed studies of source mechanism, 2) Studies of propagation effects on strong ground motion, 3) Deterministic prediction of strong shaking, 4) Estimation of torsional and strain components of ground motion, 5) Empirical scaling studies of recorded strong ground motion, and 6) Sensitivity studies of scaling parameters and the uncertainties associated with deterministic and empirical estimation of strong shaking.

The thrust of this research is to expand and enrich the usefulness of available data by carrying out studies which clarify, augment and refine existing data; by comparing and/or combining different theoretical models, techniques and methods to establish the most useful physical bases for engineering characterization of strong earthquake ground motion; and by selecting those scaling laws and parameters which significantly contribute to the design spectra for engineering scaling of strong ground motion and also suggest aspects of the problem which are useful areas for additional research.

Full-Scale Pile Vibration Tests; *Chan F. Tsai,* Fugro Inc., 3777 Long Beach Boulevard, Long Beach, CA 90807; $169,354 for 12 months beginning August 15, 1979.

A full-scale pile vibration test will be conducted to monitor the behavior of a pile-soil system under simulated earthquake shaking. Steel piles will be installed into a loose, saturated, fine sand deposit of known properties, and will be loaded to typical vertical design loads. Shaking machines will be mounted on pairs of loaded piles and operated in a controlled fashion to simulate earthquake shaking. Pile response monitoring will include load and deflection and upper pile-wall strains. Soil monitoring will include surface accelerations and pore-water pressures measured at various depths and radial distance. The phenomenon of sand liquefaction adjacent to the vibrated piles will be studied in terms of pore-water pressure build-up in the soil and anomalous pile behavior accompanying the build-up.

Analysis of Optimal Strong Motion Instrument Location in Building Structures; *F. E. Udwadia,* University of Southern California, Department of Civil Engineering, Los Angeles, CA 90007; $78,885 for 12 months beginning September 1, 1979.

This research is to develop and test methodologies for locating strong-motion instruments in buildings so that records obtained during earthquake excitations provide as much information as possible. Both the number of recording instruments and their locations will be studied to determine the information that can be obtained and to estimate the cost of alternative arrangements.

Optimized instrumentation is an important factor in the quality of the information recorded under earthquake excitation. Such data can be used to improve our understanding of structural responses during strong ground motions and could lead to improved designs and safety standards.

Risk-Based Assessment of the Safety of Dams; *Erik H. VanMarcke,* Massachusetts Institute of Technology, Department of Civil Engineering, Cambridge, MA 02139; $230,995 for 18 months beginning March 1, 1979.

The objective of this project is to develop a methodology for quantitative assessment of the risk of dam failure, to assess alternative measures for dam hazard mitigation, and to establish a scientific basis for risk-based dam safety design provisions and criteria.

Risk analysis methodology will be developed for specific dam failure causes and mechanisms such as hydrology, earthquake, stability and landslide, foundation defects and uneven settlement, and load combinations. Efforts will also be made to apply the methods developed to specific dam engineering problems in order to test methodologies, and to uncover needed improvements in procedures.

Spatial Models of Seismicity for Engineering Risk; *Daniele Veneziano,* Massachusetts Institute of Technology, Department of Civil Engineering, Cambridge, MA 02139; $108,572 for 12 months beginning December 15, 1978.

Probabilistic models of regional seismicity are needed for risk analysis and for the design of strong-motion instrument networks. Currently used models which assume spatial independence of epicenters, temporal stationary and homogeneous magnitude distribution are susceptible to large uncertainty. To correct this situation, more advanced methods and sophisticated models for seismic risk analysis are needed.

The objective of this project is to develop methods for engineering hazard assessments using physical-statistical models of seismicity that account probabilistically for different hypotheses about tectonics, earthquake source zones, their shapes, their spatial extent and variation, etc. The inference properties of such models will be investigated, computer routines for model parameter estimation will be developed, and applications in developing provincial risk maps and in the design of strong-motion instrument network will be demonstrated.

The first year of this project will be devoted to the theoretical work required. The second year's effort will emphasize the engineering applications of the developed models.

Seismic Vulnerability, Behavior and Design of Underground Piping Systems; *Leon R. Wang,* Rensselaer Polytechnic Institute, Department of Civil Engineering, Troy, NY 12181; $143,172 for 24 months beginning January 15, 1979.

Seismic damage to lifeline systems has been receiving increasing attention from the engineering profession because of potential impact upon the populace during and after a major earthquake. Buried water and sewer lines may affect the health and safety of the population through possible contamination of water supplies and reduction of firefighting capabilities after an earthquake. Usually the design of underground piping for water and sewer distribution systems to resist external loads is based on static

analyses; thus, there are no codified provisions for the design of lifeline systems to resist seismic loads.

This research will result in systematic ways of assessing the adequacy of existing water and sewer distribution systems, determining the vulnerability of such systems to earthquake damage and studying the cost-effectiveness of new designs for earthquakes of various magnitudes. Emphasis will be placed on the development of different levels of analysis and design procedures for piping systems in various seismic, soil and geological environments. The aim is to develop easily usable procedures for the design and assessment of buried water and sewer distribution systems.

Seismic-Structure-Soil-Structure Interaction of Two or More Three Dimensional Structures; *Hung L. Wong,* University of Southern California, Department of Civil Engineering, Los Angeles, CA 90007; $99,019 for 24 months beginning March 15, 1979.

In the seismic design of structures, it is generally recognized that dynamic soil-structure interaction may significantly affect the response of the structure. One such interaction problem that requires further research is the interaction between two or more adjacent structures erected on the same soil medium.

To date, only a few reports have been presented on the subject of structure-soil-structure interaction for two or more foundations; most of the literature in the past has been devoted to the study of an isolated building placed on soil. This project will study the problems in structure-soil-structure interaction.

Parametric studies of seismic interaction of two or more three-dimensional structures will be conducted. Computer programs for the analysis and engineering design will be developed. Simple and economical algorithms for embedded foundations and techniques to include nonlinear soil effects will be developed.

Earthquake Strong Motion Instrumentation and Array Design; *Francis T. Wu,* S.U.N.Y. State University at Binghamton, Department of Geological Sciences, Binghamton, NY 13901; $8,286 for 7 months beginning April 1, 1979.

Up to now the gathering of strong motion data has been performed by the fixed station technique. Only in rare cases is there an array suitably located to record strong motions systematically around a fault. Also, until recently the timing on records has not been tied to real time. It has been difficult to decipher the precise nature of the waves recorded and to generalize the obtained results for future earthquakes, since the contribution of the source and that of the path could not be easily separated.

The technology of seismic recording has advanced recently. It is now possible to record data digitally using a self-contained portable system, use a "pre-trigger" digital loop to retain the complete strong motion data, including the triggering signal, to use a low-drain accurate crystal clock for coordinated time, and to use a non-linear amplifier to increase dynamic range of the recording system. In this project two such new systems will be studied to increase the efficiency of ground motion data recordings. Optimum design of local and regional instrument arrays will also be investigated to minimize the total cost and maximize the return. The objective of this project is threefold: to develop more efficient strong-motion instruments with wider dynamic range and versatility, to develop criteria for reliable and cost-effective network design, and to study the dynamic seismic source, mechanism by using near field data.

Risk Methodologies in Geotechnical Design of Offshore Structures; *T. H. Wu,* Ohio State University, Department of Civil Engineering, Columbus, Oh 43210; $94,996 for 29 months beginning June 1, 1979.

The design and construction of offshore structures must take into account the complex problems of interaction of wave forces, earthquake loads, and soil-structure response. Since failures are costly because of large investments and possible environmental losses, the reliability of offshore structures is of concern not only to producers but to regulatory agencies.

This research will identify failure events associated with foundation performance of offshore structures; construct risk event trees; and develop a procedure to

evaluate failure probabilities. Because there are few case histories available on the performance of offshore structures, those case histories which do exist will play a large role in the design of future structures. (See also Tang, Wilson)

Seismic Response of Three-Dimensional Dam Reservoir Systems; *Theodore Y. Wu,* California Institute of Technology, Department of Engineering Science, Pasadena, CA 91104; $111,7444 for 18 months beginning July 1, 1979.

This research will use theoretical and numerical analysis to determine the seismic response of a dynamically coupled, three-dimensional dam-reservoir system including the hydro-dynamic interaction effect, the flexibility effect, the effect of phase variation and spatial attenuation of seismic waves, and the side confinement of the dam. Hydrodynamic loading functions have been determined for various reservoir configurations. In this project, studies will be made of the hydro-elasticity response of the dam-reservoir as a system during an earthquake, the effect of water compressibility, the elastic property of the dam, and the effect of wave propagation.

Response of Nonlinear Saturated Soils to Seismic Disturbances; *E. B. Wylie,* University of Michigan, Department of Civil Engineering, Ann Arbor, MI 48109; $61,654 for 12 months beginning July 1, 1979.

The objective of this research is the development of analytical procedures for the prediction of potential liquefaction of soil masses. A recently developed model, based upon the application of the method of characteristics to handle the equations for transient motion in saturated soils will be modified to incorporate a more realistic description of material properties. Parametric studies will be used to qualitatively evaluate results from the model, while comparisons with large-scale laboratory results will be utilized to demonstrate the quantitative behavior. The concepts developed in the one-dimensional model will be extended to a two-dimensional spatial domain.

Nonlinear material behavior is utilized both in the shearing stress-shearing strain and in the volumetric deformation portions of the model. These two subsets of the total model are interactively coupled so that the shearing strength of the material varies with transient pore pressure. As the pore pressure develops, the effective stress, the shear modulus and shear strength reduce, thereby permitting larger shearing strains for the same transient shear-excitation. Leakage of excess pore water in response to transient pressure gradients is permitted. The one-dimensional distributed parameter model can handle layered soils with variable soil properties. Various surface and base boundary conditions can be used. The two-dimensional model will provide the opportunity to incorporate lateral variations in material properties for *in situ* studies, in addition to the vertical layering treated by the one-dimensional model.

Probabilistic Analysis for Liquefaction; *Mishac K. Yegian,* Northeastern University, Department of Civil Engineering, Boston, MA 02115; $29,451 for 12 months beginning January 1, 1979.

An improved analytical method will be developed to calculate the probability of ground failure by liquefaction. The method will be based on field observations of liquefaction and nonliquefaction and will employ earthquake magnitude and hypocentral distance to describe the intensity of shaking at a site. In contrast to current empirical methods that are based on a limited set of parameters, the new procedure is expected to permit a more accurate evaluation of liquefaction potential by incorporating the influence of additional parameters such as earthquake duration, soil gradation, soil gradation characteristics, overburden pressure, and earthquake source mechanism. As a result of the development of the new procedure, a more precise risk analysis for earthquake-induced ground failure by liquefaction will be possible.

Hydraulic Transients in Liquid-Filled Pipelines During Earthquakes; *Fred M. Young,* Lamar University, Department of Engineering and Applied Science, Beaumont, TX 77710; $52,204 for 18 months beginning September 15, 1979.

Liquid-filled pipelines transport fuel and water. Current research on pipeline systems is focused upon damage assessment, dynamic response analysis and design criteria. One remaining question is whether or not over-pressures caused by hydraulic transients in a liquid-filled pipeline have any significant effects on the earthquakes response of the pipeline.

This research analyzes the effects of hydraulic transients on the failure potential of liquid-filled pipelines during earthquakes. The effects of hydraulic over-pressures caused by differential velocity between pipe wall and ground motion and by vaporization and water-column separation will be investigated. An analytical tool involving the modification of a one-dimensional computer program will be developed and used to examine the potential for hydraulic transients-induced damage to water pipeline systems.

Simple Shear Behavior of Fine Grained Soils Subjected to Earthquake and Other Repeated Loading; *Thomas S. Simmie,* Rensselaer Polytechnic Institute, Department of Civil Engineering, Troy, NY 12181; $84,831 for 24 months beginning March 1, 1979.

The objective of this study is to develop a theoretical model based on effective stress principles for both normally consolidated and overconsolidated soils. Stress-strain characteristics will be investigated, as well as the static behavior of soils previously subjected to repeated loading. Probability theory and reliability analysis will be used to describe the cyclic behavior of soils. Because the *in-situ* structure of cohesive soils is an important prameter in determining their behavior, only natural undisturbed soil samples will be used. Undisturbed core samples from the Atlantic Coast, the Gulf of Mexico and the Gulf of Alaska will be tested. Strength and deformation behavior will be evaluated using a Norwegian Geotechnical Institute (GEONOR) Direct Simple Shear Device. Utilizing an actuator, a wide range of controlled stress or strain load forms will be used. Equipment characteristics will also be investigated.

DESIGN

The analysis and design of buildings, dams, pipelines and other civil structures brings together information from the basic physical and natural sciences and considers functional, economic, and performance requirements necessary to maintain the integrity of the structure throughout its intended life. For natural hazard loadings, such as earthquake or wind forces, the process of design involves the formulation of these loadings, studies of the behavior of materials and elements under dynamic loading, formulation and development of conceptual and mathematical representations for structural systems, and validation of design procedures through observations and tests on real structures.

The Design subelement of the Earthquake Hazards Mitigation program has several major objectives. Research on design procedures for new structures is supported, as is research on practical methods to assess and deal with the hazard potential posed by existing structures which were constructed with inadequate dynamic load resistance. Even if the primary structure of a building has been designed to resist earthquakes, the cost of repairing secondary elements such as glass, claddings, ceilings and interior partitions, and electrical and mechanical systems which may not have received dynamic design considerations can amount to more than one-half of the original cost of the structure. In addition to economic considerations, these secondary elements can cause serious injury or loss of life. Techniques to predict the loadings which occur on secondary elements and design methods to improve their performance under stress is another objective of Design. For small or relatively rigid structures, design may be based on an assumption that the facility occupies a discrete point and that earthquake loadings are coherent or single-valued inputs. For large or distributed structures, including long bridges or pipelines, earthquake waves do not affect all parts of the structure in the same way or at the same time. Design also considers loadings on such large structures.

Investigation of Reinforced Brick Masonry Buildings Undamaged by the San Fernando Earthquake; *Samy Adham,* Agbabian Associates, 250 N. Nash Street, El Segundo, CA 90245; $95,433 for 12 months beginning May 15, 1979.

Numerous investigations have been made of damaged buildings in past earthquakes in an effort to understand how they responded to the ground shaking and how they might have been designed to eliminate or minimize the resultant damage. Little attention has been paid to undamaged structures exposed to the same ground motion environment. How a building interacts with an earthquake depends on frequency content, amplitude, and duration of the ground motion as compared with the dynamic response characteristics of the structure.

Major damage can normally be expected to occur when the predominate frequencies of the earthquake and structure allow resonance conditions to develop. However, it is believed that other aspects of the problem can be just as significant when explaining why buildings in the same area react differently to the same ground shaking. For example, local geology may cause differences in the manner in which a building interacts with the ground motions or differences in construction or building design may enable a building to respond to the ground shaking without being damaged structurally. Understanding why a structure was not damaged can contribute significantly to our knowledge of earthquake engineering and to the design and construction of earthquake-resistant structures.

Special Study of Rock Mechanics Research Requirements; *Robert L. Bangert,* National Academy of Science, 2101 Constitution Avenue, N.W., Washington, DC 20418; $42,500 for 12 months beginning October 1, 1979.

The study is a direct follow-on of earlier activities of the U.S. National Committee on Rock Mechanics (USNC/RM). The findings and recommendations of the USNC/RM have identified seven major problem areas. A Panel of specialists will be organized to study past and current rock mechanics research and identify opportunities for further research that will help solve problems which affect energy resource development, construction (both civil works and defense), and earthquake hazard reduction. It is planned that seven subpanels will be formed within the Panel, each subpanel to consist of volunteer members who have had specialized experience in the technical subject assigned. To achieve a broad and balanced perspective, members will be selected from the public and private sectors and universities. Through panel evaluation of the sectors of the seven subpanels, a comprehensive report of the study will be prepared.

The study will recommend the research to be undertaken, guidelines for how it should be pursued and for determining what organization or organizations are best equipped to conduct it, how much it is expected to cost, and how long it may take.

Earthquake Structural Response Using Fourier Transform Techniques; *Furman W. Barton,* University of Virginia, Department of Civil Engineering, Charlottesville, VA 22903; $30,000 for 12 months beginning January 1, 1979.

In order to calculate the transient response of complex structural systems subjected to earthquake excitation, and to design such systems, it is necessary to have efficient and accurate methods for response analysis. In the case of soil-structure interaction, which is usually an inherent ingredient in analyzing structural response to excitation, a number of techniques can be used, including variations of modal superimposition, direct finite element method analysis, and methods based on Discrete Fourier Transformation techniques.

The objective of this study is to develop improved numerical procedures for use with Fourier Transformation methods applied to the transient response of structures. Specifically, strategies will be sought to reduce the error introduced by the fact that the Fourier Transformation method assumes the excitation to be periodic rather than transient, and to reduce the computational effort currently required to obtain the frequency response functions used in analysis.

The research will evaluate a number of procedures, including the use of corrective impulses and the use of critical damping, as means of reducing the transient response within an overlapping period. In addition, on the basis of the solution of a number of representative problems, an optimum procedure for selecting and locating the corrective impulses will be provided.

Seismic Resistance of Precast Concrete Panel Buildings; *James M. Becker,* Massachusetts Institute of Technology, Department of Civil Engineering, Cambridge, MA 02139; $223,551 for 12 months beginning January 1, 1979.

In recent years large panel precast concrete buildings have become economically and architecturally viable. While originally developed for use in regions that were essentially nonseismic in character, such buildings are now being used in seismic regions in the United States and throughout the world. This research involves experimental and analytical work. The experimental program will examine the inelastic response of dry-type vertical connections subjected to seismic reversals. The analytical work will be in three areas: the development of a detailed nonlinear dynamic program capable of modeling two-dimensional assemblages of large panels; development of a simplified program to allow for more design-oriented analysis; and the extension of current three-dimensional linear-elastic models to handle certain aspects of inelastic response. In all three cases, the modeling efforts will use the information developed in the experimental portion of the program.

The last phase of the project will be the integration of the experimental and analytical efforts, combined with parametric studies, to develop information relevant to the aseismic design of large panel structures.

Tall buildings and Urban Habitat: Impact on the Urban Environment and Planning for Natural Disasters; *Lynn S. Beedle,* Lehigh University, Department of Civil Engineering, Bethlehem, PA 18015; $158,725 for 12 months beginning February 15, 1979.

This research will utilize data assembled by the Council on Tall Buildings and Urban Habitat. The Council, representing 1200 voluntary participants from more than 52 countries and a wide variety of professional disciplines, prepared a new and comprehensive collection of information in a five volume monograph.

This research effort will be concerned with the overall process of incorporating planning for natural disasters into high-rise structures and for assessing the impacts of such planning. This research will have three phases: utilization/implementation research, which will examine mechanisms to get material in the monographs on Tall Buildings into standards, model codes, and specifications; the development of an improved data base on dynamic forces and loads on tall buildings due to natural hazards; and a study to redefine critically needed research topics related to tall building construction.

Conference on Stability of Space Frame Structures Under Static and Dynamic Loads; *Lynn S. Beedle,* Lehigh University, Department of Civil Engineering, Bethlehem, PA 18015; $9,655 for 12 months beginning April 15, 1979.

Large space frame structures used as a means of covering large unobstructed areas (for example, the Houston Astrodome) have become popular in recent years because of their cost advantage. Such structures are assembled from large numbers of individual elements and present a complex problem for analysis for the variety of static and dynamic loads to which they may be subject. Because of the level of complexity of these structures, the analysis often has to be carried out by lumping many individual elements into equivalent continuous surfaces or sub-units. A serious problem in using such an approach is that the stability of the space frame components may not be correctly addressed.

It is the purpose of this conference to assemble an international group of research and design experts to exchange the most up-to-date knowledge on the static and dynamic behavior of such structures and to assess the needs and priorities for research in this area. The results will be published as a proceedings volume to make the information easily available to interested persons.

