RAS 3980

RELATED CORRESPONDENCE

February 19, 2002

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

DOCKETED
USNRC

February 28, 2002 (9:34AM)

OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

In the Matter of	)	
	)	
PRIVATE FUEL STORAGE L.L.C.	)	Docket No. 72-22
	)	
(Private Fuel Storage Facility)	)	ASLBP No. 97-732-02-ISFSI

APPLICANT'S NINTH SUPPLEMENTAL RESPONSE TO STATE'S FIRST REQUESTS FOR DISCOVERY

Applicant Private Fuel Storage L.L.C. ("Applicant" or "PFS") files this Ninth Supplemental Response to "State of Utah's First Set of Discovery Requests Directed to the Applicant," dated April 9, 1999 ("State's First Discovery Requests"). The Applicant files this Supplemental Response, pursuant to 10 C.F.R. § 2.740(e), to name additional witnesses it may call at hearing. The Applicant's original response to the State's First Discovery Requests noted that it would file such supplemental responses as it identified additional witnesses.[1]

I. GENERAL DISCOVERY REQUESTS

A. GENERAL INTERROGATORIES

GENERAL INTERROGATORY NO. 3. For each admitted Utah contention, give the name, address, profession, employer, area of professional expertise, and educational and scientific experience of each person whom PFS expects to call as a witness at the hearing. For purposes of answering this interrogatory, the educational and scientific experience of expected witnesses may be provided by a resume of the person attached to the response.

[1] Applicant's Objections and Non-Proprietary Responses to State's First Requests for Discovery, dated April 21, 1999, at 17.

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SECY-02

APPLICANT'S RESPONSE: The Applicant supplements its response to the State's First Discovery Requests by identifying the following additional persons whom the Applicant expects to call as witnesses at the hearing with respect to the State's Unified Contention Utah L/QQ. The Applicant is still in the process of identifying witnesses that it expects to call at the hearings and will supplement this response in accordance with 10 C.F.R. § 2.740(e).

Unified Contention Utah L/QQ[2]

Name and Address:	Mr. Bruce E. Ebbeson Stone & Webster 3 Executive Campus Route 70 & Cuthbert Boulevard Cherry Hill, NJ 08002-4167
Profession:	Structural Engineer
Employer:	Stone & Webster, Inc.
Professional Expertise:	Structural design and analysis, including seismic analysis of nuclear facilities
Educational, Scientific Experience, and Professional Qualifications:	See attached resume
Publications in the last ten years:	See attached resume
Testifying experience as expert in last four years:	None

[2] The listing of witnesses herein includes those persons that the Applicant expects to call as witnesses at the hearing with respect to Unified Contention Utah L/QQ except those previously identified in connection with former Part B of Contention Utah L, now Part E of Unified Contention Utah L/QQ. Those other witnesses are identified in Applicant's Eighth Supplemental Response to State's First Request for Discovery, dated October 2, 2001 ("PFS Eighth Supp. Response").

Subject Matter of Testimony:	Structural design of the important-to-safety structures, systems and components ("SSCs") in the Canister Transfer Building ("CTB") at the PFSF, the seismic analyses conducted by PFS for the CTB, and the ability of the CTB to withstand seismic loadings, as related to the issues raised in Parts C and D of Unified Contention Utah L/QQ.[3]
Documents reviewed and/or relied upon:	Mr. Ebbeson will rely on the design documents generated by Stone & Webster, equipment vendors and other parties for the PFSF, the PFS SAR, and other information supplied by PFS or developed by Stone & Webster. Mr. Ebbeson may rely as well on document produced by the State or other documents that may come into PFS's possession.
Name and Address:	Dr. Krishna P. Singh Holtec International 555 Lincoln Drive West Marlton, NJ 08053
Profession:	Executive and Mechanical Engineer
Employer:	Holtec International
Professional Expertise:	See attached resume
Educational, Scientific Experience, and Professional Qualifications:	See attached resume
Publications in the last ten years:	See attached resume
Testifying experience as expert in last four years:	Expert witness in fall 1995 trial between owners of the South Texas Project and Westinghouse concerning the South Texas steam generators. Was subsequently deposed in 1996 in litigation involving Pacific Northwest laboratories

[3] As set forth in PFS Eighth Supp. Response, Mr. Ebberson will also be a witness with respect to Part E of Unified Contention Utah L/QQ.

Subject matter of testimony:	Dr. Singh will testify to the design and seismic analyses of the HI-STORM 100 cask storage system and the underlying pads, as related to the issues raised in Parts C and D of Unified Contention Utah L/QQ.[4]
Documents reviewed and/or relied upon:	Dr. Singh will rely on the Topical Safety Analysis Report for the HI-STORM 100 and materials and analyses therein, and other information and analyses supplied by PFS or performed by Holtec. In addition, Dr. Singh may rely on the PFS SAR as well as documents produced by the State and other documents that may come into PFS's possession.
Name and Address:	Dr. Alan Soler Holtec International 555 Lincoln Drive West Marlton, NJ 08053
Profession:	Mechanical Engineer
Employer:	Holtec International
Professional Expertise:	Mechanical design and dynamics of spent fuel casks and fuel racks
Educational, Scientific Experience, and Professional Qualifications:	See attached resume
Publications in the last ten years:	See attached resume
Testifying experience as expert in last four years:	None
Subject Matter of Testimony:	Dr. Soler will testify to the design and seismic analyses of the HI-STORM 100 cask storage system and the underlying pads, as related to the issues raised in Parts C and D of Unified Contention Utah L/QQ.[5]

[4] As set forth in PFS Eighth Supp. Response, Dr. Singh will also be a witness with respect to Part E of Unified Contention Utah L/QQ.

[5] As set forth in PFS Eighth Supp. Response, Dr. Soler will also be a witness with respect to Part E of Unified Contention Utah L/QQ.

