RECENT AWARDS: OCTOBER-DECEMBER 1978

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NATIONAL SCIENCE FOUNDATION
Division of Problem-Focused Research Applications
Directorate for Applied Science and Research Applications
Washington, D.C. 20550

INTRODUCTION

RECENT AWARDS keeps researchers, research users and policy makers informed about projects being supported by NSF's Division of Problem-Focused Research Applications (PFRA).

The format and content of RECENT AWARDS will be substantially different beginning with this, the first issue of Fiscal Year 1979. In order to keep our readers informed in the most effective and convenient way, PFRA RECENT AWARDS now provides a more detailed summary of each project than has been given in previous editions. Readers should contact Principal Investigators directly to obtain additional information about projects or to learn of available publications.

This brochure describes the awards made by PFRA during the period October 1, 1978 through December 31, 1978 (first quarter, Fiscal Year 1979). The data have been reconciled with the NSF's Management Information System.

Readers may return the post card on page 00 to request the NSF/ASRA/PFRA publications listed. Questions on PFRA program objectives, procedures for application, or general information should be addressed to the Professional Assistant for PFRA, Room 1134 A, National Science Foundation, Washington, D.C. 20550.

NEW FISCAL YEAR 1979 PROGRAMS FOR PFRA

PFRA will initiate two applied research programs in Fiscal Year 1979.

Science and Technology to Aid the Physically Handicapped will support research on the use of the best available scientific and engineering developments to improve defective speech, visual, tactile, and hearing systems in those persons afflicted with these impairments, and also to find ways to overcome locomotion and manipulatory limitations. The program will involve researchers from many disciplines including biomedical engineering, medicine, law, and the social sciences working with the active participation of handicapped persons on these problems.

The second new program, **Human Nutrition,** will address some important nutritional concerns. An estimated 70 percent of the food consumed in the United States is derived from highly refined ingredients and is processed during manufacture with various additives and supplements. However, effects on human health and performance of the life-long consumption of such processed foods have not been determined. PFRA will support research on the assessment of the nutrient value of processed foods through investigations of the physical, chemical and biochemical changes which occur in these foods during cooking, processing, packaging and storage.

Persons wishing to be placed on our mailing lists for either or both of these new programs should complete and return the post card on page 00. Guidelines for the preparation and submission of proposals may also be obtained by returning the post card.

No awards were made in either of these new programs in the first quarter of Fiscal Year 1979

HOW TO OBTAIN PFRA RESEARCH FINDINGS AND RESULTS

One of the most important objectives of PFRA is the timely and widespread dissemination of the results of PFRA-supported research to potential users. The name and mailing address of the Principal Investigator and Grantee Institution is contained in each project description in this brochure. Persons wishing to obtain information on project findings including project reports, monographs, journal articles, technical reports, and other such relevent materials should write to the Principal Investigator at the Grantee Institution to determine what information is available and at what, if any, cost it may be obtained. The Grantee Institution may charge a nominal amount for the duplication and mailing of such materials to cover costs. The Principal Investigator may furnish information on how interested persons may acquire reports and other materials as appropriate from the National Technical Information Service (NTIS) of the Department of Commerce in lieu of furnishing the report or other material directly. NTIS is the central point in the United States for the public sale of Government-funded research and development reports

and other analyses prepared by Federal agencies, their contractors, and grantees. The Principal Investigator may also cite journals or other publications where project information may be looked up instead of furnishing a copy of the article.

DEFINITIONS AND EXPLANATION OF FORMAT

Formulation and Expression of Seismic Design Provisions;[1] Steven J. Fenves;[2] Carnegie-Mellon University, Department of Civil Engineering, Pittsburg, PA 15213;[3] **Award #76-19033 A04**[4]

1. **Title of the Specific Grant**
2. **Principal Investigator:** the chief scientist or administrator who is responsible for the research plan and fiscal expenditures as an NSF-sponsored awardee. Co-Principal Investigators will also be listed.
3. **Institution Conducting the Research:** any college, university, laboratory, industry, or other organization, whether operating on a profit or nonprofit basis, as well as State governments and Federal organizations.
4. **Award Number:** the award number and amendment number, if applicable.