Seismic Investigation and Design Criteria for Industrial Storage Racks; *John A. Blume,* John A. Blume and Associates, 130 Jessie Street, San Francisco, CA 94105; $20,549 for 6 months beginning June 15, 1979.

This project will develop criteria and procedures for the seismic design of industrial steel storage racks. Approximately 40% of all goods consumed in the United States are on storge racks at some time during their production-distribution-sales-consumption cycle. Prior to 1972, storage racks were designed and constructed to resist gravity loads and some impact from loading equipment such as fork lifts. No specific provisions for resisting earthquake motions were included. To reduce the risk of damage in future earthquakes, rational design criteria and procedures are needed.

Seismic motion criteria will be developed, and detailed dynamic analyses performed using the postulated input motion, rack load-deformation data and results of earlier studies. Results will then be correlated with the results of shaking table tests of full-scale, loaded and unloaded racks. Results of the research program will help ensure that future designs of industrial storage racks incorporate realistic seismic resistance at minimum cost.

Analysis of Structures Subjected to Earthquake Loadings; *Sidney F. Borg,* Stevens Institute of Technology, Department of Mechanical Engineering, Hoboken, NJ 07030; $30,000 for 12 months beginning January 1, 1979.

In a previous study by the Principal Investigator, a new approach was made to various aspects of the problem of the dynamic loadings imposed on ships subjected to strong waves (ship slamming). Among the different topics considered were length-of-time effects, damping, model scaling and approximate methods of dynamic analysis in the elastic and plastic ranges.

Although these were derived specifically for ships in slamming seas, the fundamental phenomenon is one which can be identified (through suitable modification) with the earthquake and tsunami problems — particularly as these affect tall buildings.

This research will develop suitable modification of the ship-slamming analysis to the earthquake problem. Practical design computational methods will be emphasized and a procedure will be developed for simplified, approximate earthquake stress analysis in its various forms — dynamic, model testing, damping, elastic and plastic. An important part of the research will be a study of the existing literature and a check of the analytical result against current methods and available experimental and field data.

Dynamic Response Analysis of Offshore Platforms; *Jack G. Bouwkamp,* J. G. Bouwkamp, Inc., 1930 Shattuck Avenue, Berkeley, CA 94704; $106,339 for 12 months beginning April 1, 1979.

Oil and gas exploration and production offshore from the U.S. has previously been confined to the Continental Shelf. Recent offshore exploration has been moving into deeper waters and into regions with high seismicity. Under these circumstances the traditional methods of analysis of offshore structures assuming static equivalent load conditions are no longer appropriate.

The purpose of this project is to develop a computer program for the three-dimensional dynamic analysis of tubular framed offshore platforms subjected to the combined loads of earthquakes and wave forces. One unique feature of this program is its ability to take into account the flexibility of the tubular joint regions of the structure. Joint flexibility can have a substantial influence on the behavior of the structure, but in the past this effect has been generally ignored in each of the analytical techniques used in the solution of such problems.

The dynamic response of typical structures in both shallow and deep waters will be analyzed, including the influence of the foundation. Simplified analytical procedures will be developed and the effect of nonlinear joint deformation will also be investigated.

Safety Evaluation of Buildings Exposed to Earthquakes and other Catastrophic Environmental Hazards; *Boris Bresler,* University of California-Berkeley, Department of Civil Engineering, Berkeley, CA 94720; $101,900 for 12 months beginning January 9, 1979.

This research project attempts to predict the potential damage which could occur to an existing structure when it is subjected to a catastrophic event such as an earthquake, severe windstorm or other natural hazard. Such information will help assess the degree of hazard for existing structures and will also be useful in guiding rehabilitation programs and in improving the design of new buildings. The approach is to establish indices of damage for both the nonstructural and structural components of buildings. These damageability indices are developed for various parts of the building as well as the entire building.

After damageability indices have been developed, they will be tested using a systematic procedure aimed at establishing priorities for reviewing classes of buildings. A methodology will be developed which may be used to assess the hazard potential in existing buildings quickly and at reasonable cost.

The Integration of Seismic Design Principles into Preliminary Architectural Design; *Kenneth I. Britz,* Carnegie Mellon University, Department of Architecture, Pittsburgh, PA 15213; $64,454 for 18 months beginning April 15, 1979.

The utilization of research on building response to seismic events has not been adequately studied. One hypothesis is that seismic provisions are perceived by architects as constraints to architectural design; thus, implementation of seismic codes may affect the visual quality of the environment. A second hypothesis is that architects find it difficult to utilize research because the methodologies are not conducive to ready assimilation of findings.

This project will assess the sensitivity of U.S. architects to seismic design principles to discover problems in assimilating seismic research in architectural practice, and will seek methods for the solution of these problems.

A survey of Eastern U.S. architects will profile the extent to which seismic design research has entered professional practice. The researchers will engage architectural firms in an empirical study of the process of integrating seismic design strategies into actual design projects. Results will be translated into operational strategies addressed to architects.

Cyclic Response of Masonry Anchor Bolts; *Russell H. Brown,* Clemson University, Department of Civil Engineering, Clemson, SC; $68,825 for 10 months beginning April 15, 1979.

Masonry loadbearing structures depend on diaphragm and shear wall action to resist lateral forces from wind or earthquake. The connection between the floor system and the bearing wall is a critical part of the structural system. Many such connections require the use of anchor bolts. This research project will provide information on the cyclic strength and behavior of anchor bolts in masonry.

Anchor bolts will be embedded in masonry walls and subjected to cyclic reversed loading applied axially and transversely simultaneously. Variables will include loading history, bolt size, bolt spacing, bolt position, mortar type, masonry unit type, and wall reinforcing.

The specific objectives of the research are to determine the strength of anchor bolts in masonry subjected to cyclic axial forces and shear forces acting simultaneously; to develop design recommendations for anchor bolts in masonry structures in high wind and earthquake zones; and to develop mathematical models to predict the behavior of anchor bolts in masonry.

Optimum Design of Three-Dimensional Building Systems for Multicomponent Earthquake Motions; *Franklin Y. Cheng,* University of Missouri, Rolla, Department of Civil Engineering, Rolla, MO 65401; $85,179 for 16 months beginning December 16, 1978.

It has been recognized by the earthquake research community that analytic and design methods are needed and the emphasis should be placed on three-dimensional structures and on the development of computer-aided optimum design methodologies. This project is designed to study the optimum design of three-dimensional building systems subjected to static loads, wind forces, and three interactive components of earthquake motions.

This research includes: (1) mathematical formulation of optimization and structural models, (2) investigation of seismic forces and structural systems (3) development of computer program for optimum design, (4) computer analysis of design options, and (5) assessment of critical structural parameters and systems. The research will lead to a practical method of seismic design which is more rational and reliable than methods commonly used today.

Seismic Behavior of Structures: Analysis and Design of Structures; *Anil K. Chopra,* University of California-Berkeley, Earthquake Engineering Research Center, Department of Civil Engineering, Berkeley, CA 94720; $240,000 for 12 months beginning April 15, 1979.

Considerable effort is needed in analytical research to achieve a better understanding of seismic perform-

ance and modes of failure of structures; to increase the reliability of controlling seismic damage; and to develop methods of design based on correlative analytical and experimental studies. These analytical and design capabilities should be applied to ensure a proper balance between the total cost and safety of structures constructed in a seismic environment.

This project is to conduct comprehensive research aimed at establishing improved analytical and design capabilities for seismic engineering. Based upon present knowledge and future research needs, emphasis on particular studies has been properly adjusted and reflected in the present project. Six complementary and interrelated sub-projects are integrated into this single project in order to maximize the productivity and benefits. These six sub-projects are: (1) Analytical Study of Building Response, (2) Soil-Structure Interaction Effects in Building Response, (3) Dynamics of Rigid Blocks and Foundation Tipping, (4) Development on Nonlinear Structural Analysis Techniques, (5) Probabilistic Studies of Seismic Response, and (6) Analytical Methods for Design.

For the last three years the investigating team at Berkeley has made significant progress and important contributions to the general research and practicing engineering communities. Many of the analysis and design methods, computer programs, etc. have been extensively applied. This project properly reflects current knowledge and practice, and addresses future research needs in outlining an integrated program of continuing efforts required to upgrade the present capabilities and design practices in earthquake engineering.

Earthquake Engineering Research Facility Support; *Ray W. Clough,* University of California-Berkeley, Department of Civil Engineering, Berkeley, CA 94720; $52,432 for 12 months beginning May 1, 1978.

The ultimate goal of this project is to develop improved computer procedures for predicting the dynamic response of structures to intense earthquake motions. The effort is divided into six technically interrelated sub-projects.

These sub-projects are: (1) Earthquake Simulator Studies — to perform dynamic tests of steel and concrete structures, (2) System Identification — to develop methods of evaluating mathematical model properties, (3) Computer Program Development — to evaluate the dynamic response of the mathematical model, (4) Energy Absorption Devices — to develop and test special structural components for improving the seismic resistance of structural systems, (5) Field Measurements — to measure the dynamic properties of actual buildings and structures, and (6) Post-Earthquake Damage Studies — to conduct reconnaissance surveys and detailed engineering analyses of earthquake damaged structures.

The earthquake simulator has proven to be a most versatile research tool during its five year existence. Continuing exploitation of its effectiveness and efforts to overcome its limitations are necessary to provide direct evidence of actual structural performance under realistic base excitations and to evaluate the predictive capability of developed computer program. System identification studies are required to define physical properties and to incorporate them into mathematical models, which will be formulated and coded to represent different structural elements and used to develop general purpose non-linear analysis programs. Mechanisms and practical utilization of energy absorbing devices will be investigated to improve the seismic performance of various types of structures. Finally, field measurements and actual earthquake damage investigations will be conducted to supplement the analytical and experimental research to achieve an improved understanding of, and to develop improved predictive capability for, the seismic behavior of structures.

Seismic Behavior of Complete Structural Systems; *Ray W. Clough,* University of California-Berkeley, Department of Civil Engineering, Berkeley, CA 94720; $350,000 for 12 months beginning April 15, 1979.

The ultimate goal of this project is to develop improved computer procedures for predicting the dynamic response of structures to intense earthquake motions. The effort is divided into six technically interrelated sub-projects centered around the earthquake simulator facility toward achieving this goal.

These sub-projects are: (1) Earthquake Simulator Studies — to perform dynamic test of steel and concrete structures, (2) System Identification — to develop methods of evaluating the mathematical model properties, (3) Computer Program Development — to evaluate the dynamic response of the

mathematical model, (4) Energy Absorption Devices — to develop and test special structural components for improving the seismic resistance of structural systems, (5) Field Measurements — to measure the dynamic properties of actual buildings and structures, and (6) Post-Earthquake Damage Studies to conduct reconnaissance surveys and detailed engineering analysis of earthquake damaged structures.

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Seismic Resistance of Buildings with Reinforced Concrete Structural Walls; *W. G. Corley,* Portland Cement Association, Old Orchard Road, Skokie, IL 60076; $499,566 for 12 months beginning April 15, 1979.

The ultimate objective of this investigation is the development of reliable and practical design procedures for earthquake-resistant reinforced concrete structural wall (shear wall) systems. Included under this broad category of structures are isolated walls, coupled walls and frame-wall systems.

Realistic estimates of the strength and deformation requirements in critical regions of structural wall systems will be obtained through dynamic inelastic analyses. These estimates will correspond to different combinations of the significant structural and ground motion parameters. Laboratory tests on large-size specimens are planned. Results of these tests and correlation with theory will be used to develop methods of predicting the available strength and deformation capacities of properly proportioned and detailed structural walls.

Development of Revisions to American National Standard A58-Building Code Requirements for Minimum Design Loads in Buildings and Other Structures; *Bruce Ellingwood,* National Bureau of Standards, Center for Building Technology, Gaithersburg, MD 20234; $85,839 for 24 months beginning March 1, 1979.

The purpose of this project is to develop a revised version of American National Standard A58 — Building Code Requirements for Minimum Design Loads in Buildings and Other Structures. This standard covers six areas of loadings, load specification methodology and failure modes which are important in building design and are related to building performance. These are Seismic Loads, Live Loads, Wind Loads, Snow Loads, Progressive Collapse and Load Factors.

The overall effort has two objectives: first, to coordinate revisions to the individual load portions of the existing A58 Standard and prepare drafts of the revised load portions; second, to assemble the revised provisions into a draft load standard (A58.1-1980/D) and supervise its processing and public review.

The primary task of developing and evaluating load provisions incorporating recent research findings and developments from practice is carried out by volunteer technical subcommittees. Support from this project will facilitate the process by allowing the groups to meet to speed the assembly and circulation of revised material and the draft load standard.

Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings; *Robert D. Ewing,* ABK, 250 North Nash Street, El Segundo, CA 90245; $462,786 for 12 months beginning October 1, 1979.

This project will evaluate the current state-of-the-art for mitigating the seismic hazards of existing unreinforced masonry buildings, develop a methodology for the mitigation of these hazards,

evaluate the methodology, and design a nationwide utilization plan for disseminating the methodology.

The program is divided into two major efforts. The first effort will evaluate codes and standards applicable to unreinforced masonry buildings; categorize nationwide existing masonry construction; evaluate current methods for selecting earthquake ground-motion input; categorize the damage from past earthquakes; review strength data; assess analytical methods to evaluate these buildings; and evaluate retrofit methods. In the second effort, a program for analytical verification and testing, including retrofit, will be conducted. Both quasi-static and dynamic tests will be performed on wood and metal diaphragms and walls, employing both out-of-plane forces and in-place forces. The results of both efforts will be integrated in the development of the required methodology.

Reliability-Based Structural Optimization; *Lewis P. Felton,* University of California-Los Angeles, Department of Mechanics/Structures, Los Angeles, CA 90024; $30,000 for 12 months beginning January 1, 1979.

This research will develop a procedure for computer-aided optimum design of structures subjected to earthquake ground motion and constrained by specified upper bounds on overall probability of failure. This reliability-based design formulation will utilize data pertaining to the nature and statistical characteristics of response spectra, as well as probabilistic representations of structural stiffness and material properties. The formulation will require the development of an appropriate nonlinear expression for statistical moments of response quantities.

Studies on Timber Diaphragms Subject to Earthquake Motions; *Hota V.S. Gangarao,* West Virginia University, Department of Engineering, Morgantown, WV 26506; $37,426 for 10 months beginning January 15, 1979.

Woods which possess high strength-to-weight ratios and excellent thermal properties are being widely used for many structural applications because of inherent economic advantages and ease of construction. Plywood roof and floor diaphragm systems under cyclic and earthquake type loading conditions will be analyzed theoretically for several boundary conditions, and for joint configurations wherein the orthotropic material properties and joint slip effects will be considered.

Sixteen different diaphragms will be subjected to cyclic and earthquake-type loadings to establish methods of construction and to verify simple design formulas developed from rigorous theoretical investigations of the seismic behavior of each system as a whole. If required, necessary modifications in the theory and the test program will be made to introduce efficient and versatile plywood roof and floor systems. Standard general purpose design guidelines for the use of practicing engineers will be developed.

Patterns of Housing Density and Type: A Basis for Analyzing Earthquake Resistance; *Urs P. Gauchat,* Harvard University, Department of Architecture, Cambridge, MA 02138; $91,936 for 15 months beginning September 1, 1979.

This research project will isolate, identify, and categorize different housing types in selected earthquake-prone areas; determine the respective number and distribution of each identified type; and, conduct seismic vulnerability studies on selected types. The study will use photogrammetric techniques to analyze existing housing stock in a given area with respect to probable behavior during an earthquake. The methodology will have applicability in any hazard location for which suitable aerial photographs and other related data can be obtained. The research will provide the back-up data and analytic tools needed to properly interpret photographic survey information. The results of this research can form the basis for retrofit, redevelopment, and land use planning strageties to mitigate the effects of earthquakes.

Influence of Nonstructural Cladding on Dynamic Properties and Response of High Rise Buildings; *Barry J. Goodno,* Georgia Institute of Technology, Department of Civil Engineering, Atlanta, GA 30332; $119,556 for 12 months beginning July 1, 1979.

In the past little attention has been paid to the effect of exterior cladding in multi-story buildings subjected to seismic forces. Recent studies have shown that cladding may actually provide a considerable amount of resistance to low level excitation and thus help control interstory drift and building motion. Reports of cladding failures prompt us to ask whether or not the stiffness and energy absorption capacity of these elements can be used to advantage in modern building designs.

This project studies the problem of cladding-structure interaction, and is designed to put future follow-on studies on a firm analytical and experimental basis. The findings are expected to be of immediate use to designers in integrating cladding into the structural design, and are directly applicable to the problem of low level response which is largely linear. With experience gained in the linear problem, future studies of cladding-structure interaction which encompass both material and geometric nonlinearities and strong ground motion excitation are anticipated.

Analytical Method for Determining Seismic Response of Cooling Towers on Footing Foundations; *Phillip L. Gould,* Washington University, Department of Civil Engineering, St. Louis, MO 63130; $104,300 for 18 months beginning April 15, 1979.

This project will investigate the response of large cooling towers founded on circular ring footings to earthquake-induced ground motion. Such structures are generally founded on deep, rigid piles or caissons, and the lower region of the shell and the foundation ring are subjected to large seismic forces. It is believed that a ring footing foundation with appropriate site conditions may mitigate seismic forces by interacting with its surrounding soil to dissipate the energy induced by seismic waves.

The major analytical component required for this study is a model of the soil-structure system. The shell and foundation components of the soil-structure system are to be modeled using high-precision rotational shell finite elements, while the surrounding soil will be represented by a finite element discretization. The response of the interacting system to earthquake-type dynamic loading will be studied for a variety of soil conditions in order to assess the importance of interaction on the response of large towers. To facilitate the utilization of the results of this research, an existing high precision finite element code (SHORE III) will be extended to include soil-structure interaction effects. Suitable documentation will be prepared in accordance with the specifications of NISEE. NISEE will also make resulting computer programs publicly available.

Workshop on Seismic Resistance of Nonengineered Structures; *Ajaya K. Gupta,* Illinois Institute of Technology, Department of Civil Engineering, Chicago, IL 60616; $46,485 for 12 months beginning May 15, 1979.

The objective of this project is to organize and hold a two day workshop at the Illinois Institute of Technology on the topic of earthquake resistance of non-engineered structures. Nonengineered structures are defined as those which, due to either their size or the scale of economic investment involved, are not subject to specific engineering analysis to determine their seismic resistance and are constructed according to general codes and/or tradition. It is estimated that up to 80% of the structures built in the U.S. fall into this category.

It is important to carefully assess the present state-of-the-art related to nonengineered structures, to improve the flow of new information and technology developed through seismic research for use in such structures, and to evaluate present and future research needs in earthquake engineering as related to nonengineered structures. The workshop will address these objectives by assembling a representative group involved in different aspects of the problem. A workshop report will be prepared which will include state-of-the-art papers and recommendations regarding problem areas and research needs on various aspects of the topic.

Cooperative Program in Earthquake Engineering-Repair and Retrofit of Structures; *Robert D. Hanson,* University of Michigan, Department of Civil Engineering, Ann Arbor, MI 48109; $45,000 for 12 months beginning May 1, 1979.

This project initiates a new international coordination effort to exchange results of earthquake engineering research on the repair and retrofit of existing buildings. The Cooperative Program serves as the focal point for the U.S.-Japan Panel on Wind and Seismic Effects, which is working to develop a coordinated research plan on this issue. Major tasks which are being undertaken include the coordination of research efforts and personnel, the establishment of priorities for specific projects, and the promotion of the exchange of information between the two countries. Periodic meetings, workshops, conferences and publications are planned.

Workshop on Interpretation of Strong-Motion Earthquake Records Obtained in and/or Near Buildings; *Gary C. Hart,* University of California-Los Angeles, Department of Mechanics and Structures, Los Angeles, CA 90024; $19,995 for 12 months beginning May 1, 1979.