Documents reviewed and/or relied upon:	The documents reviewed and relied upon by Dr. Soler will include the Topical Safety Analysis Report, the cash stability analysis of the HI-STORM casks, and other information and analyses supplied by PFS or performed by Holtec. In addition, Dr. Soler may review and rely upon documents produced by the State as well as any new information that may come into PFS's possession.
Name and Address:	Kiat Lilhanand International Civil Engineering Consultants, Inc. 1995 University Ave. Suite 119 Berkeley, CA 94704
Profession:	Civil Engineer
Employer:	International Civil Engineering Consultants, Inc.
Professional Expertise:	Seismic analysis, simulation of seismic ground motions, random vibration analysis, probabilistic approach to civil engineering structures, and computer applications on structural analysis programs
Educational, Scientific Experience, and Professional Qualifications:	See attached resume
Publications in the last ten years:	See attached list
Testifying experience as expert in last four years:	None
Subject Matter of Testimony:	Dr. Lilhanand will testify concerning the International Civil Engineering Consultants' analyses regarding the response of the concrete pads, on which the storage casks are placed, to the forces imparted by the design basis earthquake, as related to the issues raised in Parts C and D of Unified Contention Utah L/QQ.

Documents reviewed and/or relied upon:	Dr. Lilhanand will rely on the ICEC analyses, the PFS SAR, and other information supplied by PFS or developed by Stone & Webster, Holtec and ICEC. Dr. Lilhanand may rely as well on documents produced by the State or other documents that may come into PFS's possession.
Name and Address:	C.Y. Chang Geomatrix Consulting, Inc. 2101 Webster Street 12th Floor Oakland, CA 94612
Profession:	Geotechnical and Earthquake Engineer
Employer:	Geomatrix Consulting, Inc.
Professional Expertise:	Geotechnical and seismic investigations for highway bridges, dam projects, nuclear power plant sites, and nuclear waste repository facilities, including development of site-specific earthquake ground motions, seismic soil-structure and soil-pile interaction analyses, evaluations of liquefaction potential and consequence of liquefaction, evaluations of foundation capacity and deformations for seismic loading conditions, and evaluations of seismic stability and deformation potential of dams and embankments.
Educational, Scientific Experience, and Professional Qualifications:	See attached resume
Publications in the last ten years:	See attached resume
Testifying experience as expert in last four years:	None
Subject Matter of Testimony:	Dr. Chang will testify to the effects of non-vertically propagating seismic waves, in-phase motions and soil structure interactions, as related to the issues raised in Parts C and D of Unified Contention Utah L/QQ. Dr. Chang will also testify regarding related design information provided by Geomatrix for the Holtec analyses.

Documents reviewed and/or relied upon:	The documents reviewed and relied upon by Dr. Chang will include the analyses performed by Geomatrix of seismic wave propagation. In addition, Dr. Chang may review and rely upon documents produced by the State as well as any new information that may come into PFS's possession.
Name and Address:	Anwar E.Z. Wissa Ardaman & Associates, Inc. 8008 S. Orange Ave. Orlando, FL 32809
Profession:	Civil Engineer
Employer:	Ardaman & Associates, Inc.
Professional Expertise:	Soil stabilization, construction materials, pavements and geosynthetics.
Educational, Scientific Experience, and Professional Qualifications:	See attached resume
Publications in the last ten years:	See attached resume
Testifying experience as expert in last four years:	Dr. Wissa has testified in a permitting proceeding for an above ground, fresh water reservoir in Hillsboro County, Florida.
Subject Matter of Testimony:	Dr. Wissa will testify regarding the characteristics and behavior of the soil cement that PFS proposes to use at the PFS Facility, as related to the issues raised in Parts C and D of Unified Contention Utah L/QQ.
Documents reviewed and/or relied upon:	The documents reviewed and relied upon by Dr. Wissa will include the Stone & Webster program for the use of soil cement at the PFS Facility, including without limitation the definition of the soil cement testing program and its results. In addition, Dr. Wissa may review and rely upon documents produced by the State as well as any new information that may come into PFS's possession.

Name and Address:	Paul J. Trudeau Stone & Webster Engineering, Corp. 100 Technology Drive Circle Stoughton, MA 02072
Profession:	Geotechnical Engineer
Employer:	Stone and Webster Engineering, Corp.
Professional Expertise:	Geotechnical Engineering and Design
Educational, Scientific Experience, and Professional Qualifications:	See attached resume
Publications in the last ten years:	See attached resume
Testifying experience as expert in last four years:	None
Subject Matter of Testimony:	Mr. Trudeau will testify regarding the geotechnical investigations and laboratory testing programs conducted at the PFS Facility, the static and dynamic characteristics of the soils at the PFS site, and the PFS program for the design and application of the soil cement that PFS proposes to use at the PFS facility, as it relates to the issues raised in Parts C and D of Unified Contention Utah L/QQ.[6].
Documents reviewed and/or relied upon:	The documents reviewed and relied upon by Mr. Trudeau will include those prepared by Stone & Webster relating to the static and dynamic properties of the soils at the PFS site. In addition, Mr. Trudeau may review and rely upon documents produced by the State as well as any new information that may come into PFS's possession.
Name and Address:	Robert R. Youngs Geomatrix Consultants, Inc. 2101 Webster Street, Suite 1200 Oakland, California 94612-3066

[6] As set forth in PFS Eighth Supp. Response, Dr. Soler will also be a witness with respect to Part E of Unified Contention Utah L/QQ.

Profession:	Principal Geotechnical Engineer
Employer:	Geomatrix Consultants, Inc.
Professional Expertise:	Geotechnical Engineering
Educational, Scientific Experience, and Professional Qualifications:	See attached resume
Publications in the last ten years:	See attached resume
Testifying experience as expert in last four years:	None
Subject matter of testimony:	Dr. Youngs will testify regarding the propagation of seismic waves that may affect the structures at the PFS site, in-phase motion and the effect of spatial and temporal variance in seismic wave propagation, as related to the issues raised in Parts C and D of Unified Contention Utah L/QQ. Dr. Youngs will also testify regarding related design information provided by Geomatrix to Holtec.
Documents reviewed and/or relied upon:	The documents reviewed and relied upon by Dr. Youngs will include the License Application, Safety Analysis Report, responses to RAIs, NRC regulations and regulatory guides, the Geomatrix Report and calculations, and associated materials developed for the PFS Facility. In addition, Dr. Youngs may review and rely upon documents produced by the State as well as any new information that may come into PFS's possession.

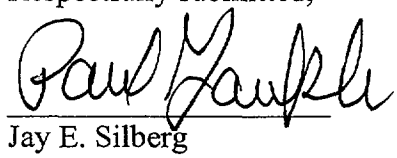
GENERAL INTERROGATORY NO. 4. For each admitted Utah contention, identify the qualifications of each expert witness whom PFS expects to call at the hearing, including but not limited to a list of all publications authored by the witness within the preceding ten years and a listing of any other cases in which the witness has testified as an expert at a trial, hearing or by deposition within the preceding four years.