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. This program is directed toward alleviating national dependence on selected scarce resources by making alternative biological sources of materials available in the United States. Three particular topics have been selected for investigation in Fiscal Year 1979: biological conversion of lignocellulosic materials to useful chemicals; biological nitrogen fixation; and production of speciality chemicals from arid land plants (specifically, production of rubber from the guayule plant).

1. Workshop on Symbiotic Nitrogen Fixation in the Management of Temperate Forests; John C. Gordon; Oregon State University, Department of Forest Science, Corvallis, OR 97331; **Award #78-2220**

   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.

2. Enzymatic Transformations of Lignin; Philip L. Hall; Virginia Polytechnic Institute, Department of Chemistry, Blacksburg, VA 24061; **Award #76-11050 A03**

   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.

3. Development of Tissue Culture Systems for Guayule; Toshio Murashige; University of California—Riverside, Department of Botany and Plant Sciences, Riverside, CA 92521; **Award #78-25829**

   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.

4. Chemicals from Western Hardwoods and Agricultural Residues; Kyosti V. Sarkanen; University of Washington, Department of Chemical Engineering, Seattle, WA 98195; **Award #77-08979 A01**

   This research will assess the potential of underutilized renewable resources such as hardwoods and agricultural residues for the production of useful chemicals. Specifically, the objectives are to characterize the essential properties of cellulose, hemicellulose, lignin and extractive components of red alder wood and wheat straw; examine novel methods for converting red alder wood and wheat straw to fibrous products in combination with by-products recovery; and convert the lignin and carbohydrate by-products to chemicals using pyrolysis and microwave degradation. Research focuses on organic solvent separations of lignocellulosic materials.

5. Bioconversion of Biomass Gasifier Product Gases to Organic Chemicals; Donald L. Wise; Dynatech Corporation, Biochemical Engineering, 99 Erie Street, Cambridge, MA 02139; **Award #78-16404**

   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.

Chemical Threats to Man and the Environment

The Chemical Threats to Man and the Environment Program supports applied research relevant to the prediction, identification, characterization, and control of hazards resulting from chemical compounds in the environment. Emphasis is placed on the development of techniques and methodologies that can be applied to a spectrum of situations, and on research on problems that are not amenable to routine approaches. Proposals in areas that are receiving considerable support from other agencies, such as NIH and EPA, are usually not funded by this program.

The Chemical Threats to Man and the Environment program's allocation for FY 1979 is $3,600,000. All awards that will be made under this program category in FY 1979 will be directed toward completion of prior program objectives. **No funds have been requested for continuation of the Chemical Threats to Man and the Environment program in the FY 1980 budget submitted to the Congress on January 22, 1979.**

1. 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; **Award #78-24463**

   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?

Community Water Management

The Community Water Management program addresses the Nation's capability to efficiently and effectively manage the use and reuse of water in the built

environment, and to reduce risks to public health, safety, and the environment that arise from or are otherwise associated with the use and reuse of water.

There were no awards made during the first quarter for this program. The Community Water Management program's allocation for FY 1979 was reduced by administrative action to a level of $700,000, an amount which is based upon continuation needs for existing grants. It is not likely that awards will be made under this program category in FY 1979 which are not directed toward completion of prior project and program objectives. **No funds have been requested for continuation of the Community Water Management program in the FY 1980 budget submitted to Congress on January 22, 1979.**

Earthquake Hazards Mitigation

The objectives of the Earthquake Hazards Mitigation program are to develop methods and techniques that can provide effective protection for man, his works and institutions from life loss, personal injury, property damage, social dislocations, and economic and ecological disruption associated with potential or realized earthquake hazards. Three major aspects of the problem are considered: Siting, Design and Policy. SITING focuses on the relationship between soil and geological conditions at a given site; strong ground motions; tsunamis; lifelines; the potential earthquake hazard of the region; and the architectural, land use and engineering practices and policies necessary to make buildings at that site earthquake resistant. DESIGN investigates the elastic and inelastic behavior of building materials used on the behavior of structures during seismic and wind excitation; ways to minimize the risk of older buildings not built to meet earthquake code standards; and the behavior of nonengineered structures and secondary components of buildings. POLICY deals with social, economic, legal, institutional and other factors which facilitate or hinder the adoption of social and technological solutions, including prediction and warning, to earthquake hazards, and also seeks effective dissemination of earthquake information to the public and to government decision-makers.