The objective of this project is to hold a workshop on the interpretation of strong-motion earthquake records obtained in and/or near buildings. The workshop will serve to answer the following questions: What methods can be used to study earthquake records in addition to those methods of analysis currently available? What are the existing building instrumentation programs and can these programs be modified to improve the information obtained? What are the most important response quantities to be measured for different types of buildings? Should there be standard analyses performed on the records? If so, then what should they be, who should do them and how should they be reported?

A comprehensive report will be published based on the workshop. Topics will include the Present State of Instrumentation, Current Signal Processing Techniques, State of Building Analysis, Information Derivable about Building's Dynamic Response Parameters (e.g. natural frequencies, mode shapes, etc), Inference of Damage from Instrument Records, Relationship, if any, between Low Level versus High Level Records, and Future Directions.

Study of Earthquake-Induced Bond Deterioration; *Neil M. Hawkins,* University of Washington, Department of Civil Engineering, Seattle, WA 89195; $59,647 for 12 months beginning May 15, 1979.

This project studies bond deterioration in reinforced concrete structures subjected to earthquake loadings. Immediate objectives include calibration experiments for collation of bar stress-slip relationships with the development of internal cracking and acoustic emissions and use of these results for experiments simulating practical connection details.

Approximately eight specimens will be tested to various levels of failure and then examined, using methods from non-destructive to sawing, to determine the degree of bond deterioration. Both straight and hooked bars will be studied. Analytical studies will be undertaken and additional tests run under progressively increasing, reversed cycle loading, using both conventional and light weight concretes. All of these studies have the long-range goals of the development of practical techniques to assess the degree of bond deterioration in a structure surviving an earthquake and the development of improved design methods and regulations for new reinforced concrete structures.

The Development of a Cost-Effective Approach to the Aseismic Design of Buildings for the Pacific Northwest; *Dean R. Heerwagen,* University of Washington, Department of Architecture, Seattle, WA 98195; $29,971 for 12 months beginning January 1, 1979.

This research will develop a technique for assessing the cost-effectiveness of aseismic building designs for the Pacific Northwest. This methodology will be employed to test several building case studies. From

these tests, guidelines will be developed for use by building owners, designers, and regulators officials. The research will provide a means for optimizing the trade-offs between building costs and the reliability of future buildings.

The research plan includes six steps: (1) modification of an optimization technique developed by Liu, Dougherty, and Neghabat for seismicity experienced in California; (2) writing of a computer program based on this modified optimization methodology; (3) identification of several medium- and high-rise buildings for analysis as case studies; (4) generation of design alternatives; (5) analysis of the existing buildings and additional alternative schemes for cost-effectiveness; and (6) preparation and distribution of a final report, professional papers, and a catalogue of the design guidelines.

Connections in Concrete Masonry Buildings Under Seismic Forces; *Gilbert A. Hegemier,* University of California-San Diego, Department of Applied Mechanics and Engineering Sciences, La Jolla, CA 92093; $315,000 for 12 months beginning May 1, 1979.

Concrete masonry systems account for approximately one-half billion dollars worth of buildings in seismically active areas of the United States. There has been very little research conducted on the basic properties of masonry or the connections of various components comprising a building structure. This project will investigate the behavior of connections between floors and walls, between walls, and between roofs and walls subjected to seismic excitations. This research project will investigate the out-of-plane forces in conjunction with in-plane loads on various types of connections subjected to seismic excitations.

Experimental investigations will be supplemented by mathematical models in order to develop design criteria techniques to evaluate existing buildings and to predict the behavior of newly constructed buildings.

The systems to be investigated are precast reinforced concrete slabs supported by interior walls, a cast-in-place slab on an interior wall, and a hollow core prestressed concrete plank on an interior masonry wall. Various oscillatory, horizontal loadings will be applied to the connections while a constant force vertical load will be maintained. Future studies will investigate oscillatory, vertical forces in conjunction with oscillatory, horizontal forces.

Contribution of Floor Systems to Earthquake Resistance of Building Structural Frames; *Ti Huang,* Lehigh University, Department of Civil Engineering, Bethlehem, PA 18015; $134,370 for 12 months beginning February 1, 1979.

This study will investigate and evaluate the contribution of floor systems to the earthquake resistance of building structural frames. The response of floor systems under earthquake loading is not adequately considered in present design practice of various floor systems. This study will examine the behavior of floors and will develop design guidelines which will analyze the floor system contribution under repeated loading into full consideration.

Both analytical and experimental investigations will be included. The study will cover many floor systems frequently used in steel or concrete buildings. Testing of typical floor system panels will provide information leading to the identification of design parameters controlling the behavior of floor systems. A computerized parametric study will be used for the generation of data and development of design guidelines suitable for incorporation into design codes.

Reduction of Overturning Potential of Seismically Excited Structures; *Arthur Huckelbridge,* Case Western Reserve University, Department of Civil Engineering, Cleveland, OH 44106; $62,656 for 18 months beginning January 15, 1979.

This research will extend our current understanding of the overturning movement problem associated with seismically excited structures. Major earthquakes impose loading conditions on structural systems in excess of normal design levels. In recognition of this fact, building codes have structural requirements which ensure ductile behavior under overload conditions. There are no corresponding provisions,

however, to consider the effect of overturning moments in excess of normal design levels.

Requiring full overturning moment capacity corresponding to levels produced by large earthquakes imposes a twofold economic penalty on the designer: the loading on the superstructure is increased, and supplementary foundation anchorage capacity may be required. Conversely, designing a limited overturning moment capacity, e.g. only that provided by gravity, implies a transient uplift condition for those time intervals when the applied overturning moment exceeds the capacity of the system.

Prior investigations have indicated that the latter approach has a number of inherent advantages: load levels are reduced, expensive anchorage may be eliminated, and damage to the superstructure may be reduced. In this effort, an analytical method validated through prior experimental investigations will be employed to explore various structural systems, configurations, and seismic ground motions with the objectives of clarifying and quantifying in exactly which situations transient uplift response could be utilized most effectively. Structural design details suitable for a prototype application will be investigated as an integral part of the program.

Seismic Response of Ground-Supported, Cylindrical Liquid Storage Tanks; *Thomas J. R. Hughes,* California Institute of Technology, Department of Engineering and Applied Science, Pasadena, CA 91125; $29,942 for 12 months beginning Janaury 1, 1979.

This research will develop a finite/element numerical method for the dynamic, three-dimensional, nonlinear, inelastic response of ground-supported, cylindrical liquid storage tanks which considers the actions of fluid-structure interaction, free-surface sloshing, and contact-impact effects associated with lift-off. The method will be coded in a "pilot" computer program which will be used to analyze tank configurations subjected to earthquake excitations.

The finite element/numerical techniques which must be employed to solve the problems considered are in an advanced state of development. Each of the constituent nonlinear effects has been studied previously by the Principal Investigator, so the emphasis of this work is to organize them into a coherent, working computer program.

Liquid Storage Tank Failure due to Earthquake Excitation; *Thomas J. R. Hughes,* California Institute of Technology, Department of Engineering and Applied Science, Pasadena, CA 91104; $125,991 for 18 months beginning April 15, 1979.

This award supports an integrated experimental and analytical research program directed towards developing improved understanding and design methodology for the strong-motion excitation of cylindrical liquid storage tanks.

The goal of the experimental work is to understand the nonlinear physical phenomena occurring during earthquake excitation of a fluid filled storage tank. This understanding will hopefully lead to simplified analytical/numerical analysis techniques useful in improving tank design. The experimental work is designed to study aspects such as flexible tank/fluid interaction, nonlinear fluid behavior (swirling, wave cresting) and tank uplifting.

The object of the analytical work is to develop a finite element method for the dynamic, three-dimensional, nonlinear, inelastic analysis of ground-supported, cylindrical liquid storage tanks, which treats the effects of fluid-structure interaction, free-surface sloshing, and contact-release effects associated with uplifting. The method will be coded and used to analyze tank configurations subjected to earthquake excitations. The computer program will be made freely available to the engineering community.

Finite Element Analysis of Reinforced Concrete for Cyclic Loading; *Anthony R. Ingraffea,* Cornell University, Department of Structural Engineering, Ithaca, NY 14850; $84,034 for 18 months beginning April 15, 1979.

An analytical formulation will be sought for bond slip in reinforced concrete structures subjected to seismic forces. Experiments have shown that up to half of the inelastic deformation in common reinforced concrete structures subjected to high-level cyclic loading is caused by bond slip. The accompanying stiffness degradation must be known in order to predict the deformations and forces in seismically loaded structures.

The problem will be approached by using sophisticated finite element techniques of nonlinear and fracture analysis to an isolated region focused on the steel-concrete interface. Experiments will also be conducted to determine the nonlinear stress-strain relationships for the crushed concrete immediately in front of the deformations on reinforcing bars that are subjected to axial forces.

An axisymmetric concrete section reinforced with a single bar will be utilized in the first phase of the analysis. This model will include concrete crushing at the reinforcement ribs, transverse crack initiation and propatation in the concrete, and yielding of the reinforcement. A three-dimensional analytical model will follow to incorporate the influence of concrete cover, bar spacing, and transverse reinforcement, plus the occurrence of axial cracking. Fracture mechanics techniques will be used to model all cracking phenomena. The end result will be a new bond finite element for nonlinear, cyclic load-slip behavior in reinforced concrete subjected to high intensity repeated and reversed loadings.

Inelastic Dynamic Building Response-Correlation with Full Scale Shaking Tests; *Lindsay R. Jones,* Computech, Inc., 2150 Shattuck Avenue, Berkeley, CA 94704; $104,598 for 12 months beginning April 15, 1979.

A twelve month research study will be carried out in which a number of correlation studies will be performed using results obtained from full-scale large amplitude shaking tests performed on an eleven story reinforced concrete building. It is proposed that state-of-the-art nonlinear dynamic analysis procedures be used to determine the extent to which they adequately model the behavior of a real building subjected to damaging force levels. The building will be further analyzed to determine its behavior when subjected to real earthquake motions as distinct from mechanical shaker-induced motions. It is important to determine whether the building will be able to withstand earthquake-induced base shear levels as high as those it withstood during testing.

Computer programs developed in the course of this study will be available through NISEE.

Multi-Design Approach to Seismic Safety; *Earle W. Kennett,* American Institute of Architects Research Corp., 1735 New York Avenue, N.W., Washington, D.C. 20006; $194,696 for 13 months beginning May 15, 1979.

This project will examine the problem of integrating design responses for a range of hazards to which buildings may be subjected. The design concerns to be addressed in this project are Earthquake, Fire, Flood, Extreme Winds, and Energy Conservation. The AIA Research Corporation proposes to identify those design issues responding to the four latter hazards which conflict with or reinforce aseismic design.

A workshop will be held for organizational representatives and representative professionals and researchers to review the interrelationships of design provisions directed mitigating the five mentioned hazards. Research staff, assisted by the workshop, will develop guidelines and strategies for harmonization of design approaches to hazard mitigation. This multi-hazard design approach will include both seismic and aseismic design principles. Conceptual solutions to problems of design conflict or incompatibility will be developed to test the practical applicability and cost effectiveness of the developed guidelines and the multi-hazard approach.

Vibration Testing of an Epoxy-Repaired 4-Story Concrete Structure; *Donald M. Kerr,* Jr., Department of Energy, P.O. Box 14100, Las Vegas, NV 89114; $148,900 for 12 months beginning April 15, 1979.

Epoxy-injection methods have been used to repair buildings, bridges and other structures which have been damaged by earthquakes. Experiments have indicated that this method is quite effective in repairing laboratory test specimens whose strength has been improved by the repair. Tests on a shaking table have indicated that epoxy-repaired structures have only a small fraction of the stiffness of the undamaged structure. At this time there is no information available concerning the effectiveness of epoxy repaired structures subjected to high amplitude destructive level vibrations. This project will develop data on this specific consideration of epoxy-repaired structures.

The project consists of several phases: a comparison of dynamic response of an epoxy-repaired structure with the original structure; an evaluation of the effect of the epoxy repair on the stiffness and natural frequencies of the structure; the effect of damping and energy absorption of the system; a comparison of damage patterns; and development of guidelines for the epoxy repair of damaged buildings.

Conference on Urban Design and Seismic Safety at a Cooperative International Level; *Henry J. Lagorio,* University of Hawaii-Manoa, Department of Architecture, Honolulu, HI 96822; $54,786 for 12 months beginning April 1, 1979.

Both the United States and Japan have major urban concentrations in severely seismic areas. The urban environment is composed of many interdependent activities, services, and functions. Assessment of the physical growth of cities indicates that many fundamental urban design principles in hazards mitigation may not have been considered, nor were the critical consequences of many design decisions foreseen. Despite many technological advances in earthquake engineering and earthquake prediction, major metropolitan centers remain extremely vulnerable to major seismic events. Because of rapid urbanization and continued development in existing, well-established urban concentrations, a major earthquake impacting a city center would result in much greater damage and life loss than ever before.

The United States-Japan Joint Seminar on Urban Design and Seismic Safety to be held in Tokyo in May 1979 will be of mutual benefit to both countries in the exchange of information and establishment of cooperative research priorities. Members of the design professions of both countries who are responsible for the planning and design of cities will attend. Earthquake hazards mitigation measures which can be achieved at the scale or urban design will significantly expand our range of approaches to limiting earthquake losses.

Lateral Load Capacity of Structural Tee X-Bracing; *Albert D. Lewis,* Purdue University, School of Civil Engineering, Lafayette, IN 47907; $28,000 for 12 months beginning March 1, 1979.

In braced buildings and similar structures, lateral bracing of adequate strength is a necessary component for reducing the hazards to life and property associated with failures during an earthquake. Simplification of fabrication and erection of X-bracing may be accomplished by using structural tee bracing members. A current practice in the design of structural tee X-bracing is to use one-half the braced panel diagonal dimension as the effective length of the compression bracing member and to ignore eccentricities of loading.

The objectives of this research are to determine if these practices produce safe designs, and to develop information on the performance of structural tee X-bracing for establishing criteria for the safe and economical design of such bracing. Analytical studies to determine the load capacity of structural tee X-bracing will be carried out. These studies will include consideration of beam-column and beam-tension member effects and buckling restraint of the compression diagonal by the tension diagonal.

Introduction of Earthquake Hazard Mitigation Through Multi-Hazard Mitigation Techniques in Areas of Low Concern for Seismic Risk; *John Loss,* North Carolina State University at Raleigh, Department of Architecture, Raleigh, NC 27607; $29,752 for 12 months beginning January 1, 1979.

The lack of seismic activity for a prolonged period produces public and private apathy relative to risk and possible damage due to earthquakes. This is true for other natural disasters, such as hurricanes, where only a few years of inactivity or lack of actual damage will cause the public to not take warnings seriously.

This research will investigate the possibility of the introduction of earthquake hazard mitigation into the codes, ordinances and construction practices of low seismic frequency regions as part of the hurricane, storm surge, and flash flood considerations currently recognized.

Two representative local communities of typical, but diverse, climatic/geographic conditions will be selected to test a multi-hazard mitigation technique.

Post-Earthquake Land Use Planning; *George G. Mader,* William Spangle and Associates, 3240 Alpine Road, Portola Valley, CA 94025; $21,300 for 0 months beginning July 1, 1979.

An interdisciplinary team of experts in the fields of geology, structural engineering, and city planning and reconstruction for three recent earthquakes (San Fernando 1971, Santa Rosa 1969, and Alaska 1964) in an effort to identify impediments to sound post-earthquake land use planning. This study has determined that significant research opportunities exist which were not evident at the outset of the research. Monitoring of responses to major land sliding in Laguna Beach, California and a case of predicted slope failure in Kodiak, Alaska represent unique opportunities which can provide contemporary parallels to out-of-date material which had been used for case studies. Documentation and study of these cases will test conclusions developed with regard to the land use decision process for known earthquake zones. This project will recommend model post-earthquake planning procedures, programs, and regulations.

Workshop on Prefabricated Concrete Buildings for Earthquake Loads; *Ronald Mayes,* Applied Technology Council, 480 California Avenue, Suite 205, San Francisco, CA 94105; $88,532 for 12 months beginning November 1, 1979.

This workshop will provide an opportunity for researchers and practitioners to identify areas where information is lacking or uncertainty exists in design analysis; construction practices, and design provisions for codes and standards for prefabricated concrete. Areas in need of research will be delineated and discussed so that priorities for research projects may be established. State-of-the-art papers will be presented, followed by group meetings to discuss specific topics of interest. A Proceedings Report will be published.

Nonlinear Analysis and Design of Steel Frames; *William McGuire,* Cornell University, Department of Structural Engineering, Ithaca, NY 14850; $127,897 for 12 months beginning February 15, 1979.

This research will further the development of interactive computer graphics as a practical, economical method for the static and dynamic nonlinear analysis and design of steel framed structures. An interactive design analysis system for two-dimensional static and dynamic nonlinear problem is to be developed. Clear directions are to be established for the treatment of three-dimensional nonlinear problems associated with earthquake-resistant design.

Seismic Behavior of Masonry Structures; *Hugh D. McNiven;* University of California-Berkeley, Department of Civil Engineering, Berkeley, CA 94720; $110,000 for 12 months beginning April 15, 1979.

Masonry construction is used extensively throughout the world for housing and office buildings. Due to lack of adequate shear strength and moment resistance as compared with steel and reinforced concrete structures, masonry structures are particularly vulnerable to strong earthquake ground shaking and pose the threat of great life and economic losses if not properly designed. Because of this, research on the earthquake behavior, and consequently the improved methods of design, of masonry structures is urgently needed.

This proposal presents an integrated experimental and analytical program for continuing research on the seismic behavior of masonry structures. Extensive shaking table tests of masonry piers and spandrel girders will be conducted to provide an adequate data base for parametric study, correlative analysis, and for development of mathematical models and analysis procedures. The methodology used is essentially a structural engineering approach in contrast with the structural mechanics approach used in a complementary project on-going at the University of California, San Diego, under Gilbert Hegemier.

Work during the project period will aim at exploratory studies of mathematical models relating loading and deformation, investigation of hysteretic behavior of masonry piers, prediction of ultimate strength of the shear, flexural and sliding modes of failures, and evaluation of the adequacy of the existing building codes. The project will be conducted with close coordination with American Masonry Institute, user's groups, and other current projects on the same subject research should provide much needed information on the use of masonry constructon in earthquake areas.

Shear Behavior of Reinforced Concrete Beam-Column Connections under Earthquake Loadings; *Donald F. Meinheit,* University of Notre Dame, Department of Civil Engineering, Notre Dame, IN 46556; $29,881 for 12 months beginning January 1, 1979.

Experimental data on the behavior of reinforced concrete beam-column connections under simulated earthquake loadings has been accumulating since 1967. Comparative analysis of the experimental data has been difficult because of differing research objectives and simulated earthquake loading histories. The need to upgrade existing structural systems and to provide better mathematical models for new designs and/or analysis suggests that the existing data be carefully scrutinized to find commonalities.

This research program will review existing information and data on reinforced concrete beam-column connections to find additional and more comprehensive means to correlate behavioral data with data on earthquake loadings.

The Dynamics of Structures with Localized Non-linearity; *Richard K. Miller,* University of California-Santa Barbara, Department of Mechanical and Environmental Engineering, Santa Barbara, CA 93106; $3,497 for 0 months beginning November 28, 1978.

Nonlinear structural behavior is of primary concern in the design and analysis of structures subjected to earthquakes. In some important applications, nonlinear behavior is restricted to one location within the structure, instead of being distributed throughout the structure. In such situations there is a need for simple and efficient methods of reducing computational costs, identifying important parameters, and interpreting response results for use in design.

This project will conduct analytical studies on the dynamics of structures with localized nonlinearity, and will extend existing methods and develop new methods for such analysis. The equation of motion for structures having local nonlinearity will be formulated and their steady-state, transient, and stochastic responses will be mathematically analyzed. This research will contribute to a better development of more efficient analysis techniques for the transient and earthquake response of such systems.