APPLICANT'S RESPONSE: See Response to General Interrogatory 3 above. The Applicant is still in the process of identifying expert witnesses that it expects to call at the hearings and will supplement this response in accordance with 10 C.F.R. § 2.740(e).

GENERAL INTERROGATORY NO. 5. For each admitted Utah contention, describe the subject matter on which each of the witnesses is expected to testify at the hearing, describe the facts and opinions to which each witness is expected to testify, including a summary of the grounds for each opinion, and identify the documents (including all pertinent pages or parts thereof), data or other information which each witness has reviewed and considered, or is expected to consider or to rely on for his or her testimony.

APPLICANT'S RESPONSE. See Applicant's Response to General Interrogatory No. 3 above. Pursuant to previous discussion and agreement with counsel for the State of Utah, Applicant will identify and/or provide copies of documents relied upon, or expected to be relied upon, by Applicant's experts.

Respectfully submitted,



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(202) 663-8000

Dated: February 19, 2002

Counsel for Private Fuel Storage L.L.C.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
PRIVATE FUEL STORAGE L.L.C.	)	Docket No. 72-22
	)	
(Private Fuel Storage Facility)	)	ASLBP No. 97-732-02-ISFSI

CERTIFICATE OF SERVICE

I hereby certify that copies of Applicant's Ninth Supplemental Response to State's First Requests for Discovery, the attached resumes and declaration of Paul Gaukler were served on the persons listed below (unless otherwise noted) by e-mail with conforming copies by U.S. mail, first class, postage prepaid, this 19th day of February, 2002.

Michael C. Farrar, Esq., Chairman
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Washington, D.C. 20555-0001
e-mail: MCF@nrc.gov

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Atomic Safety and Licensing Board Panel
U.S. Nuclear Regulatory Commission
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Dr. Peter S. Lam
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* Office of Commission Appellate Adjudication
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Office of the Secretary
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Attention: Rulemakings and Adjudications Staff
e-mail: hearingdocket@nrc.gov
(Original and two copies)

* Adjudicatory File
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Albuquerque, NM 87120
e-mail: tvollmann@hotmail.com

Paul A. Gaukler

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
PRIVATE FUEL STORAGE L.L.C.	)	Docket No. 72-22
	)	
(Private Fuel Storage Facility)	)	ASLBP No. 97-732-02-ISFSI

DECLARATION OF PAUL A. GAUKLER

Paul A. Gaukler states as follows under penalties of perjury:

1. I am with Shaw Pittman LLP in Washington, D.C.

2. I am duly authorized to verify Applicant's Ninth Supplemental Response to State's First Requests for Discovery; specifically, the supplemental response to General Interrogatory Nos. 3-5.

3. I certify that the statements in such responses are true and correct to the best of my personal knowledge and belief.

4. I declare under penalty and perjure that the foregoing is true and correct.

Executed on February 19, 2002.

Paul A. Gaukler

Resume of
Bruce E. Ebbeson

Experience Summary

Mr. Ebbeson has 30 years of experience in the engineering industry. Currently, he is the supervisor of the structural division for Stone & Webster's Cherry Hill office. He is presently involved in a number of projects, including the decommissioning of the Maine Yankee nuclear plant and the design of a facility in Utah to store spent nuclear fuel. He serves as a structural engineering consultant on various projects performed in Stone and Webster's Cherry Hill, Boston, Denver and Taiwan offices. Previously, his experience has included assignments on many nuclear power plant projects as a Principal Structural Engineer in a supervisory capacity. He has designed plant modifications and performed safety evaluations to meet licensing requirements. He also has coordinated the implementation of modifications with construction groups and has performed independent design reviews of nuclear power plants at various stages of licensing/operation.

Upon joining Stone & Webster Engineering Corporation in 1973, he was first assigned as a Career Development Engineer in the Structural Division where he was assigned to the Structural Mechanics Section. He was later assigned to the Engineering Mechanics Division as a support engineer in the Structural Mechanics Staff Group. He was reassigned to the Cherry Hill Office in July 1979, to assume the responsibilities as Principal Structural Mechanics Engineer on the River Bend Project. He has worked on various projects where his duties have included conceptual arrangement, analysis, and design of structural components of nuclear power plants.

Prior to joining Stone & Webster Engineering Corporation, Mr. Ebbeson was a Structural Design Engineer with the Philadelphia Water Department, Philadelphia, Pennsylvania.

Education

M.S., Civil Engineering - 1973
B.S., Civil Engineering - Tufts University - 1970

Training

Various courses in Engineering Management - Drexel University
Various Stone & Webster Management Training Classes

Licenses, Registrations, and Certifications

Professional Engineer - Massachusetts - 1977
Professional Engineer - Louisiana - 1981
Professional Engineer - New Jersey - 1983

Professional Affiliations

American Society of Civil Engineers - Member

Experience History

STONE & WEBSTER ENGINEERING CORPORATION, CHERRY HILL, NEW JERSEY - 1979 TO PRESENT

Structural Division Supervisor (Apr 1999 to Present)

Presently, Mr. Ebbeson is responsible for all Civil/Structural activities in the Cherry Hill Office, including hiring, personnel evaluations and technical direction. Additionally, he is actively involved as a consultant on a number of projects, including the Maine Yankee Nuclear Plant decommissioning and the AT&T 700 A Street office building project.

AT&T Point of Presence (POP) Building, 700A Street, Wilmington, DE (Sept 1999 to Jan 2000)

Mr. Ebbeson provided civil/structural consulting support for the development of conceptual designs for the 24,000 sq. ft. network building. He was involved in the review of the Geotechnical report and in the preparation of a report performed to evaluate the risk to the facility from floods.

AT&T (Oct 1998 to Nov 1999)

Mr. Ebbeson was assigned to a team responsible for performing reliability assessments of AT&T facilities including those in Durham NC, Dublin O, Chicago, Boston, Staten Island, Miami, Florham Park and Jersey City. He was responsible for performing the civil/structural portion of the assessments, including preparation of reports.

Private Fuel Storage Facility (Oct 1998 to Present)

Mr. Ebbeson is responsible for the seismic analysis and structural design of the Canister Transfer Building for a proposed facility that will store spent nuclear fuel. His duties included planning and supervising the preparation of calculations and drawings for the facility, and responding to questions posed by the Nuclear Regulatory Commission.