NOTE TO READERS: The designation (**S**) after the award number indicates that the award was made as the result of PFRA Program Solicitation NSF 78–12, *Research Initiation in Earthquake Hazards Mitigation.* These awards were made on a nation-wide competitive basis from proposals received in June 1978. The Research Initiation Grants are intended to encourage individuals from the political, earth and physical sciences, as well as those from engineering, architecture, and urban planning, who have recently started research careers or who have been active in other areas of academic research and wish to initiate research on earthquake hazards mitigation.

1. Earthquake Induced Longitudinal Vibration of Earth Dams; Ahmed M. Abdel-Ghaffar; University of Illinois–Chicago Circle, Department of Materials Engineering, Chicago, IL 60680; **Award #78–22865(S)**

   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.

2. Seismic Behavior and Design of Urban Area Tunnel Linings; Subhash C. Anand; Clemson University, Department of Civil Engineering, Clemson, SC 29631; **Award #78–22879(S)**

   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. Recommenda-

tions will be made to agencies concerned with the development of seismic codes.

3. Earthquake Structural Response Using Fourier Transform Techniques; Furman W. Barton; University of Virginia, Department of Civil Engineering, Charlottesville, VA 22903; **Award #78-23099(S)**

   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 analysing 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.

4. Analysis of Structures Subjected to Earthquake Loadings; Sidney F. Borg; Stevens Institute of Technology, Department of Mechanical Engineering, Hoboken, NJ 07030; **Award #78-22846(S)**

   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 results against current methods and available experimental and field data.

5. 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; **Award #78-82384 A02**

   This research project will attempt to predict the potential damage which could occur to an existing structure when it is subjected to catastrophic events such as earthquakes, severe windstorms or other natural hazards. Such information will not only be useful in assessing the degree of hazard for existing structures, but 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 a building. These damageability indices are developed for various parts of the building as well as for the entire building.

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

6. Methodology and Pilot Study to Inventory Local Building Stock in Regard to Seismic Hazard; Kenneth Britz; Carnegie Mellon University, Department of Architecture, Pittsburgh, PA 15213; **Award #78-22857(S)**

   This research will develop a "sketch" inventory method to profile a city's building stock with respect to potential seismic hazard. The "sketch" method will utilize stratified sampling techniques with sampling frames classified by land use. Therefore, only 10 small samples of buildings need be studied for their typical characteristics. The profile will describe interrelationships between structural and non-structural components, occupancy load and any special characteristics of use. Each contiguous set of land parcels defined by a land use category will be associated with a set of existing building conditions considered to be typical for that category. Each land use parcel will become a planning unit. The planning unit data will be mapped over a local soil geology analysis, so that a potential seismic hazard perspective can be described for each planning unit.

A pilot study will apply the sketch inventory method to the city of Buffalo, New York. The results will be used to evaluate the method and to provide a factual basis for decision-making on seismic safety and planning at the local level.

7. Design Method for Predicting Footing Settlement from Earthquake Effect; Ching S. Chang; University of Massachusetts—Amherst Campus, Department of Civil Engineering, Amherst, MA 01003; **Award 78-22852(S)**

   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.

8. 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; **Award #78-23094(S)**

   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 yield 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 tiraxial 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.

9. Earthquake-Induced Landslides; Wai-Fah Chen; Purdue University, School of Civil Engineering, Lafayette, IN 47907; **Award #78-09326**

   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.

10. 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; **Award #78-05694 A02**

    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.

11. Response of Submerged Shells to Seismic Waves; Subhendu K. Datta; University of Colorado, Department of Mechanical Engineering, Boulder, CO 80309; **Award #78-22848(S)**

    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.

12. 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; **Award #78-22876(S)**

    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-depostied 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.

13. 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; **Award #78-23078(S)**

    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, and computer-aided design by allowing parametric definition of system properties.

14. Reliability-Based Structural Optimization; Lewis P. Felton; University of California—Los Angeles, Department of Mechanics/Structures, Los Angeles, CA 90024; **Award #78-23093(S)**

    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.

15. 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; **Award #78-22875(S)**

    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 regulatory 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.

16. 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; **Award #78-23102(S)**

    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.

17. 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; **Award #78-23100(S)**

    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.

18. Prediction of Dynamic Material Properties from their Static Shear Behavior; Edward Kavazanjian; Stanford University, Department of Civil Engineering, Stanford, CA 94305; **Award #78-23092(S)**

    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.