Development of a Unified Approach to the Design of Window Glass Subjected to Dynamic Forces; *Joseph E. Minor,* Texas Tech University, Institute for Disaster Research, Lubbock, TX 79409; $116,370 for 12 months beginning September 1, 1979.

This research will utilize current knowledge and techniques in a critical review of the process by which glass panels are selected for use in engineered structures. It is anticipated that this review can reduce uncertainties inherent in current processes thus enabling practitioners to effect safe, economical designs for glass windows.

This research will develop a tractable approach to the design of glass windows by utilizing current knowledge in wind engineering, glass material properties, and structural response of thin rectangular panels. A utilization plan will be implemented to relate this new approach to current professional practice and to expose the architectural and engineering professions to the new approach.

Analytical and Experimental Investigation of Structural Response — The Imperial County Services Building; *Gerard C. Pardoen,* University of California-Irvine, Department of Engineering, Irvine, CA 92664; $30,000 for 12 months beginning January 1, 1979.

Inasmuch as a structure's analytical model dictates a significant part of its overall design, it is imperative, particularly in highly seismic areas, that the model accurately represent the full-scale structure. One means of validating analytical procedures is to perform experimental studies of full-scale structures and compare actual results with those of the analytical model.

This research effort will be devoted to an in-depth experimental and analytical study of the Imperical County Services Building in El Centro, California. The experimental component of the research project will be devoted to low level structural excitations (ambient and forced vibration). The potential for obtaining results due to strong motion exists, since the candidate structure is in a highly seismic area and is instrumented under the California Strong Motion Instrumentation Program. The analytical component of the research will develop a mathematical model to represent low-level forced vibration. Methods and techniques needed to represent nonlinear structural behavior due to strong motion will also be investigated.

Error Evaluation of Inelastic Response Method for Earthquake Design; *Mario Paz,* University of Louisville, Department of Civil Engineering, Louisville, KY 40208; $30,000 for 12 months beginning January 1, 1979.

The response spectrum method for earthquake design of structure requires the superposition of modal components, thus making its application valid only for linear systems. Recently the response spectrum method has been extended into the inelastic range by using inelastic spectral charts in conjunction with modal analysis. The inelastic response spectrum method is both economical and practical, but its validity has not been theoretically justified.

The objective of this research is to evaluate the error involved in the application of modal superposition method in conjunction with the use of inelastic response spectra. The objective will be accomplished by investigating the following aspects of the problem: (1) definition of ductility factor for multi-degree-of-freedom systems, (2) definition of error in response spectrum methods for both elastic as well as inelastic structural behaviors, (3) estimation of minimum error range in response spectrum method, and (4) evaluation of error range for inelastic response spectrum method.

The results obtained by completion of this proposed research will provide valuable assistance for earthquake resistance design in the inelastic range by giving a precise definition of the pertinent parameters and by providing an evaluation of approximations and errors for the inelastic response spectrum method.

Seismic Behavior of Precast Curtain Walls in High Rise Buildings; *Dale C. Perry,* University of Idaho, Department of Civil Engineering, Moscow, ID 83843; $61,680 for 15 months beginning June 14, 1979.

This research consists of a broad program of full-scale laboratory studies and companion analytical investigations to explore the nature of curtain wall participation in the total structural response characteristics of high-rise buildings subjected to seismic excitation. Primary emphasis of this effort will be placed on the generation of full-scale test data for specific curtain wall assemblages in order to quantify the constitutive relationships for precast concrete cladding systems commonly employed in contemporary structures. The experimental data thus obtained will be utilized in the development of analytical models suitable for predicting the contribution of exterior, normally "non-structural", fascia panels to total building stiffness and energy dissipation. Comparisons will be made of reported full-scale building response measurements with the mathematical model predictions based on the results of this program.

Seismic Behavior of Structural Components; *Egor P. Popov,* University of California-Berkeley, Department of Civil Engineering, Berkeley, CA 94720; $370,224 for 12 months beginning April 15, 1979.

This project represents a major, continuing experimental effort in studying the complex inelastic seismic behavior of essential structural components commonly used in practice. One emphasis is to make use of the sophisticated laboratory testing and data recording and analysis facilities for detailed, slow-motion observations of structural deformations under simulated intensive earthquake excitation. Another emphasis is to conduct correlative experimental and analytical studies in order to establish improved mathematical models and develop general purpose computer programs.

The research is divided into five inter-related subprojects. These are: 1) Braced steel frames, 2) Reinforced concrete (R/C) walls and infilled frames, 3) R/C ductile frames, 4) R/C beam column components, and 5) Correlative general computer programs. All five sub-projects are extensions of current work concerning both steel and reinforced concrete structures. In the experiments, large-scale components of structural systems will be designed, fabricated and tested in the laboratory by subjecting them to slowly applied loadings in a quasi-static manner simulating earthquake motions. The results of the experimental work will be used as the basis for the construction and verification of mathematical models of structural components. The analytical work and experimental efforts are complementary so that the capabilities for analyzing the inelastic behavior of structural components can be broadened. The research findings of the project will lead to a better understanding of structural behavior and improved methods of analysis and design of earthquake-resistant steel and reinforced concrete structures.

Study of Behavior of Architectural (Non-Structural) Building Components During Earthquakes; *Satwant S. Rihal,* California State University-San Luis Obispo, Department of Architectural Engineering, San Luis Obispo, CA 93407; $30,000 for 12 months beginning January 1, 1979.

This research will review current practices for seismic design and detailing of building partition systems and suspended ceilings. A series of dynamic analysis will be performed to establish quantitative design forces and design deformations for the systems.

Full-size partitions will be tested for static deformations similar to expected seismic interstory drift. The behavior of the panel and the joints between panel and structure will be investigated, and the threshold of damage established.

Sections of suspended ceiling will be tested on a shaking table and the dynamic behavior of various configurations of bracing systems under seismic excitation determined.

Results of the research will verify recommendations for code provisions and development of methods for safer design of architectural components, connection types and geometrical arrangements.

An Analytical Technique for Establishing Emergency Services Planning Policy: Effects of Building Characteristics on Forecasts of Seismically-Induced Route Blockages, *David Schwarz,* San Jose State University, Department of Geography, San Jose, CA 95192; $30,000 for 12 months beginning January 15, 1979.

This research will develop techniques evaluating how well existing emergency services in earthquake-prone cities could serve earthquake victims. Indices of street blockages by rubble accumulation will be developed based on such factors as building type and mass, street-width, and building set-back and slope. These data will be derived from aerial photographs, where possible by delincating photomorphic regions indicative of urban form rather than the usual interpretation and classification by land-use type. These indices will be combined with existing data, especially those of spatial variation in seismic risk, and a weighting of factors will be calculated to estimate and map probable route blockages for portions of the San Francisco, San Jose, and Los Angeles, California metropolitan areas. Mapped data will include such measures as probable route distance between blockages and/or probability or blockage within a specified distance. When these maps are correlated with existing locations of emergency services, the effectiveness of such sites for serving the surrounding population following the disruption of the earthquake can be predicted. This research can also aid contingency planning to provide optimum relocations of services and to develop policies for new urban development.

Connections of Precast Prestressed Concrete Construction to Withstand Earthquakes; *Norman L. Scott,* The Consulting Engineers Group, 1701 E. Lake Avenue, Glenview, IL 60025; $111,374 for 15 months beginning June 15, 1979.

Precast prestressed concrete, an important method of construction, has the unique advantages of long spans with shallow depths, fire resistance, durability and minimum maintenance, attractive appearance, reduced construction time and competitive costs. Connections between members have been a major problem in design and performance of precast prestressed construction. Perhaps the most difficult requirements occur in structures designed to withstand the consequences of earthquakes and high winds.

The objective of this project is to document and evaluate the precast prestressed concrete connections used in structures to withstand earthquakes and high winds. This comprehensive state-of-the-art study will result in the classification of connection methods presently employed with respect to their performance history. The research plan is to conduct a literature study of precast connections for structures in earthquake areas, a survey of precast concrete manufacturers, engineers and architects and, most importantly, a classification of connection methods currently employed with respect to performance. Prestressed Concrete Institute will publish and distribute results from this study and will conduct seminars for designers and precast prestressed concrete manufacturers on connections for earthquake resistance.

Envelope Curves for Confined Concrete Subjected to Cyclic Loading; *Surendra P. Shah,* University of Illinois-Chicago Circle, Department of Materials Engineering, Chicago, IL 60680; $29,419 for 12 months beginning January 1, 1979.

The primary goal of this investigation is to test the following hypothesis: an "envelope" curve exists for cyclically loaded concrete specimens and that envelope curve is approximately the same as the complete stress-strain curve of the corresponding concrete. An envelope curve is the line which no stress-strain curve exceeds regardless of the loading history. If this hypothesis is verified, then the complete stress-strain curve provides a simple means to quantify the limit behavior of concrete subjected to seismic excitation, and provides a basis on which a more rational analysis of the response of reinforced and prestressed concrete structural members can be performed. Normal weight and lightweight concrete specimens of compressive strengths varying from 3000 to 12,000 psi and with different amount and types of confining

reinforcement will be subjected to a variety of cyclic loading as well as monotonically increasing loading. Analytical expressions for the envelope curves will be developed to include the effects of lateral reinforcement, compressive strength and the type of aggregates.

Effects of Earthquake Motions on Reinforced Concrete Buildings; *Mete A. Sozen,* University of Illinois-Urbana, Department of Civil Engineering, Urbana, IL 61801; $200,000 for 12 months beginning February 1, 1979.

The objectives of this study are to develop information to improve design methods and to investigate the effects of abrupt changes in stiffness on the response of structural frames and frame-wall combinations in the nonlinear range of response.

The principal experimental program involves small-scale structures subjected to simulated earthquake motions. The scope of the work includes tests of a nine-story frame with a tall first story; tests of three nine-story structures, each comprising two frames and a wall; development of analytical models to interpret and expand the scope of the experimental results; comparative studies of the observed behavior of all types of structures tested (coupled walls, frames, and frame-wall combinations); and synthesis of the resulting information for the development of practical methods for proportioning structures and for selecting structural systems for earthquake resistance.

The amount and distribution of reinforcement in each test structure will be based on a simple "design model" which reflects the influence of design decisions made concerning the tolerable damage in different structural elements.

Probabilistic Analyses of Nonlinear-Inelastic Earthquake Responses of Structures; *Pol Spanos,* University of Texas at Austin, Aeronautical Engineering and Engineering Mechanics, Austin, TX 78712; $26,968 for 12 months beginning January 1, 1979.

Probabilistic approaches will be used to study nonlinear and inelastic responses of structures to seismic excitation. Several nonlinear models of structures will be examined. The distributed element model for hyteresis will be used to investigate inelastic characteristics of structural response. The nonlinear or inelastic structure will be substituted by an optimal linear one to obtain analytical solutions for the determination of the time-dependent statistics of the structural response. These statistics will be used to construct average nonlinear response spectra. Several parameter studies will be performed. The objective will be the generation of reliable approximate methods for analysis and design purposes.

Dynamic Testing and Acoustic Analysis of Concrete Dams; *G. Bruce Taylor,* Anco Engineers Inc., 1701 Colorado Avenue, Santa Monica, CA 90404; $165,496 for 18 months beginning June 1, 1979.

A dynamic test procedure for concrete dams will be developed to acoustically detect defects in the dam which could cause failure under extreme conditions. A gas expansion device will be submerged in the reservoir near the face of the dam. The shock wave thus produced in the water will interact with the concrete interface and excite motion in the dam. Any defects which exist in the structure will emit acoustic signals which will be located through triangulation. The testing program will be augmented with a detailed analytical study of the structure utilizing finite element analysis techniques. Approximately eight concrete dams located in the United States will be examined. This non-destructive test method should be of great value in helping to evaluate the safety of dams subjected to seismic and other loadings.

Dissemination of Earthquake Damage Mitigation Techniques to Homeowners and Renters; *I.D. Terner,* University of California-Berkeley, Department of Architecture, Berkeley, CA 94720; $60,590 for 9 months beginning August 15, 1979.

The goal of this research is to design, test, and evaluate a prototype technical assistance service to enable homeowners and tenants to make seismic-strengthening modifications to their homes. The research team will establish, operate, and evaluate a pilot-scale prototype of an Earthquake Advisory Service (EAS) in the cities of Oakland and Hayward, California as a joint undertaking between the University of California, Berkeley and the Building Inspection Departments of the two municipalities.

The prototype of the EAS will seek to accomplish five tasks: 1) To catalogue seismic hazard procedures for representative small-scale residential structures; 2) To simplify and translate existing technical information into practical, easy-to-use instructions for homeowners and tenants; 3) To inform residents of seismic hazard zones, and to motivate them to undertake home modifications that will increase their safety in the event of an earthquake; 4) To assist and advise motivated residents to undertake these modifications on a "do-it-yourself" or minimum cost basis; and 5) To evaluate the effectiveness of the outreach, and the safety, cost and efficiency of the hazard mitigation work after it has been completed.

Design of Multi-Story Buildings by Component Mode Synthesis; *Morteza A. Torkamani,* Illinois Institute of Technology, Department of Civil Engineering, Chicago, IL 60616; $30,000 for 12 months beginning January 1, 1979.

The most frequently used procedures in computer programs for the linear dynamic analysis of earthquake-resistant design of multi-story buildings consider three degrees of freedom per story in the three dimensional case or use finite element representation of the mathematical model. The former considers many degrees of freedom, which usually exceeds the capacity of moderate size computers, while the latter will not result in a valid representation of the mathematical model of the building. An intermediate computer program to analyze high rise buildings using a better representation of the mathematical model and a relatively small number of degrees of freedom is required.

This research will apply component mode synthesis in linear dynamic analyses of multi-story buildings subjected to earthquake ground motion to allow better representation of the contribution of elastic component behavior.

Dynamic Inelastic Response of Reinforced Concrete Connections; *William H. Townsend,* SUNY State University at Buffalo, Department of Civil Engineering Buffalo, NY 14260; $30,000 for 12 months beginning January 1, 1979.

In this research reinforced concrete beam-column segments will be tested in order to construct a model for use in multi-story dynamic analysis. The main parameter studied will be girder depth and its effect on the inelastic response of connections. The connection segments will be tested dynamically by developing a model incorporating dynamic behavior.

Twelve beam-column exterior connection segments will be designed to meet seismic design requirements and will be built using concrete strengths of 4 Ksi and 5.5 Ksi. Only the joint-core segment will be constructed and tested, omitting the beam and column portions. These smaller structural components, being easier to construct, will make a parametric study of connections more feasible. The depth of joint-core, girder depth, will vary from 24 inches to 42 inches. Dynamic loads will be applied using 250 Kip hydraulic actuators with dynamic controls. The data will be recorded using a 28-channel analog tape recorder.

Prediction of Earthquake Resistance of Structures; *Ping Chun Wang,* Polytechnic Institute of New York, Department of Electrical Engineering and Electrophysics, Brooklyn, NY 11201; $10,904 for 0 months beginning December 1, 1978.

This project continues research on the development of a minimum method to generate reliable structural designs. A linear method has already been fully developed and a nonlinear method has been partially developed. Both methods have been applied to a limited number of test designs in previous studies.

This project is directed at the full implementation of the developed methods for elastic structures, and will complete the development of the theory, method, and design methods for inelastic structures. The research tasks to be carried out include: development of critical response spectra; development of computer programs; establishment of procedures for the choice of representative design variables; and the development of computational aids and computer programs in forms that can be directly used by the practicing engineers.

Experimental Investigation of Reinforced Concrete Beam-Connections Subjected to Earthquake Type Loading; *James K. Wight,* University of Michigan, Department of Civil Engineering, Ann Arbor, MI 48109; $69,373 for 12 months beginning May 1, 1979.

Twenty-four internal and external beam-to-column connections will be constructed and subjected to laboratory simulations of earthquake-type loadings. In order to more closely simulate real beam-to-column subassemblages, half of the specimens will have a floor slab and transverse beams in addition to the main beam and column. The other half of the specimens will be "bare" connections and are intended to serve as benchmarks for comparison with existing experimental data. Other primary variables will be the ratio of the column moment capacity to that of the beam, and the percentage of transverse reinforcement in the connection. The ratio of the column-to-beam moment capacity was shown to be very important in a recent investigation.

An analytical investigation will parallel these experimental studies. Its first phase will be to develop a mathematical model capable of reproducing the experimental results. The second phase will be to incorporate this model into an inelastic structural analysis program and to study its effect on the seismic response of various buildings.

The need for the information to be derived from this project was pointed out by the design recommendations of Joint Committee 352 of the American Concrete Institute and the American Society of Civil Engineers. It was found that current practices are too conservative and that construction of beam column connections are difficult to build in actual buildings and as a result that the costs are very expensive. The experimental program will study several variables in order to determine the most efficient amount of steel reinforcement required at the connections of beams to columns.

Stochastic Response of Tall Structures Under Environmental Loads; *J. N. Yang,* George Washington University, Civil, Mechanical and Environmental Engineering, Washington, DC 20052; $113,962 for 24 months beginning March 1, 1979.

One of the most important problems in earthquake hazards mitigation research is to develop methods for stochastic dynamic analyses of structural responses. Environmental loads caused by earthquakes and wind are generally random in nature. Stochastic methods have not been fully developed or utilized to date because of the high level of mathematical sophistication and computational schemes required.

This research will develop efficient analytical procedures for stochastic dynamic response analysis, taking into account the coupling effect of torsional and lateral motions. Loadings will be modeled as stationary and non-stationary random processes. A transfer matrix formulation will be developed and the computations will be performed utilizing a computer program. Development of approximate analytic procedures, treatment of non-linear effects, and sensitivity studies will also be included.

Reliability of Existing Buildings in Earthquake Zones; *James T. Yao,* Purdue University, Department of Civil Engineering, Lafayette, IN 47907; $16,906 for 6 months beginning July 1, 1979.

One important research task in Earthquake Engineering is to develop means by which existing buildings in earthquake zones can be appraised in terms of how they might respond during an earthquake. This project is a joint effort by the University of California, Berkeley and Purdue University. Berkeley will develop mathematical model by the system identification approach, and will test physical frame models on the shaking table. Purdue will formulate reliability criteria and analyze test results in terms of damage probability and other probabilistic response measures. This research will provide the basis for formulating effective and realistic counter measures to mitigate damage and losses associated with non-engineered existing buildings in seismic areas.

Vertical Motion of Highway Bridge Structures Due to an Earthquake; *Chai H. Yoo,* Marquette University, Department of Civil Engineering, Milwaukee, WI 53233; $29,755 for 12 months beginning January 1, 1979.

This research will involve an analytical investigation of the vertical and horizontal behavior of highway bridge structures under earthquake-induced loadings. Mathematical models of bridges will be developed to incorporate the earthquake loadings, thus permitting study of dynamic behaviors of multispan continuous grider bridges.

The current American Highway Design Code (AASHTO) does not specify any provision against the vertical motion of bridge structures during an earthquake; for the Japanese Code, a uniform vertical seismic coefficient of 0.10 is required. The results of this study will help determine whether a vertical seismic coefficient is needed, and if so, what it should be. Using various computer programs which will be developed for the mathematical model, numerous hypothetical and existing bridges will be formulated in terms of such parameters as span length, supports movements and accelerations in vertical and horizontal directions.

Measurements of On-Site Dynamic Parameters for Seismic Evaluations; *Roger M. Zimmerman,* New Mexico State University, Department of Civil Engineering, Las Cruces, NM 88003; $29,895 for 12 months beginning January 1, 1979.

The objective of this proposed research effort is to develop, laboratory test, and field tests a non-contact electromagnetic induction device that can be used to measure the vibrational properties of existing bridges. The purpose of the overall effort is to contribute towards the development of a mobile unit that can be used to measure these properties on in-service bridges and similar structures. With this information these structures can be evaluated for their seismic resistivity using other analytical techniques.