Public Service Electric & Gas Company (Feb 1990 to Oct 1998)

As Lead Civil/Structural Task Manager, Mr. Ebbeson was responsible for coordinating the civil/structural activities on all tasks for the Hope Creek and Salem Nuclear Generating Stations. He has developed design criteria and technical standards for the design of structures and structural components. He has performed and directed structural activities for a number of major design changes, including feedwater heater replacement, control room architectural renovation, auxiliary building ventilation upgrades, containment fan coil unit upgrades, addition of tornado missile barriers and Salem Unit 3 leakage/spill containment. These activities include design of HVAC, electrical raceway and piping systems, seismic qualification of safety-related equipment, design of equipment supports, design of new structures, evaluation of existing structures for increased loadings, and design of rigging systems. When necessary, finite element and structural dynamic analyses were performed. He also served as Task Manager, responsible for developing schedules and budgets, managing the task execution, and interfacing with the client's Project Manager, for a number of projects.

Browns Ferry Nuclear Plant (Sept 1989 to Dec 1989)
Tennessee Valley Authority

Assigned to the site as lead Structural Engineer, Mr. Ebbeson was responsible for the update and verification of the Final Safety Analysis Report (FSAR).

Industrial Projects Group (May 1989 to Sept 1989)

As Principal Structural Engineer, Mr. Ebbeson was responsible for a variety of structural tasks, including design of steel and concrete structures for a solid waste resource recovery facility (Pasco County), design of improvements to office buildings (New Jersey Bell), and rewriting of structural specifications (Niagara Mohawk Power Corporation's Nine Mile Point Nuclear Station). Also responsible for investigation of structural adequacy at IBM's East Fishkill, New York, facility.

Limerick Generating Station - Unit 2 (June 1988 to Apr 1989)
Philadelphia Electric Company

As Lead Structural Engineer, Mr. Ebbeson was responsible for the preparation of review plans, performing technical reviews and writing a final report for submittal to the NRC as part of the integrated design and construction assessment.

Brown's Ferry Nuclear Plant (Feb 1988 to Apr 1989)
Tennessee Valley Authority

As Lead Structural Engineer, Mr. Ebbeson was responsible for directing the structural portion of the calculation review program. This program consisted of a technical review of the structural design to verify the adequacy of the existing facility. Also responsible for directing the structural design and analysis tasks required to improve the design of the existing plant.

Comanche Peak Steam Electric Station (Sept 1986 to Jan 1988)
TU Electric Company

As Assistant Lead Engineer, Mr. Ebbeson was responsible for design verification of the containment building base mat and shell, the auxiliary/electric building and the safeguards building. Responsible also for the verification of structural seismic analysis results. Duties also included preparation of estimates, development of design criteria, and writing of reports.

Beaver Valley Power Station Unit 2 - (May 1986 to June 1986)
Duquesne Light Company

As Technical Reviewer, Mr. Ebbeson was responsible for the overall review of structural work. Activities included review of licensing criteria, design basis, technical review of calculations, review of drawings and specifications, and preparation of a final report.

BWR Continuing Services Project (Mar 1986 to Aug 1987)

As Lead Structural Engineer, Mr. Ebbeson was responsible for all structural work performed by SWEC on three existing BWR nuclear projects.

Oyster Creek Nuclear Generating Station (Nov 1983 to Feb 1986)
General Public Utilities Nuclear Corporation

As Lead Structural Engineer, Mr. Ebbeson was responsible for all structural work, concerned with field modifications to the existing nuclear facility.

Structural Division Staff (June 1982 to Feb 1985)

As Principal Staff Engineer, Mr. Ebbeson was responsible for planning and supervising all structural seismic and hydrodynamic analyses for nuclear projects.

Field Assignment (March 1983 to June 1983)

Temporary assignment to Washington Public Power Supply System (WPPSS) offices in Richland, Washington. Mr. Ebbeson served as a consultant to WPPSS in the civil/structural area during final design reverification of a nuclear project.

River Bend Station - Unit 1 (July 1979 to May 1982)
Gulf States Utilities Company

As Principal Engineer, Mr. Ebbeson was responsible for the planning and supervision of the analysis and design of the reactor building concrete structures and steel containment as well as the dynamic analyses of all Category I buildings. Also responsible for preparing licensing documents, writing reports, and resolving construction problems.

STONE & WEBSTER ENGINEERING CORPORATION, BOSTON, MASSACHUSETTS - 1973 TO 1979

As Structural Engineer (Dec 1978 to July 1979), Mr. Ebbeson was responsible for analysis and design of nuclear power plant containment structures and internal structural components. Projects included Montague (miscellaneous studies), NYSE&G, and the EPRI breeder conceptual study (structural design of reactor building). Also worked on a special task force to re-analyze five nuclear plant shut down in March 1979.

As Support Engineer (Aug 1973 to Dec 1978), Mr. Ebbeson was responsible for working in the area of barrier designs for protection from tornados and accident generated missiles. Also responsible for development of computer programs, planning of a physical testing program, inspection of a tornado disaster area, and analysis and design of steel and concrete missile barriers. Also worked on analysis and design of structures on various projects. Projects included Shoreham, Philadelphia Electric (equipment drop impact problems), SWEC's Reference Nuclear Power Plant (RNPP) (conceptual design of containment internal structures and seismic analysis), and Beaver Valley - Unit 2 (seismic analysis and checking of containment internal structures design).

Oswego Steam Station - Units 5 and 6
Niagara Mohawk Power Corporation (June 1973 to Aug 1973)

As Career Development Engineer, Mr. Ebbeson was responsible for assisting Structural Engineers on a fossil fuel power plant project. Duties included helping with the preparation of specifications, comparison of bids, and coordination of design and construction activities.

PHILADELPHIA WATER DEPARTMENT, PHILADELPHIA, PENNSYLVANIA - 1970 TO 1971

As Structural Design Engineer (June 1970 to Aug 1971), Mr. Ebbeson was responsible for design of steel and concrete structural elements, preparation of drawings, and checking of designs and drawings.