19. Earthquake Engineering Applications of Nonstationary Autoregressive Models; Frank Kozin; Polytechnic Institute of New York, Department of Electrical Engineering, Brooklyn, NY 11201; **Award #78-08811**

    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.

20. Lateral Load Capacity of Structural Tee X-Bracing; Albert D. Lewis; Purdue University, School of Civil Engineering, Lafayette, IN 47907; **Award #78-22870(S)**

    In braced buidlings 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.

21. 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; **Award #78-23076(S)**

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.

22. 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; **Award #78-22860(S)**

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.

23. The Dynamics of Structures with Localized Nonlinearity; Richard K. Miller; University of California-Santa Barbara, Department of Mechanical and Environmental Engineering, Santa Barbara, CA 93106; **Award #77-01096 A01**

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.

24. Analytical Modeling of Buried Pipeline Response to Static Earthquake Displacement; Thomas D. O'Rourke; Cornell University, Department of Civil/Environmental Engineering, Ithaca, NY 14850; **Award #78-23096(S)**

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.

25. 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; **Award #78-22863(S)**

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 Imperial 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.

26. Error Evaluation of Inelastic Response Method for Earthquake Design; Mario Paz, University of Louisville, Department of Civil Engineering, Louisville, KY 40208; **Award #78-22847(S)**

The response spectrum method for earthquake design of structures 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.

27. Study of Behavior of Architectural (Non-Structural) Building Components During Earthquake; Satwant S. Rihal; California State University—San Luis Obispo, Department of Architectural Engineering, San Luis Obispo, CA 93407; **Award #78-23085(S)**

This research will review current practices for seismic design and detailing of building partition systems and suspended ceilings. A series of dynamic analyses 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.

28. 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; **Award #78-23097(S)**

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 delineating 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 an 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.

29. Envelope Curves for Confined Concrete Subjected to Cyclic Loading; Surendra P. Shah; Univerisity of Illinois—Chicago Circle, Department of Materials Engineering, Chicago, IL 60680; **Award #78-22878(S)**

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 aggragates.

30. Dynamic Properties of a Cohesive Soil; M. G. Sharma; Pennsylvania State University, Department of Science and Medicine, University Park, PA 16802; **Award #78-23098(S)**

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 (superimposed 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.

31. Seismic Stability Evaluation of Earth Structures; Mahendra P. Singh; Virginia Polytechnic Institute, Department of Engineering Science/Mechanics, Blacksburg, VA 24061; **Award #78-23095(S)**

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.

32. Dynamic Behavior of Cohesive Soils; Frank Somogyi; Wayne State University, Department of Civil Engineering, Detroit, MI 48202; **Award #78-23079(S)**

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.

33. Probabilistic Analyses of Nonlinear-Inelastic Earthquake Responses of Structures; Pol Spanos; University of Texas at Austin, Aeronatical Engineering and Engineering Mechanics, Austin, TX 78712; **Award #78-22868(S)**

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.

34. Design of Multi-Story Buildings by Component Mode Synthesis; Morteza A. Torkamani; Illinois Institute of Technology, Department of Civil Engineering, Chicago, IL 60616; **Award #78-22881(S)**

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.

35. Dynamic Inelastic Response of Reinforced Concrete Connections; William H. Townsend, SUNY State University at Buffalo, Department of Civil Engineering; Buffalo, NY 14260; **Award #78-22874(S)**

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.

36. Spatial Models of Seismicity for Engineering Risk; Daniele Veneziano; Massachusetts Institute of Technology, Department of Civil Engineering, Cambridge, MA 02139; **Award #78-09626**

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.

37. Probabilistic Analysis for Liquefaction; Mishac K. Yegian, Northeastern University, Department of Civil Engineering, Boston, MA 02115; **Award #78-23082(S)**

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.

38. Vertical Motion of Highway Bridge Structures Due to an Earthquake; Chai H. Yoo; Marquette University, Department of Civil Engineering, Milwaukee, WI 53233; **Award #78-22845(S)**

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, support movements and accelerations in vertical and horizontal directions.

39. Measurements of On-Site Dynamic Parameters for Seismic Evaluations; Roger M. Zimmerman; New Mexico State University, Department of Civil Engineering, Las Cruces, NM 88003; **Award #78-23083(S)**

The objective of this proposed research effort is to develop, laboratory test, and field test 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.

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