Specifically, the longitudinal, torsional, and flexural natural frequencies and damping ratios are sought for these existing structures. The non-contact measurement technique involves developing sensors composed of three coils aligned along orthogonal axes and positioned on a unit that is bonded at a specified location on a bridge. The test bridge is excited to resonance with a variable frequency oscillating eccentric mass. The tricoil sensor is activated when an electromagnet with a static field is brought into proximity. This electromagnetic field will be supported external to the bridge. The induced current in the coils will be proportional to their displacements on the bridge. Thus, the amplitude-time trace can be determined for each coil and the desired dynamic properties obtained.

POLICY

The Policy subelement of the Earthquake Hazards Mitigation program is intended to benefit local communities and State and Federal agencies by supporting research to develop an increased understanding of the adjustments society can make to earthquakes and other natural hazards. This includes studies of mechanisms to facilitate the adoption of such adjustments. Research on protective measures such as land use planning, preparedness, insurance, building standards and codes, and relief and rehabilitation is supported. In addition, public information and education efforts to evaluate relevant knowledge and disseminate hazard mitigation information to the public and user groups are supported.

A Longitudinal and Cross-Cultural Study of the Post-Impact Phases of a Major National Disaster; *Frederick L. Bates,* University of Georgia, Department of Sociology, Athens, GA 30602; $191,677 for 12 months beginning June 1, 1979.

The purpose of this multi-year research project is to analyze the long-term effects of the February, 1976 earthquake in Guatemala on the populations affected by the earthquake; to assess the results of U.S. Government and other relief and rehabilitation efforts; and to determine what social changes have occurred in Guatemala which can be attributed to the earthquake and to relief and rehabilitation efforts. Results are intended to provide information useful to Guatemala, to other Central and South American nations, and to agencies engaged in disaster relief and reconstruction in improving efforts to assist disaster stricken communities in the future.

Community Response to Natural Hazard Warning; *Robert K. Leik,* University of Minnesota, Department of Sociology, Minncapolis, MN 55455; $231,925 for 12 months beginning March 3, 1979.

This continuing research is providing information on how families and organizations in communities at risk to hurricanes, tornadoes, floods and earthquakes perceive, prepare for, make decisions on, and respond to warnings of natural hazards. Data have been obtained from 1,085 organizations involved with issuing and responding to warnings and from 5,714 households in hazard-prone sites. Laboratory experimental studies are being conducted to determine responses to specific types of warnings. Analyses of the data obtained will focus on matters such as the relationships between warning responses and the content and timing of the warning message; the comparative effectiveness of alternative organizational arrangements in responding to the occurrence of a natural hazard; and the levels of knowledge and of preparedness of households in sites subject to hazards.

Social-Behavioral Responses to Chemical Hazards; *E. L. Quarantelli,* Ohio State University, Department of Sociology, Columbus, OH 43210; $182,209 for 12 months beginning September 1, 1979.

This is a study of the socioeconomic and political factors related to the adjustment of communities to chemical hazards and disasters. The research involves investigation of preparations for chemical disasters in selected vulnerable locations; in-depth analysis of the emergency responses of organizations and communities to catastrophic events, major accidents, acute hazardous episodes and severe chronic events;

and examination of the long-term impact of chemical disasters on communities. The study will identify options and alternative strategies public and private groups might use to prepare for, respond to, and recover from chemical disasters.

Community Response to Earthquake Threat in Southern California; *Ralph H. Turner,* University of California-Berkeley, Department of Sociology, Berkeley, CA 94720; $168,862 for 13 months beginning January 15, 1979.

This study focuses on social response to a major uplift along the San Andreas fault and other premonitory signs of a destructive earthquake in the Los Angeles area. The data include results of a sample survey of residents of Los Angeles County, periodic follow-up telephone interviews, monitoring of the mass media, and interviews with selected public- and private-sector leaders. An innovative feature of the research plan is the development of special variations of a telephone reinterview schedule that can be fielded within a few days of any of the following contingencies: a destructive earthquake; a mild but widely felt earthquake; a new or more definite or threatening prediction announcement; cancellation of a prediction or warning; or disconfirmation of a prediction. The research should produce recommendations on optimal ways to release earthquake prediction information, effective strategies for involving State and local government leaders in the warning process, and useful strategies for securing public cooperation in a hazard-reducing response to earthquake prediction.

A Clearinghouse on Natural Hazards Research and Applications; *Gilbert F. White,* University of Colorado at Boulder, Institute of Behavioral Science, Boulder, CO 80309; $18,340 for 12 months beginning June 1, 1979.

Under this award, the Natural Hazards Research and Applications Information Center will continue to: (1) bring together selected users and producers of important research relating to natural hazards; (2) identify new or emerging needs for research; and (3) identify possible new producers of research findings on earthquakes and other hazards and encourage them to move ahead in the field. A major function of the Center is to help improve the dissemination of information on earthquakes and other natural hazards to such users as local, State and Federal officials. The Center will continue its efforts in this area through its Annual Natural Hazards Research Workshop which brings together research and user groups and through its quarterly publication, *Natural Hazards Observer,* which is distributed to 5,000 persons.

HUMAN NUTRITION

The Human Nutrition program supports research to assess the nutrient value of processed foods by investigating the physical and chemical changes which occur to them during cooking, processing, packaging and storage. Interdisciplinary research, including the participation of non-traditional nutrition-related disciplines; university-industry collaborative research; and the participation of small businesses are stressed.

Research topics of interest to the Human Nutrition program include the bioavailability of nutrients; binding of nutrients on non-digestible ingredients; digestion, absorption and metabolism of nutrients; the function of microflora; and interactions between nutrients and food additives.

Conference and Workshop on "Protein Quality in Humans: Assessment and in Vitro Estimation"; March 16-19, 1980; *James S. Adkins,* Howard University, School of Human Ecology, Washington, DC 20059; $18,501 for 12 months beginning September 1, 1979.

This award will support a workshop on "Protein Quality in Humans: Assessment and *In Vitro* Estimation". It will bring together leading scientists from universities, government, and industry in the field of protein quality research. The objectives are: to assess the precision of protein nutritional values obtained in human studies; to establish the degree of protein nutritional values acceptable for regulatory and manufacturing purposes; and, to assess the current status and potential applications of *in vitro* measures of protein nutritional quality. The workshop will develop conclusions and make recommendations on the use of rapid *in vitro* assays as alternatives to bioassays with rats or humans for estimating protein nutritional quality.

Effects of Food Additives on the Function of the Intestinal Microflora; *George W. Chang,* University of California-Berkeley, Department of Nutritional Sciences, Berkeley, CA 94720; $61,753 for 12 months beginning October 1, 1979.

This project will examine the interaction between food additives and intestinal flora. It will study the effects of widely used gums and modified starches on the proliferation and metabolism of intestinal bacteria in rats, and especially on the ability of such bacteria to produce harmful enzymes and toxic substances. Particular attention will be paid to the production of *b*-glucoronidase, which is involved in the recycling of toxins; mucinases, which may increase the permeability of the gut to toxins; and amino acid metabolites such as indole.

The Effects of Processing and Storage on the Oxidative Stability of Cholesterol in Dehydrated Foods; *J. I. Gray,* Michigan State University, Department of Food Science and Human Nutrition, East Lansing, MI 48824; $61,846 for 24 months beginning September 15, 1979.

Many foods, particularly those containing unsaturated double bonds, lose stability and nutritional quality through the oxidation of lipids. To date, there has been little data regarding the oxidation of cholesterol and other sterols in dehydrated food systems. This study will determine the environmental factors which contribute to the oxidation of cholesterol in both model food systems and

dehydrated foods, such as spray-dried egg and milk products, and will suggest packaging and storage conditions for minimizing the extent of cholesterol oxidation. A quantitative approach for evaluating the effect of environmental factors on storage stability, based on a combination of kinetic data and mass transfer characteristics of the package, will be employed to ascertain the optimum storage conditions for dehydrated cholesterol-containing foods. Results should contribute to improved understanding of the involvement of oxidation products of cholesterol in the development of cardiovascular disease.

Assessment of Chloro-Organics Formed in Foods; *James R. Kirk,* University of Florida, Department of Food Science and Human Nutrition, Gainesville, FL 32611; $81,069 for 12 months beginning April 1, 1979.

Chlorine is used in water treatment processes and food processing to control microbial growth. Chloro-organic compounds some of which may be carcinogens, may be formed during water treatment and food processing procedures. This study proposes to determine the effect of reactant species, reactant concentration, pH, temperature, and light on the rate of chlorine incorporation by bio-organic compounds in foods. The incorporation of chlorine into proteins, lipids, carbohydrates, vitamins, and selected food additives will be studied by determining the identity and concentration of chlorinated reaction products.

Initial studies will be carried out in model systems containing a single substrate in a buffered solution or suspension to which various concentrations of hypochlorous acid will be added. Chlorine incorporation will be determined by scintillation counting of labeled chlorine in organic reaction products. Identification of chlorinated organic compounds will be carried out using chromatography and mass spectrometry.

Real food systems will be investigated to determine the effect of these complex systems on chlorine incorporation. The rate of diffusion of hypochlorous acid and chlorinated reaction products will be determined as a function of pH, temperature, and basic physiological structure of the food system. The stability of chloro-organics will be studied. Collection and interpretation of these data will be used to establish guidelines for the safe use of aqueous chlorine with foods.

Nutrient Losses in Pasta Under Constant and Fluctuating Conditions; *Theodore P. Labuza,* University of Minnesota, Department of Food Science and Nutrition, St. Paul, MN 55114; $57,463 for 12 months beginning September 15, 1979.

The objective of this project is to determine the kinetics of the loss of the vitamins thiamin, riboflavin, niacin and of the amino acid lysine in a pasta product under steady state conditions in a range of water activity from 0.11 to 0.75 and temperatures from 25 to 45 °C. The rate of loss will also be measured under light and dark conditions. From this information, and information gathered on the rate of moisture transfer for various packaging materials, predictions of the losses occurring based on kinetic analysis will be made for different distribution conditions. Finally, the predictions will be tested by an actual measurement of losses that occur in simulated variable temperature, light, and humidity tests. If significant losses do occur under the conditions of this study, the results will be used to make recommendations of how pasta should be packaged and distributed.

Effects of Processing on Nutritive Content and Bioavailability of Selected Nutrients in Commonly Consumed Foods; *James E. Leklem,* Oregon State University, Department of Foods and Nutrition, Corvallis, OR 97331; $83,427 for 12 months beginning September 15, 1979.

This project will examine the levels of certain nutrients (vitamin B6, selenium, copper, zinc, sodium, potassium, calcium, and phosphorus) at specific stages of processing for ten commonly consumed foods (wheat and wheat products, canned tuna, french fried potatoes, canned peaches, peanut butter, canned and frozen green beans, canned and frozen corn, canned carrots, frozen broccoli, and frozen

cauliflower). For two nutrients, vitamin B6 and selenium, bioavailability will be assessed in a microbiological and rat model, respectively. Finally, the bioavailability of vitamin B6 and selenium from tuna, whole wheat bread, and peanut butter will be assessed in humans using a controlled metabolic feeding study. The results obtained with the microbiological and rat study will be compared with the human study to assess the applicability of these two models for determining the bioavailability of selenium and vitamin B6 for food consumed by humans.

Conference on Micronutrient Interactions: Vitamins, Minerals and Hazardous Elements; *Orville A. Levander,* New York Academy of Sciences, 2 East 63rd Street, New York, NY 10001; $5,000 for 12 months beginning September 1, 1979.

Although numerous conferences have discussed specific vitamins, minerals, or hazardous elements, few meetings have considered the possible interactions among these substances. This conference will enable scientists who have done outstanding work in this area to exchange ideas and to stimulate new investigators to initiate research. Certain interactions (such as those of vitamin D and calcium, of copper, molybdenum and sulfur, and of lead and calcium) have been recognized for a long time, but others are not so well appreciated. The timeliness of the conference is assured by the presentation of recent work dealing with the relation between nutritional factors and environmental hazards.

Chemico-Physical Analysis of Dietary Fiber in Foods; *Bertha A. Lewis,* Cornell University, Department of Nutritional Sciences, Ithaca, NY 14850; $123,472 for 12 months beginning September 15, 1979.

A study will be made of the effects of cooking and processing of foods (freezing, canning, drying) on the composition and bioavailability of non-structural carbohydrates and the dietary fiber complex. One research objective is to evaluate the adequacy and reliability of currently available methods for analyzing dietary fiber and non-structural carbohydrates and to improve these existing methodologies for routine analyses. Since the analytical methods depend on a physical rather than chemical properties of the dietary fiber components, any alteration of physical properties through cooking or processing could affect the validity of the analytical results. Reliable methodology is essential for food labeling regulations, in diet therapy, and in performing and interpreting *in vivo* studies of the effect of dietary fiber on gastrointestinal function. The physical properties of the dietary fiber complex and its components will be determined (in particular, particle size, water-holding capacity, ion-exchange capacity and adsorption of nutrients such as cations, anions and bile acids).

Meat Curing Effects on Heme and Nonheme Iron Bioavailability in Rats and C. Botulinum; *Arthur W. Mahoney,* Utah State University, Department of Nutrition and Food Science, Logan, UT; $141,233 for 36 months beginning September 15, 1979.

Data concerning the relative availability of heme and nonheme iron to microbial systems would be of great value in developing nitrite-free meat curing formulations to minimize formation of carcinogenic nitrosamines. Preliminary data indicate that both heating and nitrite curing may lower iron bioavailability for animals. Nitrites may also lower the availability of iron to microbial systems, and that this may cause inhibition of *C. botulinum* growth in cured meats. However, it is not known whether curing affects bioavailability of heme iron, nonheme iron in meat, or both.

Therefore, the research will evaluate the effects of curing procedures on relative bioavailability of heme and nonheme iron in both animal and microbial models and will also evaluate heme and nonheme iron chelators as substitutes for nitrite in cured meats. These data will be useful in developing nitrite-free meat curing formulations based on the relative levels of heme and nonheme iron in meats.

The Bioavailabilities of Iron and Zinc from Foods; *Dennis D. Miller,* Cornell University, Department of Food Science and Nutrition Science, Ithaca, NY 14850; $111,057 for 24 months beginning September 15, 1979.

This research will develop *in vitro* methods for estimating the bioavailability of iron and zinc in foods; evaluate the reliability of these methods as estimators of iron and zinc bioavailabilities; and use *in vitro* methods to assess iron and zinc bioavailabilities of selected foods and diets. Emphasis will be given to the measurement of bioavailability changes that occur during food processing. Effects of changes in dietary habits on iron and zinc bioavailabilities will be assessed.

Methods development will involve adaptions of recently reported *in vitro* methods. Foods will be subjected to simulated gastrointestinal conditions and soluble iron and zinc (both intrinsic stable iron and zinc and added radioactive iron and zinc) will be measured. The reliability of the method will be tested using foods with known iron availabilities.

Effect of Food Additives on Metabolic Activities of the Human Colonic Microflora; *Abigail A. Salyers,* University of Illinois-Urbana, Department of Microbiology, Urbana, IL 61801; $93,847 for 36 months beginning September 15, 1979.

The chemical environment of the human colon is determined in large part by the metabolic activities of bacteria that reside there. The diet of the host is thought to determine the metabolic activities of the colonic flora. Virtually nothing is known about the effects of processed foods on these metabolic activities. Some components of processed foods which might affect bacterial function are: anti-oxidants such as BHA or BHT which could interfere with membrane function; products of non-enzymatic browning reactions such as glycosylamines which could mimic natural substrates; and polysaccharide emulsifiers such as guar gum which are degraded by some colon bacteria and could act as an alternative carbon source.

This research is designed to assess the effects of long-term exposure to low concentrations of antioxidants, non-enzymatic browning products and guar gum on key metabolic activities of some major species of colon bacteria. Results will indicate what impact these components of processed foods have on the metabolic activities of colon bacteria. This information will aid in the design of experiments to test the effect of processed foods on colonic microflora *in vivo.*

The Effects of Processing on the Protein Quality of Legume-Based Foods and Collaborative Testing of the C-Per Assay; *Lowell D. Satterlee,* University of Nebraska-Lincoln, Food Production Research Group, Lincoln, NE 68508; $72,329 for 12 months beginning November 1, 1979.

This project builds upon the findings of a two year NSF-sponsored research program conducted by the Food Protein Research Group (FPRG), University of Nebraska.

The output of the current FPRG models for estimating nutritional quality of proteins closely agrees with data obtained from traditional Protein Efficiency Ratio (PER) assays — except for legume-based proteins, where the models overestimate nutritional quality. Recent human bioassay data also indicate that legume-based proteins are of higher quality than indicated by PER studies. Food processing may alter the methionine, cysteine and lysine residues in a manner that could account for the differing results of human, chemical and rat assays. This project will determine the effects of processing on legume-based food protein nutritional quality.

Bioavailability of Selenium and Zinc in Processed Human Food Based on Soy Protein: Studies Using Stable Isotope Tracers; *Vernon R. Young,* Massachusetts Institute of Technology, Department of Nutrition and Food Science, Cambridge, MA 02139; $70,701 for 12 months beginning September 15, 1979.

Increasing commercialization and consumption of vegetable protein in human foods originally based on animal proteins (such as meat and milk) raise important nutritional and public health considerations. This research addresses the nutritional content, dietary availability, and collateral dietary effects of a processed meat product and processed infant formula based on soy protein, on two essential trace mineral nutrients, zinc and selenium.

Stable (non-radioactive) isotopes of minerals will be used as tracers for neutron activation analysis of the fate of zinc and selenium added during food processing. Basic theoretical assumptions related to inherent experimental error, comparability with radioisotopic studies and evaluation of "extrinsic" labeling procedures will be tested in an experimental animal model for mineral bioavailability studies. Analytical methods of stable isotope determination using neutron activation will be refined and extended. The effect of replacing beef or casein with soybean protein in a sausage and infant formula on the bioavailability of zinc and selenium using extrinsic tags (^{70}Zn and ^{74}Se) will be explored and quantitative estimates of the bioavailability of "fortification" levels of zinc and selenium investigated in human subjects. The effect of soy protein on the availability of zinc and selenium from other components of a mixed diet and the relative availability of inorganic (selenite) and organic (selenomethionine) selenium will be determined.

SCIENCE AND TECHNOLOGY TO AID THE PHYSICALLY HANDICAPPED

The Science and Technology to Aid the Physically Handicapped program supports research on the use of the best available scientific and engineering developments to improve defective speech, visual, tactile, and hearing systems in persons afflicted with these impairments, and also to find ways to overcome locomotion and manipulatory limitations. The program involves researchers from many disciplines, including medicine, law, economics, the natural sciences, and engineering, working with the active participation of handicapped persons to ensure that the social and economic needs of the handicapped, as well as their physical needs, are best served. Research objectives include development of a better understanding of the social, economic and institutional barriers which inhibit the full participation of the handicapped in society, as well as research to develop and test low-cost technological aids which meet the needs of the handicapped.

Development of a Micro-Solenoid Operated Braille Display Cell; *Ernesto E. Blanco,* Universal Textile Machine, Department of Mechanical Engineering, P.O. Box 897, Lawrence, MA 01842; $25,000 for 6 months beginning October 1, 1979.

Embossed braille is costly and bulky. There is great need for "soft-copy" tactile display systems in which braille text can be erased and reset on command. To date, efforts to develop a bi-stable braille cell unit compact enough to fit into standard braille letter and line spacings have not achieved the desired results.

The system proposed for development under this award was investigated in preliminary form through an experimental thesis at MIT and found to have the desired characteristics. It consists of individual braille letter units. Each unit or module contains six microsolenoid-actuated stimulators with a unique passive locking mechanism to hold them in the display mode without drawing power.

Phase I of this research will investigate critical design parameters such as actuation force, heat dissipation, locking strength, and materials selection. Emphasis will be on manufacturability and low cost. Phase II will comprise the fabrication of a test surface under digital command for experimentation with blind subjects. A Phase III follow-on is intended to provide the blind with a reasonably priced, portable reading machine, approximately the size of a notebook, operable from a standard tape cassette.