Resume of
Krishna P. Singh

RESUME

KRISHNA P. SINGH, Ph.D.
PRESIDENT & CEO

EDUCATION

University of Pennsylvania
Ph.D. in Mechanical Engineering (1972)

University of Pennsylvania
M.S. in Mechanical Engineering (1969)

B.I.T. Sindri, Ranchi University
B.S. In Mechanical Engineering (1967)

PROFESSIONAL EXPERIENCE

HOLTEC INTERNATIONAL
Marlton, New Jersey

1986 - Present President and CEO

JOSEPH OAT CORPORATION
Camden, New Jersey

1979 - 1986	Vice President of Engineering
1974 - 1979	Chief Engineer
1971 - 1974	Principal Engineer

R.I.T. ALLAHABAD
India

1967 - 1968 Assistant Professor of Applied Mechanics

LICENSES

Registered Professional Engineer - Pennsylvania (1974 - present)

Registered Professional Engineer - Michigan (1980 - present)

PROFESSIONAL MEMBERSHIPS/ACTIVITIES

Fellow of the ASME; Member ANS; Chairman, TEMA Vibration Committee (1979 - 1986); Chairman, PVP Committee Of the ASME, Nuclear Engineering Division (1988-92); Member, ASME O&M Committee (1991 to present); Member ASCE (1977-83), Member, Heat Exchange Institute (1976-86).

PATENTS

"Heat Exchanger for Withstanding Cycle Changes in Temperature" (with M. Holtz and A. Soler), Patent No. 4,207,944 (1980).

"Radioactive Fuel Cell Storage Rack" (with M. Holtz), U.S. Patent No. 4,382,060 (May, 1983).

BOOKS AND ARCHIVAL VOLUMES (authored or edited):

1. "Mechanical Design of Heat Exchangers and Pressure Vessel Components", (with A. I. Soler), Arcturus Publishers, Cherry Hill, New Jersey, 1100 pages, hardbound (1984).

2. "Theory and Practice of Heat Exchanger Design", Arcturus Publishers (c. 1995).

3. "Feedwater Heater Workshop Proceedings", with Tom Libs, EPRI 78-123 (1979).

4. "Feedwater Heater Technology: State-of-the-Art", EPRI - cs - 4155 (1985).

5. "Analytical Correlations of Fluid Drag of Fuel Drag of Fuel Assemblies in Fuel Rack Storage Locations", EPRI Project RP-2124.

6. "Thermal/Mechanical Heat Exchanger Design", ASME, PVP - Vol. 118 (1986).

7. "Time Dependent and Steady State Characterization of the CAES Recuperator", EPRI TR-104224 (July 1994).

8. "Pressure Vessels, Heat Exchangers and Piping", Proc. ASME, IEEE Joint Power Generation Conference, NE-14 (1994).

ACADEMIC ACTIVITIES

Chair, Advisory Committee On Mechanical Engineering and Mechanics, University of Pennsylvania (1993-)

Professor (Adjunct) in Mechanical Engineering and Mechanics, University of Pennsylvania (1986-92), Graduate and Undergraduate Courses in Heat Transfer Equipment

CONTINUING EDUCATION COURSES OFFERED ON HEAT EXCHANGE AND STEAM GENERATION

1. I.I.T. Bombay, One Week Course on Heat Exchanger Design (1979).

2. Duke Power Company, Charlotte, NC (1982, 1983, 1986, 1990) - In-house Course on Heat Exchanger Design and Testing.

3. National Italian Reactor Authority, Genoa, Italy - On Condensers, Steam Generators, and Moisture Separator Reheaters (1985).

4. Mississippi Power & Light Company, In-House Course on Moisture Separator Reheaters and Surface Condensers (1987).

5. Center for Professional Advancement (1988, New Brunswick, NJ; 1990, Caracas, Venezuela; 1991, Houston, Texas; 1992, Amsterdam, Holland).

CONSULTING

Consultant to Electric Power Research Institute (EPRI); Pressure Vessel Research Council (PVRC); Tubular Exchanger Manufacturers Association (TEMA); Department of Energy (DOE) (Idaho Operations); Department of Energy (DOE) (Chicago Operations); American Electric Power Corporation; Baltimore Gas and Electric; Carolina Power & Light; Commonwealth Edison Company; Detroit Edison Company; Duke Power Company; Entergy Operations; GPU Nuclear; Iowa Electric Light and Power; New York Power Authority; Niagara Mohawk Power Corporation; North Atlantic Energy Services; Northeast Utilities; Northeast Nuclear Energy; Pacific Gas and Electric Company; PECO Energy; Southern Nuclear Operating Company; Tennessee Valley Authority.

PUBLICATIONS

1. "A Method for Solving Ill-Posed Integral Equations of the First Kind", (with B. Paul), Computer Methods in Applied Mechanics and Engineering 2 (1973) 339-348.

2. "Numerical Solutions of Non-Hertzian Elastic Contact Problems", (with B. Paul), Journal of Applied Mechanics, Vol. 41, No. 2, 484-490, June, 1974.

3. "On the Inadequacy of Hertzian Solution of Two Dimensional Line Contact Problems", Journal of the Franklin Institute, Vol, 298, No. 2, 139-141 (1974).

4. "How to Locate Impingement Plates in Tubular Heat Exchangers", Hydrocarbon Processing, Vol. 10, 147-149 (1974).

5. "Stress Concentration in Crowned Rollers", (with B. Paul), Journal of Engineering for Industry, Trans. ASME, Vol. 97, Series B, No. 3, 990-994 (1975).

6. "Application of Spiral Wound Gaskets for Leak Tight Joints", Journal of Pressure Vessel Technology, Trans. ASME, Vol. 97, Series J, No. 1, 91-93 (1975).

7. "Contact Stresses for Multiply-Connected Regions - The Case of Pitted Spheres:, with B. Paul and W. S. Woodward, Proceedings of the IUTAM Symposium on Contact Stresses, August 1974, Holland, Delft University Press, 264-281, (1976).

8. "Design of Skirt-Mounted Supports:, Hydrocarbon Processing, Vol. 4, 199-203, April 1976.

9. "Predicting Flow Induced Vibration in U-Bend Regions of Heat Exchangers - An Engineering Solution". Journal of the Franklin Institute, Vol. 302, No. 2, 195-205, August 1976.

10. "A Method to Design Shell-side Pressure Drop Constrained Tubular Heat Exchangers", with Mr. Holtz, Journal of Engineering for Power, Trans. of the ASME, Vol. 99, No. 3 July 1977, pp 441-448.

11. "An Efficient Design Method for Obround Pressure Vessels and Their End Closures", International Journal of Pressure Vessel and Piping, Vol. 5, 1977, pp 309-320.

12. "Analysis of Vertically mounted Through-Tube Heat Exchangers", Journal of Engineering for Power, Trans. ASME, Vol. 100, No. 2, April, 1978, pp 380-390.

13. "Study of Bolted Joint Integrity and Inter-Tube-Pass Leakage in U-Tube Heat Exchangers: Part I - Analysis", Journal of Engineering for Power, Trans. ASME, Vol. 101, No. 1, pp 9-15 (1979).

14. "Study of bolted Joint Integrity and Inter-Tube-Pass Leakage in U-Tube Heat Exchangers, Part II - Applications", Journal of Engineering for Power, Trans. ASME, Vol. 101, No. 1, pp 16-22 (1979).

15. "On Thermal Expansion Induced Stresses in U-Bends of Shell-and-Tube Heat Exchangers", (with Maurice Holtz); Trans. ASME, Journal of Engineering for Power, Vol. 101, No. 4, October, 1979, pp. 634-639.

16. "Heat Transfer Characteristics of a Generalized Divided Flow Heat Exchanger", Proceedings of the Conference on Industrial Energy Conservation Technology, Houston, Texas, pp 88-97 (1979).

17. "An Approximate Analysis of Foundation Stresses in Horizontal Pressure Vessels", (with Vincent Luk), Paper No. 79-NE-1, Trans. ASME, Journal of Engineering for Power, Vol. 102, No. 3, pp 555-557, July, 1980.

18. "Generalization of the Split Flow Heat Exchanger Geometry for Enhanced Heat Transfer", (with Michael Holtz), AIChe. Symposium Series 189, Vol. 75, pp 219-226 (1979).

19. "Analysis of Temperature Induced Stresses in the Body Bolts of Single Pass Heat Exchangers", ASME Winter Annual Meeting, Paper No. 79 QA/NE-7, New York, NY, 1979.

20. "Optimization of Two-Stage Evaporators for Minimizing Rad-Waste Entrainment", (with Maurice Holtz), Journal of Mechanical Design, Trans. of the ASME, Vol. 102, No. 4, pp 804-806 (1980).

21. "A Comparison of Thermal Performance of Two and Four Tube Pass Designs for Split Flow Shells", (with M. J. Holtz), Journal of Heat Transfer, Trans. of the ASME, Vol. 103, No. 1, pp 169-172, February, 1981.

22. "A Method for Maximizing Support Leg Stress in a Pressure Vessel Mounted on Four Legs Subject to Moment and Lateral Loadings". International Journal of Pressure Vessels and Piping, Vol. 9, No. 1, pp 11-25 (1981).

23. "Design, Stress Analysis and Operating Experience in Feedwater Heaters",, (with Tom Libs), Proceedings of the Conference on Industrial Energy Conservation Technology, Houston, pp 113-118 (1980).

24. "On the Necessary Criteria for Stream Symmetric Tubular Heat Exchanger Geometries", Heat Transfer Engineering, Vol. 3, No. 1 (1981).

25. "Some Fundamental Relationships for Tubular Heat Exchanger Thermal Performance", Trans. ASME, Journal of Heat Transfer, Vol. 103, pp 573-578 (1981).

26. "Transient Swelling of Liquid Level During Pool Boiling in an Emergency Condenser", (with J. P. Gupta). Letters in Heat and Mass Transfer, Vol. 8, No. 1, pp 25-33, Jan/Feb., 1981.

27. "An Approximate Method for Evaluating the Temperature Field in Tubesheet Ligaments Under Steady State Conditions", (with M. Holtz), Journal of Engineering for Power, Trans. ASME, Vol. 104, pp 895-900 (1982).

28. "Feasibility Study of A Multi-Purpose Computer Program to Optimize Power Cycles for Operative Plants", (with Y. Menuchin and N. Hirota), Proceedings of the Conference on Industrial Energy Conservation Technology, Houston, (1981).

29. "Design Parameters Affecting Bolt Load in Ring Type Gasketed Joints", (with A. I. Soler), Trans. ASME, Journal of Pressure Vessel Technology, Vol 105, pp 11-13 (1983).

30. "A Design Concept for Minimizing Tubesheet Stress and Tubejoint Load in Fixed Tubesheet Heat Exchangers", (with A. I. Soler), Trans. ASME (C. 1982).

31. "Dynamic Coupling in a Closely Spaced Two-Body System Vibrating in Liquid Medium: The Case of Fuel Racks", (with A. I. Soler), Proceedings of the Third International Conference on "Vibration in Nuclear Plant", Keswick, England, May, 1982, pp. 815-834.

32. "Effect of Nonuniform Inlet Air Flow on Air Cooled Heat Exchanger Performance", (with A. I. Soler and Lee Ng), Proceedings of the Joint ASME-JSME Heat Transfer Conference, 1983, pp. 537-542.

33. "Seismic Response of Free Standing Fuel Rack Constructions to 3-D Motions", (with A. I. Soler), Nuclear Engineering and Design, Vol. 80, (1984), pp. 315-329.

34. "A Method for Computing Maximum Water Temperature in a Fuel Pool Containing Spent Nuclear Fuel", Heat Transfer Engineering, Hemisphere, Dec. (1986).

35. "On Minimization of Radwaste Carry-Over in a N-stage Evaporator", (with Maurice Holtz and Vincent Luk), Heat Transfer Engineering, pp. 68-73, Vol. 5, No. 1-1 (1984).

36. "Feedwater Heater Procurement Guidelines - Some New Performance Criteria", Symposium on State-of-the-art Feedwater Heater Technology, EPRI (c. 1984).

37. "Method for Quantifying Heat Duty Derating due to Inter-Pass Leakage in Bolted Flat Cover Heat Exchangers", Heat Transfer Engineering, pp. 19-23, Vol. 4, No. 3-4 (1983).

38. "On Some Performance Parameters for Closed Feedwater Heaters, Journal of Pressure Vessel Technology, Trans. ASME (1987).

39. "A Design Procedure for Evaluating the Tube Axial Load Due to Thermal Effects in Multi-Pass Fixed Tubesheet Heat Exchangers", (with A. I. Soler), Journal of Pressure Vessel Technology, Trans. ASME (1987).

40. "An Elastic-Plastic Analysis of the Integral Tubesheet in U-Tube Heat Exchangers - Towards an ASME Code Oriented Approach", Int. Journal of Vessel and Piping (c. 1987).

41. "Feedwater Heaters", Heat Transfer Equipment Design, R. Shal et. al (editor), Hemisphere (c. 1988).