Needs and Design Concepts for Voice-Output Communication Aids; *Bruce J. Boehm,* Telesensory Systems Inc., 3408 Hillview Avenue, P.O. Box 10099, Palo Alto, CA 94304; $156,120 for 18 months beginning October 1, 1979.

This project will determine the feasibility of, and design concepts for, low-cost voice-output modules for vocally disabled individuals. Such modules speed communication, minimize the need for user interaction, and are effectively matched to the vocabularies and other output characteristics of available communication aids. The concepts considered will be sufficiently versatile and flexible so as to be useful to non-vocal consumers with a variety of needs and capabilities. Resulting aids will help vocally disabled individuals communicate more effectively, have greater educational and vocational opportunities, and lead richer lives.

Research steps are to evaluate existing communication aids, analyze consumer requirements, analyze the technical, economic and human factors aspects of

alternative approaches, develop and evaluate new designs, and investigate the feasibility of cost-effective products. Vocally disabled consumers will play a major role in determining requirements and evaluating alternatives. Commercial development will be encouraged by organizing a workshop and inviting representatives of industrial, academic, research and consumer organizations to learn of early findings, by distributing final reports to these organizations and, if advisable, by other dissemination efforts.

Automatic Measurement of Laryngeal Vibratory Patterns; *Donald G. Childers,* University of Florida, Department of Electrical Engineering, Gainesville, FL 32611; $143,788 for 24 months beginning March 15, 1979.

Inability to provide vocal output prevents communication acoustically. This research will lead to an improved understanding of laryngeal vibrations and thereby aid in addressing the problems of correcting this physical handicap.

This study is directed toward establishing a relationship between parameters of focal cord motion as measured from ultra high speed laryngeal films and acoustic parameters extracted from audio recordings of phonation obtained simultaneously during the laryngeal filming process. The specific goal is to quantify and relate aspects of laryngeal vibratory motion by processing ultra high speed laryngeal films and simultaneously recorded phonations.

Automated analysis procedures will be developed to process both the films and the recorded phonations. Numerous parameters will be measured including glottal area, length, width, perimeter, velocity of motion, opening and closing phase, closed phase, open quotient, speed quotient, jitter and shimmer. The film analysis system will include algorithms to compensate for artifacts such as mucus in the glottal opening and the occlusion of the glottal boundary by the epiglottis and/or the arytenoids. The phonations will be processed by inverse filtering to obtain the glottal volume-velocity and residue. Comparisons will be made between the glottal area, the glottal volume-velocity and other parameters to determine which features are the most sensitive indicators of variations in the frequency and intensity of the subject's phonations.

The results of the study will contribute to our understanding of the manner in which the motions of the vocal folds are transformed into the unique sound generated.

An Ocular-Controlled Intelligent Speech Prosthesis; *Kenneth M. Colby,* University of California-Los Angeles, Department of Psychiatry, Los Angeles, CA 90024; $186,012 for 12 months beginning October 1, 1979.

This project will interface an intelligent speech prosthesis, already under development at the University of California at Los Angeles, with an ocular-control device under development at the Denver Research Institute. The resultant device, an ocular-controlled intelligent speech prosthesis, will provide a means of communication for the non-vocal population through the use of synthetic speech. The user will generate synthetic speech by looking at letters on the lenses of spectacles connected to the intelligent speech prosthesis.

In its first phase, the research will involve the hardware-software linkage of the two devices which utilizes a microprocessor and a speech synthesizer. In the second phase of the research, the feasibility of the device will be evaluated using individually selected patients, in particular those suffering from aphasia following a stroke, patients with cerebral palsy, and quadriplegics unable to speak.

The significance of this research lies in its ability to utilize new technological advances to provide spoken communication for the non-vocal population.

Study of Fast Feature Extraction for Blind Mobility; *Carter C. Collins,* Institute of Medical Sciences, Department of Visual Sciences, San Francisco, CA 94115; $184,208 for 24 months beginning September 1, 1979.

The research will investigate the feasibility of employing real-time automatic obstacle and landmark recognition for increasing and improving the mobility of the blind. The research team has successfully demonstrated a new feature extraction algorithm which will be implemented in real-time with a fast, portable microprocessor. Input will be obtained from a miniature, solid-state IV camera worn by the user.

The description and location of obstacles and navigational landmarks will be presented to a blind pedestrian through a combination of simple codes and machine generated speech. This information should improve mobility, permitting a blind person to acquire desired landmark goals as well as to avoid obstacles.

Feasibility of this approach will be tested in terms of objectively measured mobility performance. Indoor tests will be made on a mobility obstacle course with an existing sonar subject tracking system and microcomputer statistical evaluation equipment. Outdoor tests will measure environmental sensing, orientation and navigational skill improvements compared with the long cane. The criteria for success of the evaluation trials will be the subjects' reaching their destinations safely, efficiently and in reasonable time.

Replacement of Sensory Capabilities for the Physically Handicapped; *Donald R. Cowsar,* Southern Research Institute, Biosystems Divisons, 2000 9th Avenue South, Birmingham, AL 35205; $105,819 for 12 months beginning September 15, 1979.

At this time, there are no good measures to prevent decubitus ulcers and accidental injuries which result from loss of tactile and pain sensory capabilities. This problem adds millions of dollars annually to national health care costs. This project will seek to develop a new method to replace the senses of touch and pain in neurologically-injured patients by developing pressure-sensitive conductive elastomers in which electrical conductance is related to static pressure. The films can be made very thin and can readily conform to the shape of the interface without significantly distorting the pressure distribution. Sensors will be fabricated as a matrix array with strips of highly conductive elastomer connecting each sensor to electronic circuitry. The resistance of each sensor will be processed and converted into a pressure profile which can then be displayed in a form appropriate to the particular clinical application.

Electrical Stimulation of the Skin as a Basis for Sensory Prostheses; *William H. Dobelle,* Columbia University, Department of Surgery, New York, NY 10023; $87,700 for 12 months beginning September 1, 1979.

This project investigates the potential use of electrocutaneous stimulation in prosthetic devices for individuals with sensory handicaps. The investigation will differ from previous studies of similar devices which focused on mechanical stimulation systems which were expensive, bulky, and had high power requirements. Unlike many previous studies, this project will determine general methods of presenting patterns on the skin, rather than the investigation of a specific prosthetic system.

A highly flexible computer-controlled electrical stimulation system and electrode technology will be used for this investigation because the investigators feel that previous studies in this area were limited by the use of hardwired (and thus inflexible) stimulation and input transfer systems. The equipment was designed and is used for the safe electrical stimulation of the visual cortex and cochlea. Researchers will conduct a systematic investigation of electrocutaneous display methods using psychophysical techniques aimed at providing a body of basic information about the ability of human observers to perceive complex, dynamic patterns of input imposed on the skin. This information will be essential for the future design of non-invasive prosthetic devices.

Children's Auditory Discrimination and Perception of Monosyllabic Words; *Lois L. Elliott,* Northwestern University, Department of Communicative Disorders, 2299 Sheridan Road, Evanston, IL 60201; $225,170 for 36 months beginning September 1, 1979.

Research has shown that auditory perceptual "thresholds" for monosyllabic nouns that are within the receptive vocabularies of inner-city, three-year-old children decrease as a function of chronologic age and do not asymptote until the age of ten years. This project will determine whether this occurs because of differences between abilities of children and adults in detecting acoustic stimuli, in discriminating acoustic changes that are associated with speech sounds; in identifying phonemes of speech; or in achieving an

organized and integrated percept of a word. Synthesized speech stimuli and pure tones will be used in detection, discrimination and identification procedures that require the subject to select a response from among alternatives; reaction times will also be measured. Although normal children will be studied, project results may have potential applicability to handicapped populations such as hearing-impaired (moderate loss) and language-delayed children.

Visual Feedback Speech Training for the Deaf — Phase II: Speech Analysis Using Acoustic and Glottal Sensors; *Walter C. Gish,* Integrated Sciences Corp., 1640 Fifth Street #204, Santa Monica, CA 90401; $118,801 for 18 months beginning March 1, 1979.

This award supports Phase II or research initiated under NSF Program Solicitation 77-12: "Small Business Innovation Applied to National Needs." The goal is to develop a visual display of speech in a form useful for training the deaf.

The overall objective of Phase II is to provide an accurate parameterization of speech signals in terms of a speech model derived from the linear speech production theory. Results are expected to facilitate the application of previously developed statistical and pattern recognition techniques in providing more accurate and robust determinations of the speaker invariant characteristics of speech.

Microprocessor-Based Prosthetic Control; *Donald E. Gustafson,* Scientific Systems, Inc., 186 Alewife Brook Parkway, Cambridge, MA 02138; $94,886 for 24 months beginning April 1, 1979.

This research is concerned with the design of a system to provide control signals for a multifunctional prosthesis from a set of surface electromyelogram (EMG) signals. This will be accomplished by using both temporal and spatial variations in an effort to extract all of the available information. Temporal information at frequencies up to about 1000 Hz will be utilized. Spatial variation will be studied using at least four electrodes. The EMG signals will be modeled as multivariate Markov processes, with a different model used for each prosthesis function. Models will be developed using modern system identification techniques. A multiple-model Kalman filter will be designed to detect and identify the intended prosthesis function on-line; muscle force and intended velocity of the prosthetic arm will also be estimated. Recordings from both normal subjects and amputees will be made and will include: (1) elbow flexion and extension, (2) subination and supination, (3) wrist flexion and extension, (4) grasp, (5) relax, (6) thumb and index finger closure. The investigation will include analysis of electrode locations to maximize discrimination accuracy, and determination of the minimum number of required electrodes. Crosstalk between signals from different electrodes will be used to determine the location of the active muscles. This information is required for efficient function discrimination. In addition, the optimal sampling rate for the EMG will be determined. Algorithms will be developed and evaluated. The feasibility of microprocessor implementation will be evaluated through simulation.

Application of Personal Computers to Assist the Handicapped; *Paul L. Hazan,* Johns Hopkins University, Applied Physics Laboratory, Baltimore, MD 21218; $20,000 for 5 months beginning August 15, 1979.

The Johns Hopkins University Applied Physics Laboratory will administer the problem definition phase of project to organize a series of regional and national competitions to trigger innovative applications by individual Personal Computer users to assist the handicapped.

The handicapped, computer, educational, government, and volunteer service communities will be represented on an Advisory Committee which will define the detailed program. This definition will establish: Categories of Applications, Handicapped Situations to be Addressed, Levels of Individual Participation, Individual Project Maturity Level, and Award Strategies and their Potential Sources. The Advisory Committee will also establish evaluation procedures.

Neurophysiologically-Based Adaptive Controllers for Assistive Devices; *Neville Hogan,* Massachusetts Institute of Technology, Department of Mechanical Engineering, Cambridge, MA 02139; $138,039 for 24 months beginning September 1, 1979.

The objective of this project is to develop the best controller for interfacing a disabled user with an assistive device (such as an artificial limb) by taking advantage of the state-of-the-art in both technology and neurophysiology. Because of the importance of human operators' ability to adapt their behavior to a task being performed, this project will design, develop, test and evaluate a controller which will give an artificial limb the same adjustable capabilities as a natural limb. Myoelectric activity (the natural electrical activity of muscle) will be used for communication between man and machine. The controller will use natural patterns of simultaneous contraction of opposing muscles to control the adjustment of the artificial limb. To permit active involvement of the user population in the design and development phases, the research methodology features a wearable, versatile, artificial limb simulator which can be programmed to mimic the behavior of any proposed artificial limb design. Because it is worn by an amputee, the amputee can evaluate the proposed design and indicate its weaknesses; modifications can be made directly by simply reprogramming the device. The final design arrived at in this way will then be implemented on a self-contained artificial limb.

Low-Cost, High Performance Speech Recognizer for the Handicapped; *Charles S. Klayman,* Threshold Technology Inc., 1829 Underwood Boulevard, Delran, NJ 08075; $25,000 for 6 months beginning October 1, 1979.

The limited ability of handicapped persons to control their actions and to perform useful tasks makes them dependent on external systems and assistance. By using voice-controlled aids and devices, the performance of simple functions may be made possible for physically handicapped individuals and may thereby allow them to communicate with their environment, to control it, and perform productive tasks.

This research involves the development of low-cost, high performance speech recognition devices suitable for use by the handicapped. Although low-cost speech recognition devices previously have been demonstrated, their performance has not been adequate. This research studies techniques whereby existing high-quality speech recognition devices can be modified or adapted so that they can be produced at low cost while maintaining high performance.

Hearing Aids for Spatial Perception and Localization; *George F. Kuhn,* Vibrasound Research Corp., 4673 South Zenobia Street, Denver, CO 80236; $24,815 for 6 months beginning October 1, 1979.

It is well known that for human listeners the primary localization cues in the horizontal plane are the interaural time- and the interaural pressure level-differences at low and high frequencies, respectively. An analytical model developed by the Principal Investigator has been found to be an accurate predictor of the localization cue in the horizontal plane for normally hearing individuals. The localization cue in the vertical median plane is known to be produced by spectral cues generated by the diffraction of sound by the torso and head at low frequencies; spectral cues at high frequencies are produced by higher order acoustic modes in the pinna. A correlation between these modes and their associated localization cues has recently been determined by the Principal Investigator. While mathematical and physical models of the auditory information are beginning to be defined for the normally hearing person, no models, analytical or empirical, exist for partially deaf individuals. Therefore, models for auditory localization for aided listeners are proposed to be investigated and developed. An error analysis will be made of localization cues as a function of hearing aid location and frequency. These models and error analysis are expected to lead to a hearing aid design, using digital filtering techniques and/or delay networks, to reconstitute the localization cue as nearly as possible to that of the unaided listener. Thus, localization ability is restored to the partially deaf person.

Integrated Electro-Mechanical Transducer Systems; *John G. Linvill,* Stanford University, Department of Electrical Engineering, Stanford, CA 94305; $50,000 for 12 months beginning February 15, 1979.

The electrical properties of polyvinylidene fluoride sheets will be examined and used to develop models that characterize devices fabricated with the polymer. Primary device interest is centered on tactile sensors that consist of arrays of vibrating plates. Novel methods for using the polymer to stimulate the plates or to serve as the plates themselves will be studied. One objective of this project is to develop a planar technology approach to design of the electro-mechanical transducers. The design of integrated driver circuits for the transducers is a second concern.

Electronic Information Exchange in Research on Devices for the Disabled; *Jane McCarroll,* Innovative Systems Research, Inc., 103 Cooper River Plaza East, Pennsauken, NJ 08109; $20,275 for 12 months beginning June 1, 1979.

This project is to conduct a planning meeting and pilot test of the use of electronic information exchange in the development of an improved nationwide delivery system for rehabilitation technology products, services, and information. The project will be jointly supported by NSF's Division of Information Science and Technology and EAS's Science and Technology to Aid the Physically Handicapped program.

An Engineering Foundation Conference on "Biomechanics of Movement"; *William R. Rymer,* United Engineering Trustees, 345 E. 47 Street, New York, NY 10017; $10,000 for 6 months beginning June 1, 1979.

The control of movement in man requires that neural signals, both afferent and efferent, interface with physical structures (such as muscles and limbs) which possess a range of inertial, elastic frictional and viscous properties. Motor systems neurophysiologists, for the most part preoccupied with electrophysiological aspects of movement control, have devoted less attention to the properties of the mechanical systems which must necessarily be controlled for movement to be executed. On the other hand, engineers interested in movement have been oriented towards precise descriptions of "plant" characteristics and behavior, and have attempted to use the methodology of control theory to formulate (largely unsuccessful) models of the control of movement.

The objective of this meeting is to attempt some synthesis of these disparate approaches by addressing aspects of biomechanics which are relevant to neural control strategies and highlighting recent developments in neurophysiology which may shed light on the neural-mechanical interaction. Thus, neuroscientists may better appreciate the nature of the control problem, while the bioengineer may be influenced by the techniques used by the nervous system to deal with these control problems in life.

Investigation of Polyvinylidene Fluoride as a Tactile Stimulator for the Optacon; *James F. Tetzlaff,* Telesensory Systems, Inc., 3408 Hillview Avenue, P.O. Box 10099, Palo Alto, CA 94304; $24,640 for 6 months beginning October 1, 1979.

At present, the tactile stimulators for the Optacon, a reading aid for the blind, are made from ceramic (PZT) bimorphs. Although the tactile screen made of PZT has given reliable service, it is the part of the instrument most susceptible to damage in use and contributes significantly to the size, weight, and cost of the instrument. An alternative approach to construction of the tactile screen is an array of cylindrical stimulators made from the piezoelectric polymer polyvinylidene fluoride (PVF_2). These stimulators can operate directly in the transverse mode resulting in a simple mechanical design with low acoustic noise.

A PVF_2 tactile stimulator array will enable construction of a one-hand Optacon in which the photosensing and tactile output arrays are located in the same package and small enough to be held in one hand. This configuration would eliminate the need for two-handed coordination. This feature would expand the range of tasks with which a blind person could use an Optacon.