42. "Surface Condensers", Heat Transfer Equipment Design, R. Shal et. al (editor), Hemisphere (c. 1988).

43. "FLow Induced Vibration", Heat Transfer Equipment Design, R. Shal et. al (editor), Hemisphere (c. 1988).

44. "Mechanical Design of Heat Exchangers", Heat Transfer Equipment Design, R. Shal et. al (editor), Hemisphere (c. 1988).

45. "A Rational Method for Analyzing Expansion Joints":, (with A. Soler), ASME, Journal of Pressure Vessel Technology (c. 1988).

46. "An Analysis of the Improvement in the Thermal Performance of Surface Condenser Equipped with Tweener Supports", ASME Joint Power Generation Conference, Miami (Oct. 1987).

47. "Pressure Vessels - Design & Operation", Chemical Engineering, pp 62-70, Chemical Engineering, July 1990, McGraw Hill, N.Y.

48. "Spent Fuel Storage Options: A Critical Appraisal", Power Generation Technology, pp 137-140, Sterling Publications, U.K. (1990-91).

49. "Design Strength of Primary Structural Welds in Free-Standing Structures", with A.I. Soler and S. Bhattacharya, Journal of Pressure Vessel Technology, Trans. ASME (c' 1991).

50. "Seismic Qualification of Free-Standing Nuclear Fuel Storage Modules - The Chin Shan Experience", Nuclear Engineering International, U.K. (March, 1991).

51. "Transient Response of Large Inertia Cross Flow Heat Exchangers", with Y. Wang, A.I. Soler and K. Iulianetti, ASME 91-JPGC-NE-27 (1991).

52. "Some Results from Simultaneous Seismic Simulations of All Racks in a Fuel Pool", with A.I. I. Soler, INNM Spent Fuel Management Seminar X, Washington, D.C., January, 1993.

53. "A Case for Wet Storage", INNM Spent Fuel Management Seminar X, Washington, D.C., January, 1993.

54. "Application of Transient Analysis Methodology to Heat Exchanger Performance Testing" with I. Rampall and Benjamin H. Scott, ASME Joint Power Generation Conference, October, 1994.

55. "Predicting Thermal Performance of Heat Exchangers Using In-Situ Testing and Statistical Correlation", with K. Iulianetti and Benjamin H. Scott, ASME Joint Power Generation Conference (1994).

56. "Shellside Boiling in Narrow Crevices", with I. Rampall (to be submitted for publication, Heat Transfer Engineering (ca. 1996)).

Resume of
Alan I. Soler

ALAN I. SOLER, Ph.D.

EXECUTIVE VICE PRESIDENT
HOLTEC INTERNATIONAL

EDUCATION

University of Pennsylvania
Ph.D. in Mechanical Engineering (1962)

California Institute of Technology
M.S. in Mechanical Engineering (1959)

University of Pennsylvania
B.S. in Mechanical Engineering (1958)

AREAS OF PROFESSIONAL CONCENTRATION

Dynamics of casks and fuel racks, impact, mechanical design of cask and MPCs, failure analysis of reinforced concrete structures, cask transporter design, NUREG-0612 compliance, crane design and stress analysis.

PROFESSIONAL EXPERIENCE

HOLTEC INTERNATIONAL
Marlton, New Jersey
1986 – Present — Executive Engineer

UNIVERSITY OF PENNSYLVANIA
Philadelphia, Pennsylvania
1966 - 1991 — Professor of Mechanical Engineering and Applied Mechanics

INGERSOLL-RAND RESEARCH CENTER
Princeton, New Jersey
May 1964–Sept. 1965 — Member of Technical Staff

DYNASTRUCTURES, INC., CONSULTANTS IN APPLIED MECHANICS
Philadelphia, Pennsylvania
May 1962–May 1964 — Research Specialist

ACADEMIC HONORS

Tau Beta Pi
Sigma Tau
Society of Sigma Xi

PROFESSIONAL SOCIETY MEMBERSHIPS/ACTIVITIES

Member, ASME, Fellow ASME, 1986
Treasurer, University of Pennsylvania Chapter, Sigma Xi, 1968-70.
General Arrangements Committee Member, 1969, ASME Vibrations Conference.
ASEE Local Activity Coordinator, 1968-1974.

Member, Rotordynamics Subcommittee, ASME Design Division, 1973-1974.
Local Arrangements Committee, 1971 Summer ASME Applied Mechanics Meeting.
Recording Secretary, ASME Applied Mechanics Division, Publication Committee, 1971-1972.
-Applied Mechanics Representative to ASME Power Division Subcommittee on Environmental Policy, 1974-1976.
Member, Turbine and Auxiliaries Committee, ASME Power Division, 1974-76, Papers Review
Member, Task Group on Heat Transfer Equipment, ASME, working group #1 (tubesheets), 1975-1998.
Member - Subcommittee on Pressure Vessels and Piping, Nuclear Engineering Division, ASME, 1976-1987, Chairman, 1984-1987.

TECHNICAL CONSULTING

Consultant to Solid Mechanics Group, Ingersoll-Rand Research Center, Princeton, New Jersey, September 1965 - December 1966.
Consultant to Condenser Engineering Department, Ingersoll-Rand Corporation, Phillipsburg, New Jersey, September 1965 – 1982. Consultant to Structural Mechanics Associates, November 1958 - January 1969.
Visiting Scientist, Mechanical Engineering Research Division, Livermore Laboratories, Livermore, CA, Summer 1973, 1974 (AEC "Q" Clearance).
Member of Consulting Group, Thermac Associates, 1975 - 1986.
Consultant to Joseph Oat Corp. - Manufacturers of Nuclear Heat Exchangers. Camden, New Jersey, 1975 - 1986.
Consultant to Heat Exchange Institute - Nuclear HEX, 1978-1979.
Consultant, Inc., Wilson Div., Reading, PA, 1979-1980.
Consultant, NADC, Willow Grove, PA, 1984-1986.

PATENTS

Patent #3,382,918, May 1968, Reinforcing Structure for Direct Flow Steam Dome for Condensers (with Mr. R. J. Stoker and Dr. B. Paul of Ingersoll-Rand Corporation).

DRY SPENT FUEL STORAGE TECHNOLOGY

1992-Present: Lead Analyst in Mechanical/Seismic/Structural analysis in support of Holtec=s Dry Storage submittals for dual-purpose casks (HI-STAR 100 for Storage and Transport) and for METCON casks (HI-STORM 100 for Storage).