APPENDIX A

DIVISION OF PROBLEM-FOCUSED RESEARCH
FY 1979 AWARDS

Principal Investigator/ Institution	*Project Title*	*Amount*	*Effective Date/Award Duration*	*Page*
	ALTERNATIVE BIOLOGICAL SOURCES OF MATERIALS			
Chauncey R. Benedict Texas A&M University	The Regulation of Rubber Formation in Guayule *(Parthenium Argentatum)* Plants	$49,621	8/1/79 12 months	5
John R. Benemann Ecoenergetics Inc.	Polysaccharide Production by Microalgae	$24,696	10/1/79 6 months	5
H. Earl Bloss University of Arizona	Mycorrhizae for Guayule and Jojoba Productivity	$30,674	3/15/79 12 months	6
Winston J. Brill University of Wisconsin-Madison	Enhancing Plant Productivity With Nitrogen-Fixing Bacteria	$207,540	6/1/79 12 months	6
Ronald L. Crawford University of Minnesota	Bacterial Transformations of Lignin	$46,038	8/1/79 12 months	6
Delmar D. Fangmeier University of Arizona	Water Use and Production Practices for Guayule	$82,688	8/15/79 12 months	7
Wolfgang G. Glasser Virginia Polytechnic Institute	Enzymatic Transformations of Lignin	$200,289	7/15/79 12 months	7
Irving S. Goldstein North Carolina State University at Raleigh	An Integrated Approach to the Conversion of Lignocellulose from Wood into Useful Chemicals	$214,760	7/1/79 12 months	7
John C. Gordon Oregon State University	Workshop on Symbiotic Nitrogen Fixation in the Management of Temperate Forests	$25,315	12/1/78 12 months	7
Edward A. Grula Oklahoma State University	Insecticidal Activity of *Beauveria bassiana*	$0	9/1/79 12 months	8
Philip L. Hall Virginia Polytechnic Institute	Enzymatic Transformations of Lignin	$40,625	11/7/79 12 months	8
George P. Hanson California Arboretum Foundation	Chemical Stimulation of Rubber Synthesis in Guayule	$65,825	5/1/79 12 months	8
George P. Hanson California Arboretum Foundation	Breeding Improvement of Rubber Yield in Guayule	$144,056	4/1/79 12 months	8
Donald R. Helinski University of California-San Diego	Enhancement of Biological Nitrogen Fixation by Genetic Manipulation of Rhizobium	$110,871	6/1/79 12 months	9
Victor R. Koch EIC Corporation	Low Temperature Thermoconversion of Biomass to Useful Chemicals by Lewis Acid Catalysts	$22,024	10/1/79 6 months	9
Marvin Lamborg Chas. F. Kettering Foundation Research Laboratory	A Multifaceted Approach to Enhancing Biological Nitrogen Fixation	$175,954	7/15/79 12 months	9
James M. Lyons University of California-Davis	Enhancing Biological Production of Ammonia from Atmospheric Nitrogen and Soil Nitrate	$91,021	6/15/70 12 months	9
John A. Manson Lehigh University	New Polymers Based on Industrial Oils from Renewable Resources	$64,625	5/15/79 12 months	10
Akira Mitsui University of Miami	Nitrogen Fixation with Photosynthetic Marine Microorganisms	$117,983	1/19/79 12 months	10
Akira Mitsui University of Miami	Production of Hydrogen by Marine Blue-Green Algae	$162,897	6/15/79 12 months	10

Principal Investigator/ Institution	*Project Title*	*Amount*	*Effective Date/Award Duration*	*Page*
Toshio Murashige University of California-Riverside	Development of Tissue Culture Systems for Guayule	$72,484	12/15/78 12 months	10
Michael Neushul Neushul Mariculture Inc.	Experimental Macro-Algal Mariculture	$335,207	7/1/79 24 months	11
Dale M. Norris University of Wisconsin	Isolation of Lignocellulose-Transforming Micro-organisms	$112,678	1/19/79 12 months	11
Peter J. Reilly Iowa State University of Science and Technology	The Conversion of Agricultural By-Products to Sugars	$124,100	3/15/79 12 months	11
Eloy Rodriguez University of California-Irvine	Toxicological Studies on Guayule	$52,329	2/15/79 12 months	11
David D. Rubis University of Arizona	Natural Rubber from Guayule	$100,318	8/15/79 12 months	12
Kyosti V. Sarkanen University of Washington	Chemicals from Western Hardwoods and Agricultural Residues (Amendment 1)	$124,375	11/2/78 12 months	12
Kyosti V. Sarkanen University of Washington	Chemicals from Western Hardwoods and Agricultural Residues (Amendment 3)	$92,495	10/1/79 9 months	12
Peter Schauffler Bio-Energy Council	Capturing the Sun through Bioconversion—Conference II	$25,000	7/15/79 24 months	12
Fred Shafizadeh University of Montana	Investigation of Sagebrush as a Major Biological Source of Materials	$83,521	9/15/79 24 months	12
James F. Shepard Kansas State University	Regeneration, Selection and Evaluation of Plants from Protoplasts of Potato	$100,000	1/24/79 12 months	13
Anthony J. Verbiscar Anver Bioscience Design, Inc.	Jojoba Meal as a Livestock Feed	$128,371	12/1/78 12 months	13
J. W. Whitworth New Mexico State University	Herbicides for Weed Control in Guayule Plantations and their Influence on Rubber Yields	$45,806	6/1/79 12 months	13
Donald L. Wise Dynatech Corporation	Bioconversion of Biomass Gasifier Product Gases to Organic Chemicals	$166,706	11/1/78 18 months	13
Demetrios M. Yermanos University of California-Riverside	Development of Superior Cultivars of Jojoba	$102,545	10/1/79 12 months	14
J. G. Zeikus University of Wisconsin-Madison	Biological Systems for Lignocellulose Conversion	$98,690	8/15/79 12 months	14

CHEMICAL THREATS TO MAN AND THE ENVIRONMENT

Fred R. Albright Lancaster Laboratories, Inc.	Research on a Rapid and Simple Detection Method for Asbestos	$21,210	10/1/79 6 months	15
Silverio P. Almeida Virginia Polytechnic Institute	A Water Pollution Monitoring Laser System	$103,607	3/1/79 12 months	15
Alan R. Bandy Drexel University	Field Studies of Biologically Produced Atmospheric Sulfur Compounds	$127,052	3/6/79 12 months	16
John J. Black Health Research, Inc.	Investigation of Water-Borne Cancer Hazards Associated with the Buffalo River Environment	$170,000	5/1/79 30 months	16
John M. Bremner Iowa State University of Science and Technology	Natural and Fertilizer-Induced Emissions of Nitrous Oxide from Soils	$110,195	2/15/79 12 months	16
Peter R. Buseck Arizona State University	Quantitative Electron Microprobe Analysis of Individual Airborne Particles	$148,868	4/1/79 14 months	17
Ananda M. Chakrabarty University of Illinois at the Medical Center	Microbial Biodegradation of Synthetic Environmental Pollutants	$151,718	8/1/79 24 months	17

Principal Investigator/ Institution	*Project Title*	*Amount*	*Effective Date/Award Duration*	*Page*
Fun Sun Chu University of Wisconsin-Madison	Studies on the Metabolism of Ochratoxin A and Citrinin	$135,437	3/15/79 36 months	17
John M. Duxbury Cornell University	Soils as a Source or Sink of Atmospheric Nitrous Oxide	$114,145	8/15/79 12 months	18
David H. Fine New England Institute for Life Sciences Inc.	The Chemistry of N-Nitroso Compounds and their Occurrence in the Environment	$199,474	9/1/79 12 months	18
Paul O. Fromm Michigan State University	Effects of Pollutants on Gills of Freshwater Fishes	$46,383	7/1/79 12 months	18
Anil C. Ghosh SISA Incorporated	Mycotoxins: A Potential Human Health Hazard	$188,640	7/15/79 24 months	19
Gershon M. Goldberg Ionomet Company, Inc.	Vapor Deposited Silver Halides for Thin Layer Chromatography	$24,980	10/1/79 6 months	19
Glen E. Gordon University of Maryland-College Park	Sources, Transformations, and Chemical Nature of Atmospheric Pollutants	$51,364	12/1/78 12 months	19
Robert K. Gould Acrochem Research Labs, Inc.	Aerosol Characterization in Real Time	$99,937	5/1/79 12 months	20
John E. Hawley Hazen Research Inc.	Separation of Radium-226 and Thorium-230 from Uranium Ore	$24,600	10/1/79 6 months	20
Delbert D. Hemphill University of Missouri, Columbia	Annual Conferences on Trace Substances in Environmental Health	$24,425	6/15/79 12 months	20
T. C. Hsu University of Texas	Cytogenetic Effects of Mutagens and Mitotic Poisons on Mammalian Cells	$86,703	1/19/79 12 months	20
James J. Huntzicker Oregon Graduate Center	Analysis of Organic, Elemental and Carbonate Carbon in Atmospheric Aerosols	$36,203	8/1/79 12 months	21
Gregory L. Kok Harvey Mudd College	Analytical Instrumentation for the Determination of Formaldehyde in the Ambient Atmosphere	$30,351	2/15/79 16 months	21
Walter J. Maier University of Minnesota	Characterization and Transformations of Aquatic Organics and Complexes	$135,932	8/1/79 18 months	21
Arlan Mantz Laser Analytics Inc.	Improved Sensitivity of Laser Absorption Techniques for Atmospheric Pollutant Monitoring	$76,018	5/15/79 12 months	22
Theodore Mill SRI International	Oxidation Processes in Soil	$175,375	5/1/79 6 months	22
Aaron L. Mills University of Virginia	Evaluation of Effects of Acid Mine Drainage on Microbial Community Structure and Function in a Freshwater Lake	$94,926	8/1/79 24 months	22
Volker A. Mohnen SUNY State University at Albany	SO_2 Oxidation Rate on Well-Characterized Surfaces—A Laboratory Study	$100,035	8/1/79 12 months	23
David F. Natusch Colorado State University	A Field Study of Biogenic Sulfur Gas Releases from Inland Surface Waters	$77,727	8/1/79 12 months	23
Arthur S. Obermayer Moleculon Research Corp.	Poroplastic Personnel Vapor Monitoring Badges	$106,822	1/22/79 12 months	23
Richard H. Pierce Jr. Florida Institute of Technology	Pentachlorophenol and Pentachlorophenol Degradation Product Persistence in Lake Sediment	$43,350	1/1/79 24 months	24
James N. Pitts University of California-Riverside	Atmospheric Transformations and Mutagenic Activity of Primary and Secondary Air Pollutants	249,949	2/5/79 12 months	24
Eugene P. Scheide Environmetrics	Personal Dosimeter for Anesthetic Gases	$24,973	10/1/79 6 months	24
Henry J. Segall University of California-Davis	The Detection of Pyrrolizidine Alkaloids and their Metabolites	$86,015	6/1/79 12 months	25

Principal Investigator/ Institution	*Project Title*	*Amount*	*Effective Date/Award Duration*	*Page*
Peter S. Spencer Yeshiva University	Chemical Threats to Man's Nervous System	$131,741	1/1/79 12 months	25
Raymond L. Teplitz City of Hope National Medical Center	Development of Screening Methods for Developmental Abnormalities	$89,999	7/1/79 12 months	25
David R. Young Southern California Coastal Water Research	Pollutant Flow through the Marine Food Web	$602,662	8/1/79 24 months	26
	COMMUNITY WATER MANAGEMENT			
Francis C. Brown EIC Corporation	Chromium Recovery from Tannery Industry Wastes	$24,931	10/1/79 6 months	27
Ronald Capalaces Forum Inc.	Utilization of Wetlands for Wastewater Management	$59,384	5/1/79 8 months	27
D. B. Clayton D. B. Clayton and Associates	Removal of Silica from Cooling Water by Activated Alumina	$25,000	10/1/79 6 months	28
Richard R. Dedolph Gravi-Mechanics Company	The Entrapment Concentration and Recovery of Heavy Metals from High-Yield Exhausts by use of Stabilized Soil Adsorption Beds	$24,970	10/1/79 6 months	28
Richard I. Dick Cornell University	Process Integration for Optimum Management of Municipal Wastewater Treatment Sludges	$77,800	7/1/79 12 months	28
Clayton Edwards Image Associates	Utilization of Wetlands for Wastewater Management	$3,000	5/21/79 2 months	28
Harris Gold Water Purification Associates	Water Management in New England: A Method for Investigating Short-Run Operational and Long-Range Investment Strategies	$130,102	9/1/79 12 months	29
Clarence G. Golueke CAL Recovery Systems Inc.	Benefits and Problems of Refuse-Sludge Composting	$19,599	10/1/79 6 months	29
Roger Haag Rickel Manufacturing Corp.	Agricultural Utilization of Sludges from Treatment of Community Wastewater	$25,000	10/1/79 6 months	29
Roy C. Hartenstein S.U.N.Y.	Stabilization of Community Wastewater Sludges by Soil Invertebrates	$90,000	6/1/79 12 months	29
Robert H. Kadlec University of Michigan	Wetland Utilization for Management of Community Wastewater	$152,275	5/1/79 12 months	30
Paul S. Kernion Sonic-Clean Inc.	Application of Ultrasonics and Electrostatics in Wastewater Treatment and Disinfection	$25,000	10/1/79 6 months	30
John G. Trump Massachusetts Institute of Technology	Disinfection of Community Wastewater Sludges by use of High Energy Electrons	$90,000	7/1/79 12 months	30
Leon W. Weinberger Environmental Quality Systems	Prediction and Control of Heavy Metals and Toxic Organic Materials in Sludges	$123,234	9/1/79 12 months	30
	EARTHQUAKE HAZARDS MITIGATION **Siting**			
Ahmed M. Abdel-Ghaffar University of Illinois-Chicago Circle	Earthquake Induced Longitudinal Vibration of Earth Dams	$29,929	1/1/79 12 months	33
M. S. Agbabian Earthquake Engineering Research Institute	Engineering Monographs on Earthquake Criteria and Structural Design	$140,000	6/1/79 18 months	33
Keiiti Aki Massachusetts Institute of Technology	A New Approach to the Prediction of Earthquake Strong Motion	$119,166	3/8/79 16 months	34
Subhash C. Anand Clemson University	Seismic Behavior and Design of Urban Area Tunnel Linings	$29,966	1/1/79 12 months	34

Principal Investigator/ Institution	*Project Title*	*Amount*	*Effective Date/Award Duration*	*Page*
Christoph E. Arnold Building Systems Development, Inc.	Methods and Costs of Maintaining Hospital Functions in Earthquakes	$187,304	8/15/79 18 months	34
Richard E. Barlow University of California-Berkeley	Analysis of Lifelines Subjected to Earthquakes	$86,256	6/1/79 12 months	35
Melvin L. Baron Weidlinger Associates	Underground Lifelines in a Seismic Environment	$417,829	5/1/79 12 months	35
Theodore B. Belytschko Northwestern University	Dynamic Analysis of Earthquake Shaking Deformations for Large Caverns in Jointed Rock	$175,900	1/15/79 24 months	35
Jack R. Benjamin Jack R. Benjamin Associates Inc.	Optimal Design of Earthquake Strong-Motion Networks	$34,886	10/1/79 12 months	36
Joseph W. Berg National Academy of Sciences	Partial Support of the Committee on Seismology	$20,000	10/1/79 24 months	36
John M. Biggs Massachusetts Institute of Technology	Flexible Sub-Surface Building-Foundation Interfaces for Aseismic Design	$114,927	9/1/79 12 months	36
John A. Blume Earthquake Engineering Research Institute	Scientific and Technical Information Exchange in Earthquake Research between the United States and the People's Republic of China	$34,940	8/1/79 6 months	36
Bruce A. Bolt University of California-Berkeley	Taiwan Large-Scale Strong-Motion Array Project	$336,477	7/15/79 24 months	37
A. G. Brady U.S. Geological Survey	The National Program on Strong-Motion Instrumentation	$993,880	5/1/79 12 months	37
Colin B. Brown University of Washington	Objective and Subjective Seismic Safety Considerations	$47,625	7/15/79 12 months	37
James N. Brune University of California-San Diego	Numerical and Experimental Study of Earthquake Strong Motion	$144,875	6/15/79 12 months	38
Ching S. Chang University of Massachusetts Amherst Campus	Design Method for Predicting Footing Settlement from Earthquake Effect	$29,317	1/1/79 12 months	38
Nien Yin Chang University of Colorado at Denver	Effects of Grain-size Distribution on Dynamic Properties and Liquefaction Potential of Granular Soils	$29,960	1/1/79 12 months	38
Wai-Fah Chen Purdue University	Earthquake-Induced Landslides	$194,289	1/1/79 24 months	39
James A. Cheney University of California-Davis	Centrifuge Facility for Research in Geotechnical Engineering	$16,583	8/15/79 12 months	39
Anil K. Chopra University of California-Berkeley	US/Taiwan Cooperative Research in Earthquake Engineering	$67,269	9/1/79 24 months	39
Ray W. Clough University of California-Berkeley	Earthquake Behavior of Techi Dam	$140,173	1/15/79 24 months	39
Lloyd S. Cluff Woodward-Clyde Consultants	Probabilistic Earthquake Hazard and Risk Assessments	$59,615	6/1/79 18 months	40
C. Allen Cornell Massachusetts Institute of Technology	Engineering Ground Motion Prediction Procedures	$292,810	7/15/79 24 months	40
Subhendu K. Datta University of Colorado	Response of Submerged Shells to Seismic Waves	$30,000	1/1/79 12 months	40

Principal Investigator/ Institution	*Project Title*	*Amount*	*Effective Date/Award Duration*	*Page*
Pedro A. DeAlba University of New Hampshire	A Model Study of Pile Bearing Capacity in Liquefiable Sand Deposits under Earthquake Loading	$29,660	1/1/79 12 months	40
Ricardo Dobry Rensselaer Polytechnic Institute	Duration Characteristics of Horizontal Components of Strong Motion Earthquake Records	$233,037	9/1/79 24 months	41
John O. Dow University of Colorado	A Symbol Processor for Earth Dam Seismic Response with a Nonlinear-Inelastic Soil Model	$28,160	1/1/79 12 months	41
C. M. Duke Earthquake Engineering Institute	Maximizing the Learning from Destructive Earthquakes	$50,005	7/1/79 12 months	41
Edward Epremian National Academy of Sciences	Post Event Investigations to Maximize Learning from Destructive Natural Disasters	$85,000	9/1/79 12 months	42
George T. Goforth Department of Defense	1979 Multiprotection Design Institute; August 6 through August 17, 1979; DCPA Staff College; Battle Creek, Michigan	$25,000	8/1/79 6 months	42
Donald V. Helmberger California Institute of Technology	Seismological Investigation of Strong Ground Motion	$61,080	2/1/79 12 months	42
R. S. Hickman University of California-Santa Barbara	Generate Mathematical Models of Slide Induced Waves	$29,320	1/1/79 12 months	42
George W. Housner California Institute of Technology	Seismic Response of Structures and Strong-Motion Instrumentation	$404,552	5/1/79 12 months	43
George W. Housner California Institute of Technology	National Information Service for Earthquake Engineering	$90,493	7/1/79 12 months	43
Paul Ibanez ANCO Engineers, Inc.	*In Situ* Soil Dynamic Testing and Analysis to Determine Soil Constitutive Properties	$121,187	7/1/79 15 months	43
Edward Kavazanjian Stanford University	Prediction of Dynamic Material Properties from their Static Shear Behavior	$30,000	1/1/79 12 months	44
Leon Knopoff University of California-Los Angeles	Statistical Investigation of Engineering Seismology	$100,523	3/1/79 16 months	44
Denny R. Ko Dynamics Technology Inc.	Development of a Computer Code for the Response of Submerged Structures to Seismic Excitations	$125,719	7/1/79 12 months	44
Hon-Yim Ko Univesity of Colorado	Dynamic Properties of Clays under General Three-Dimensional Stresses	$140,845	4/15/79 24 months	44
Frank Kozin Polytechnic Institute of New York	Earthquake Engineering Applications of Nonstationary Autoregressive Models	$168,217	12/1/78 24 months	45
Bernard M. Leadon University of Florida	Fluctuating Pressures on Tall Buildings	$77,311	10/1/79 12 months	45
Y. K. Lin University of Illinois-Urbana	Structural Response under Random Wind Loading	$9,000	6/1/79 3 months	45
Philip L. F. Liu Cornell University	Numerical Modeling of Tsunamis	$51,420	12/15/78 12 months	46
Juan E. Luco University of California-San Diego	Response of Three-Dimensional Structures to Non-Vertically Incident Seismic Waves	$141,295	4/15/79 24 months	46
Ajit K. Mal University of California-Los Angeles	Site and Source Effects on Design Earthquake Motions	$160,000	5/1/79 24 months	46

Principal Investigator/ Institution	*Project Title*	*Amount*	*Effective Date/Award Duration*	*Page*
Kishor C. Mehta Texas Tech University	Workshop on Wind Characterization for Dynamic Analysis of Structures	$15,195	8/15/79 12 months	46
Irving J. Oppenheim Carnegie Mellon University	Vulnerability of Transportation and Water Systems to Seismic Hazards	$105,120	3/15/79 12 months	47
Thomas D. O'Rourke Cornell University	Analytical Modeling of Buried Pipeline Response to Static Earthquake Displacement	$28,970	1/1/79 12 months	47
Joseph Penzien University of California-Berkeley	National Information Service for Earthquake Engineering	$318,485	4/1/79 12 months	47
Joseph Penzien University of California-Berkeley	The United States-Japan Cooperative Research Program on Large-Scale Structural Systems: A Planning Study	$8,570	3/1/79 6 months	48
Bruce B. Redpath John A. Blume and Associates	Development of Field Techniques to Measure Damping Values for Near-Surface Rocks and Soils	$183,241	8/1/79 18 months	48
Adel S. Saada Case Western Reserve	An Evaluation of Laboratory Testing Techniques in Soil Dynamics	$136,274	7/1/79 24 months	48
Dwight A. Sangrey Cornell University	Development of an *In Situ* Liquefaction Evaluation System	$145,575	6/15/79 24 months	49
Anshel J. Schiff Purdue University	Improving Earthquake Resistance of Power Transmission Substations	$94,029	6/1/79 12 months	49
M. G. Sharma Pennsylvania State University	Dynamic Properties of a Cohesive Soil	$30,000	1/1/79 12 months	49
Emil Simiu National Bureau of Standards	Probability Distribution of Extreme Wind Speeds	$68,286	5/15/79 12 months	50
Mahendra P. Singh Virginia Polytechnic Institute	Seismic Stability Evaluation of Earth Structures	$30,000	1/1/79 12 months	50
Lars Skjelbreia Science Engineering Associates	Earthquake Induced Soil-Structure-Water Interaction for Gravity-Type Ocean Structures	$198,360	7/1/79 24 months	50
Frank Somogyi Wayne State University	Dynamic Behavior of Cohesive Soils	$30,000	1/1/79 12 months	51
Ronald L. Street University of Kentucky	Predicting Response Spectra in Eastern United States from known Displacement Spectra Densities	$130,642	5/1/79 36 months	51
Wilson H. Tang University of Illinois-Urbana	Rick Methodologies in Geotechnical Design of Offshore Structures	$97,637	6/1/79 30 months	51
Theodore G. Toridis George Washington University	An Improved Computational Strategy for the Nonlinear Analysis of Structures Subjected to Earthquake and Wind Loads	$69,646	9/1/79 12 months	52
Mihajlo D. Trifunac University of Southern California	Earthquake Engineering Investigation of Strong Ground Motion	$199,696	4/15/79 24 months	52
Chan F. Tsai Fugro Inc.	Full-Scale Pile Vibration Tests	$169,354	8/15/79 12 months	52
F. E. Udwadia University of Southern California	Analysis of Optimal Strong Motion Instrument Location in Building Structures	$78,885	9/1/79 12 months	53
Erik H. Vanmarcke Massachusetts Institute of Technology	Risk-Based Assessment of the Safety of Dams	$230,995	3/1/79 18 months	53
Daniele Veneziano Massachusetts Institute of Technology	Spatial Models of Seismicity for Engineering Risk	$108,572	12/15/78	53
Leon R. Wang Rensselaer Polytechnic Institute	Seismic Vulnerability, Behavior and Design of Underground Piping Systems	$143,172	1/15/79 24 months	53

Principal Investigator/ Institution	*Project Title*	*Amount*	*Effective Date/Award Duration*	*Page*
Hung L. Wong University of Southern California	Seismic-Structure-Soil-Structure Interaction of Two or More Three-Dimensional Structures	$99,019	3/15/79 24 months	54
Francis T. Wu S.U.N.Y. State University at Binghamton	Earthquake Strong Motion Instrumentation and Array Design	$8,286	4/1/79 7 months	54
T. H. Wu Ohio State University	Risk Methodologies in Geotechnical Design of Offshore Structures	$94,996	6/1/79 29 months	54
Theodore Y. Wu California Institute of Technology	Seismic Response of Three-Dimensional Dam Reservoir Systems	$111,744	7/1/79 18 months	55
E. B. Wylie University of Michigan	Response of Nonlinear Saturated Soils to Seismic Disturbances	$61,654	7/1/79 12 months	55
Mishac K. Yegian Northeastern University	Probabilistic Analysis for Liquefaction	$29,451	1/1/79 12 months	55
Fred M. Young Lamar University	Hydraulic Transients in Liquid-Filled Pipelines during Earthquakes	$52,204	9/15/79 18 months	56
Thomas S. Zimmie Rensselaer Polytechnic Institute	Simple Shear Behavior of Fine Grained Soils Subjected to Earthquake and Other Repeated Loading	$84,831	3/1/79 24 months	56
	Design			
Samy Adham Agbabian Associates	Investigation of Reinforced Brick Masonry Buildings Undamaged by the San Fernando Earthquake	$95,433	5/15/79 12 months	57
Robert L. Bangert National Academy of Sciences	Special Study of Rock Mechanics Research Requirements	$42,500	10/1/79 12 months	58
Furman W. Barton University of Virginia	Earthquake Structural Response using Fourier Transform Techniques	$30,000	1/1/79 12 months	58
James M. Becker Massachusetts Institute of Technology	Seismic Resistance of Precast Concrete Panel Buildings	$223,551	1/1/79 12 months	58
Lynn S. Beedle Lehigh University	Tall Buildings and Urban Habitat: Impact on the Urban Environment and Planning for Natural Disasters	$158,725	2/15/79 12 months	59
Lynn S. Beedle Lehigh University	Conference on Stability of Space Frame Structures Under Static and Dynamic Loads	$9,655	4/15/79 12 months	59
John A. Blume John A. Blume and Associates	Seismic Investigation and Design Criteria for Industrial Storage Racks	$20,549	6/15/79 6 months	59
Sidney F. Borg Stevens Institute of Technology	Analysis of Structures Subjected to Earthquake Loadings	$30,000	1/1/79 12 months	60
Jack G. Bouwkamp J. G. Bouwkamp, Inc.	Dynamic Response Analysis of Offshore Platforms	$106,339	4/1/79 12 months	60
Boris Bresler University of California-Berkeley	Safety Evaluation of Buildings Exposed to Earthquakes and other Catastrophic Environmental Hazards	$101,900	1/9/79 12 months	60
Kenneth I. Britz Carnegie Mellon University	The Integration of Seismic Design Principles into Preliminary Architectural Design	$64,454	4/15/19 18 months	61
Russell H. Brown Clemson University	Cyclic Response of Masonry Anchor Bolts	$68,825	4/15/79 10 months	61
Franklin Y. Cheng University of Missouri, Rolla	Optimum Design of Three-Dimensional Building Systems for Multicomponent Earthquake Motions	$85,179	12/16/78 16 months	61
Anil K. Chopra University of California-Berkeley	Seismic Behavior of Structures: Analysis and Design of Structures	$240,000	4/15/79 12 months	61
Ray W. Clough University of California-Berkeley	Earthquake Engineering Research Facility Support	$52,432	5/1/79 12 months	62

Principal Investigator/ Institution	*Project Title*	*Amount*	*Effective Date/Award Duration*	*Page*
Ray W. Clough University of California-Berkeley	Seismic Behavior of Complete Structural Systems	$350,000	4/15/79 12 months	62
W. G. Corley Portland Cement Association	Seismic Resistance of Buildings with Reinforced Concrete Structural Walls	$499,566	4/15/79 12 months	63
Bruce Ellingwood National Bureau of Standards	Development of Revisions to American National Standard A58 — Building Code Requirements for Minimum Design Loads in Buildings and other Structures	$85,839	3/1/79 24 months	63
Robert D. Ewing ABK	Methodology for Mitigation of Seismic Hazards in Existing Unreinforced Masonry Buildings	$462,786	10/1/79 12 months	63
Lewis P. Felton University of California-Los Angeles	Reliability-Based Structural Optimization	$30,000	1/1/79 12 months	64
Hota V. S. Gangarao West Virginia University	Studies on Timber Diaphragms Subject to Earthquake Motions	$37,426	1/15/79 10 months	64
Urs P. Gauchat Harvard University	Patterns of Housing Density and Type: A Basis for Analyzing Earthquake Resistance	$91,936	9/1/79 15 months	64
Barry J. Goodno Georgia Institute of Technology	Influence of Nonstructural Cladding on Dynamic Properties and Response of High Rise Buildings	$119,556	7/1/79 12 months	65
Phillip L. Gould Washington University	Analytical Method for Determining Seismic Response of Cooling Towers on Footing Foundations	$104,300	4/15/79 18 months	65
Ajaya K. Gupta Illinois Institute of Technology	Workshop on Seismic Resistance of Nonengineered Structures	$46,485 $46,485	5/15/79 12 months	65
Robert D. Hanson University of Michigan	Cooperative Program in Earthquake Engineering-Repair and Retrofit of Structures	$45,000	5/1/79 12 months	66
Gary C. Hart University of California-Los Angeles	Workshop in Interpretation of Strong-Motion Earthquake Records Obtained in and/or near Buildings	$19,995	5/1/79 12 months	66
Neil M. Hawkins University of Washington	Study of Earthquake-Induced Bond Deterioration	$59,647	5/15/79 12 months	66
Dean R. Heerwagen University of Washington	The Development of a Cost-Effective Approach to the Aseismic Design of Buildings for the Pacific Northwest	$29,971	1/1/79 12 months	66
Gilbert A. Hegemier University of California-San Diego	Connections in Concrete Masonry Buildings under Seismic Forces	$315,000	5/1/79 12 months	67
Ti Huang Lehigh University	Contribution of Floor Systems to Earthquake Resistance of Building Structural Frames	$134,370	2/1/79 12 months	67
Arthur Huckelbridge Case Western Reserve University	Reduction of Overturning Potential of Seismically Excited Structures	$62,656	1/15/79 18 months	67
Thomas J. R. Hughes California Institute of Technology	Seismic Response of Ground-Supported, Cylindrical Liquid Storage Tanks	$29,942	1/1/79 12 months	68
Thomas J. R. Hughes California Institute of Technology	Liquid Storage Tank Failure due to Earthquake Excitation	$125,991	4/15/79 18 months	68
Anthony R. Ingraffea Cornell University	Finite Element Analysis of Reinforced Concrete for Cyclic Loading	$84,034	4/5/79 18 months	69
Lindsay R. Jones Computech, Inc.	Inelastic Dynamic Building Response-Correlation with Full Scale Shaking Tests	$104,598	4/15/79 12 months	69
Earle W. Kennett American Institute of Architects Research Corp.	Multi-Design Approach to Seismic Safety	$194,696	5/15/79 13 months	69

Principal Investigator/ Institution	*Project Title*	*Amount*	*Effective Date/Award Duration*	*Page*
Donald M. Kerr, Jr. Department of Energy	Vibration Testing of an Epoxy-Repaired 4-Story Concrete Structure	$148,900	4/15/79 12 months	70
Henry J. Lagorio University of Hawaii-Manoa	Conference on Urban Design and Seismic Safety at a Cooperative International Level	$54,786	4/1/79 12 months	70
Albert D. Lewis Purdue University	Lateral Load Capacity of Structural Tee X-Bracing	$28,000	3/1/79 12 months	70
John Loss North Carolina State University at Raleigh	Introduction of Earthquake Hazard Mitigation through Multi-Hazard Mitigation Techniques in Areas of Low Concern for Seismic Risk	$29,752	1/1/79 12 months	71
George G. Mader William Spangle and Associates	Post-Earthquake Land Use Planning	$21,300	7/1/79 0 months	71
Ronald Mayes Applied Technology Council	Workshop on Prefabricated Concrete Buildings for Earthquake Loads	$88,532	11/1/79 12 months	71
William McGuire Cornell University	Nonlinear Analysis and Design of Steel Frames	$127,897	2/15/79 12 months	71
Hugh D. McNiven University of California-Berkeley	Seismic Behavior of Masonry Structures	$110,000	4/15/79 12 months	72
Donald F. Meinheit University of Notre Dame	Shear Behavior of Reinforced Concrete Beam-Column Connections under Earthquake Loadings	$29,881	1/1/79 12 months	72
Richard K. Miller University of California-Santa Barbara	The Dynamics of Structures with Localized Nonlinearity	$3,497	11/28/78 0 months	72
Joseph E. Minor Texas Tech University	Development of a Unified Approach to the Design of Window Glass Subjected to Dynamic Forces	$116,370	9/1/79 12 months	73
Gerard C. Pardoen University of California-Irvine	Analytical and Experimental Investigation of Structural Response—The Imperial County Services Building	$30,000	1/1/79 12 months	73
Mario Paz University of Louisville	Error Evaluation of Inelastic Response Method for Earthquake Design	$30,000	1/1/79 12 months	73
Dale C. Perry University of Idaho	Seismic Behavior of Precast Curtain Walls in High Rise Buildings	$61,680	6/14/79 15 months	74
Egor P. Popov University of California-Berkeley	Seismic Behavior of Structural Components	$370,224	4/15/79 12 months	74
Satwant S. Rihal California State University	Study of Behavior of Architectural (Non-Structural) Building Components during Earthquakes	$30,000	1/1/79 12 months	74
David Schwarz San Jose State University	An Analytical Technique for Establishing Emergency Services Planning Policy: Effects of Building Characteristics on Forecasts of Seismically-Induced Route Blockages	$30,000	1/15/79 12 months	75
Norman L. Scott The Consulting Engineers Group	Connections of Precast Prestressed Concrete Construction to withstand Earthquakes	$111,374	6/15/79 15 months	75
Surendra P. Shah University of Illinois-Chicago Circle	Envelope Curves for Confined Concrete Subjected to Cyclic Loading	$29,419	1/1/79 12 months	75
Mete A. Sozen University of Illinois-Urbana	Effects of Earthquake Motions on Reinforced Concrete Buildings	$200,000	2/1/79 12 months	76
Pol Spanos University of Texas at Austin	Probabilistic Analyses of Nonlinear-Inelastic Earthquake Responses of Structures	$26,968	1/1/79 12 months	76
G. Bruce Taylor ANCO Engineers Inc.	Dynamic Testing and Acoustic Analysis of Concrete Dams	$165,496	6/1/79 18 months	76

Principal Investigator/ Institution	*Project Title*	*Amount*	*Effective Date/Award Duration*	*Page*
I. D. Terner University of California-Berkeley	Dissemination of Earthquake Damage Mitigation Techniques to Homeowners and Renters	$60,590	8/15/79 9 months	77
Morteza A. Torkamani Illinois Institute of Technology	Design of Multi-Story Buildings by Component Mode Synthesis	$30,000	1/1/79 12 months	77
William H. Townsend SUNY State University at Buffalo	Dynamic Inelastic Response of Reinforced Concrete Connections	$30,000	1/1/79 12 months	77
Ping Chun Wang Polytechnic Institute of New York	Prediction of Earthquake Resistance of Structures	$10,904	12/1/78 0 months	78
James K. Wight University of Michigan	Experimental Investigation of Reinforced Concrete Beam-Connections Subjected to Earthquake Type Loading	$69,373	5/1/79 12 months	78
J. N. Yang George Washington University	Stochastic Response of Tall Structures under Environmental Loads	$113,962	3/1/79 24 months	78
James T. Yao Purdue University	Reliability of Existing Buildings in Earthquake Zones	$16,906	7/1/79 6 months	79
Chai H. Yoo Marquette University	Vertical Motion of Highway Bridge Structures due to an Earthquake	$29,755	1/1/79 12 months	79
Roger M. Zimmerman New Mexico State University	Measurements of On-Site Dynamic Parameters for Seismic Evaluations	$29,895	1/1/79 12 months	79
	Policy			
Frederick L. Bates University of Georgia	A Longitudinal and Cross-Cultural Study of the Post-Impact Phases of a Major National Disaster	$191,677	6/1/79 12 months	80
Robert K. Leik University of Minnesota	Community Response to Natural Hazard Warnings	$231,925	3/3/79 12 months	80
E. L. Quarantelli Ohio State University	Social-Behavioral Responses to Chemical Hazards	$182,209	9/1/79 12 months	80
Ralph H. Turner University of California-Berkeley	Community Response to Earthquake Threat in Southern California	$168,862	1/15/79 13 months	81
Gilbert F. White University of Colorado at Boulder	A Clearinghouse on Natural Hazards Research and Applications	$18,340	6/1/79 12 months	81
	HUMAN NUTRITION			
James S. Adkins Howard University	Conference and Workshop on "Protein Quality in Humans: Assessment and *In Vitro* Estimation"	$18,501	9/1/79 12 months	82
George W. Chang University of California-Berkeley	Effects of Food Additives on the Function of the Intestinal Microflora	$61,753	10/1/79 12 months	82
J. K. Gray Michigan State University	The Effects of Processing and Storage on the Oxidative Stability of Cholesterol in Dehydrated Foods	$61,846	9/15/79 24 months	82
James R. Kirk University of Florida	Assessment of Chloro-Organics Formed in Foods	$81,069	4/1/79 12 months	83
Theodore P. Labuza University of Minnesota	Nutrient Losses in Pasta under Constant and Fluctuating Conditions	$57,463	9/15/79 12 months	83
James E. Leklem Oregon State University	Effects of Processing on Nutritive Content and Bioavailability of Selected Nutrients in Commonly Consumed Foods	$83,427	9/15/79 12 months	83
Orville A. Levander New York Academy of Sciences	Conference on Micronutrient Interactions: Vitamins, Minerals and Hazardous Elements	$5,000	9/1/79 12 months	84
Bertha A. Lewis Cornell University	Chemico-Physical Analysis of Dietary Fiber in Foods	$123,472	9/15/79 12 months	84

Principal Investigator/ Institution	*Project Title*	*Amount*	*Effective Date/Award Duration*	*Page*
Arthur W. Mahoney Utah State University	Meat Curing Effects on Heme and Nonheme Iron Bioavailability in Rats and *C. botulinum*	$141,233	9/15/79 36 months	84
Dennis D. Miller Cornell University	The Bioavailabilities of Iron and Zinc from Foods	$111,057	9/15/79 24 months	85
Abigail A. Salyers University of Illinois-Urbana	Effect of Food Additives on Metabolic Activities of the Human Colonic Microflora	$93,847	9/15/79 36 months	85
Lowell D. Satterlee University of Nebraska-Lincoln	The Effects of Processing on the Protein Quality of Legume-Based Foods and Collaborative Testing of the C-Per Assay	$72,329	11/1/79 12 months	85
Vernon R. Young Massachusetts Institute of Technology	Bioavailability of Selenium and Zinc in Processed Human Food Based on Soy Protein: Studies using Stable Isotope Tracers	$70,701	9/15/79 12 months	86
SCIENCE AND TECHNOLOGY TO AID THE PHYSICALLY HANDICAPPED				
Ernesto E. Blanco Universal Texile Machine	Development of a Micro-Solenoid Operated Braille Display Cell	$25,000	10/1/79 6 months	87
Bruce J. Boehm Telesensory Systems Inc.	Needs and Design Concepts for Voice-Output Communication Aids	$156,120	10/1/79 18 months	87
Donald G. Childers University of Florida	Automatic Measurement of Laryngeal Vibratory Patterns	$143,788	3/15/79 24 months	88
Kenneth M. Colby University of California-Los Angeles	An Ocular-Controlled Intelligent Speech Prosthesis	$186,012	10/1/79 12 months	88
Carter C. Collins Institute of Medical Sciences	Study of Fast Feature Extraction for Blind Mobility	$184,208	9/1/79 24 months	88
Donald R. Cowsar Southern Research Institute	Replacement of Sensory Capabilities for the Physically Handicapped	$105,819	9/15/79 12 months	89
William H. Dobelle Columbia University	Electrical Stimulation of the Skin as a Basis for Sensory Prostheses	$87,700	9/1/79 12 months	89
Lois L. Elliott Northwestern University	Children's Auditory Discrimination and Perception of Monosyllabic Words	$225,170	9/1/79 36 months	89
Walter C. Gish Integrated Sciences Corp.	Visual Feedback Speech Training for the Deaf—Phase II	$118,801	3/1/79 18 months	90
Donald E. Gustafson Scientific Systems, Inc.	Microprocessor-Based Prosthetic Control	$94,886	4/1/79 24 months	90
Paul L. Hazan Johns Hopkins University	Application of Personal Computers to Assist the Handicapped	$20,000	8/15/79 5 months	90
Neville Hogan Massachusetts Institute of Technology	Neurophysiologically-Based Adaptive Controllers for Assistive Devices	$138,039	9/1/79 24 months	91
Charles S. Klayman Threshold Technology Inc.	Low-Cost, High Performance Speech Recognizer for the Handicapped	$25,000	10/1/79 6 months	91
George F. Kuhn Vibrasound Research Corp.	Hearing Aids for Spatial Perception and Localization	$24,815	10/1/79 6 months	91
John G. Linvill Stanford University	Integrated Electro-Mechanical Transducer Systems	$50,000	2/15/79 12 months	92
Jane McCarroll Innovative Systems Research, Inc.	Electronic Information Exchange in Research on Devices for the Disabled	$20,275	6/1/79 12 months	92
William R. Rymer United Engineering Trustees	An Engineering Foundation Conference on "Biomechanics of Movement"	$10,000	6/1/79 6 months	92
James F. Tetzlaff Telesensory Systems, Inc.	Investigation of Polyvinylidene Fluoride as a Tactile Stimulator for the Optacon	$24,640	10/1/79 6 months	92

Note: Data for this report were taken from program records and therefore may differ from official National Science Foundation source documents such as TAB A to the Budget and Part II of the Annual Report which are generated from the Management Information System data base and which may contain different inclusions/exclusions.