1994: Performed cask tip-over and drop analysis to support §50.59 effort for defueling Shoreham Station using IF-300 casks.

1995: Principal Analyst for evaluating cask drop events for Connecticut Yankee.

1997: Co-developer of the dynamic formalism to predict peak cask deceleration from cask tip-over and drop event on ISFSI pads.

1996: Principal designer of HI-STAR 100 Impact Limiter.

1998: Developer of the "penetration area principle" to predict impact limiter response under cask drop events; method was verified using quarter-scale tests.

1999: Designer and principal analyst for Holtec International's autonomous "Cask Transfer Facility" (CTF).

HIGH DENSITY FUEL RACK STRESS ANALYSIS

- Principal developer of Holtec's rack dynamic analysis code DYNARACK. This code is widely recognized as the most sophisticated program for high density rack seismic analysis.
- Performed seismic analysis of high density racks for 36 Nuclear Power Plants in the period 1980 to present.
- Pioneered dynamic analysis techniques of elevated pool slabs. Qualified the elevated pool slabs of Quad City Units 1 and 2, Grand Gulf and Oyster Creek using dynamic reinforced concrete analysis (all approved by the USNRC).

LICENSING SUPPORT

- Provided licensing support on over forty high-density rack applications to the USNRC (in the past twenty years).
- Appeared as expert witness (support) for Pacific Gas & Electric in Diablo Canyon reracking license review (1987).

PUBLICATIONS/PRESENTATIONS

1. "On the Lobar and Longitudinal Vibrations of Solid Propellant Rocket Motors", (with H. B. Kingsbury and J. R. Vinson) Proceedings of the 6th Solid Propellant Rocket Conference, AIAA, Washington, D.C. (February 1965).
2. "On the Solution to Transient Coupled Thermoelastic Problems by Perturbation Techniques", (with M. A. Brull) presented at the Summer Applied Mechanics Meeting of ASME (June 1965) and published in the Journal of Applied Mechanics (June 1965).
3. "A New Perturbation Technique for Differential Equations with Small Parameters", (with M. A. Brull), Quarterly of Applied Mathematics XXIV, No. 2 (July 1966) and presented at the 5th National Congress on Applied Mechanics, Minneapolis, Minnesota (June 1966).
4. "On Rolling Contact and the Theorem of Angular Momentum", (with S. C. Batterman), Journal of Engineering Education 67, 9 (May 1967).
5. "Higher Order Effects in Thick Rectangular Beams", International Journal of Solids and Structures 4, (July 1968) pp. 723-739.
6. "On the Vibrations and Stability of Moving Bands", Journal of the Franklin Institute (October 1968).
7. "Higher Order Theories for Structural Analysis Using Legendre Polynomial Expansions", presented at ASME Winter Annual Meeting, Los Angeles, CA (November 1969), and published in Journal of Applied Mechanics (December 1969).

8. "One Dimensional Viscous Magnetofluidynamic Flow in an Annulus", (with S. Schwietzer), presented at the AIAA Fluid and Plasma Dynamics Conference, San Francisco, California (June 1969), and published in Journal of the Franklin Institute 289, No. 6 (June 1970).

9. "On the Solution of Finite Deformation Problems of Beams Using Rate Equations", (with J. Lehner), Journal of Applied Mechanics, (March 1970) pp. 207-210.

10. "Approximate Theory for Locally Loaded Plant Orthotropic Beams", (with H. Tsai), International Journal of Solids and Structures 6, (1970) pp. 1055-1068.

11. "Approximate Solution of the Finite Cylinder Problem Using Legendre Polynomials'< (with J. Fellers), AIAA Journal 8, No. 11 (November 1970) and presented at the 6th U.S. Congress on Applied Mechanics (June 1970).

12. "On Analysis of Cable Network Systems Using Galerkin's Method", (with H. Afshari), Journal of Applied Mechanics, (September 1970) pp. 606-612.

13. "On the Buckling of Rings", (with S. C. Batterman), ASCE Engineering Mechanics Journal (December 1970).

14. "Dynamic Response of Sincle Cables with Initial Sag", Journal of the Franklin Institute (October 1970).

15. "Analysis of Cable Dynamics and Optimum Towing Strategies for Tethered Submersibles", (with B. Paul), presented at the Ocean Engineering Symposium, University of Pennsylvania (November 19-20, 1970), and published in Journal of Marine Technology 6, 2 (April 1972) pp. 34-41.

16. "Circumferential Forces and Moments in Edge Loaded Conical Shell Elements", Journal of Applied Mechanics (March 1972) pp. 290-291.

17. "Pre-twisted Curved Beams of Thin-Walled Open Section", Journal of Applied Mechanics (September 1972) pp. 779-786.

18. "Thermal Stresses and Initial Deformation of Heated Condenser Tubes", Journal of Engineering for Power (April 1973) pp. 84-91.

19. "New Results on Applications of Multi-Segment Stepwise Integration to First Order Equations", (with G. J. Hutchins), Journal of Computer Methods in Applied Mechanics and Engineering (1972) pp. 307-316.

20. "Dynamics of Cables and Cable Systems", Shock and Vibration Digest 5, 3 (March 1973) pp. 1-9.

21. "Cable Network Vibrations Using Galerkin's Method of Polynomial Approximating Functions", (with H. Afshari), Journal of Applied Mechanics (June 1973) pp. 622-624.

22. "Analysis of Moderately Thick Shells of Revolution", (with G. J. Hutchins), Journal of Applied Mechanics (December 1973) pp. 955-961.

23. "Project Cyclops - A Design Study of a System for Detecting Extraterrestrial Life", contributing author, NASA Report CR114445 (October 1972).

24. "Vibration of Cable Gridworks with Small Initial Deformation", (with H. Afshari), Journal of Applied Mechanics (December 1973), and presented at Winter ASME Meeting, Detroit, Michigan (November 1973).

25. "Transverse Elastic Buckling of Plane Pipe Gridworks", (with H. Afshari, Journal of Structures, ASCE (April 1974).

26. "On Seal Forces in Removable End Closure in Very High Pressure Test Chambers", ASME Journal of Pressure Vessel Technology (February 1975).

27. "Limit Design of Condenser Hotwell Floors", ASME Journal of Engineering for Power (October 1975) pp. 628-633.

28. "Stability of Rotor-Bearing Systems with Generalized Support Flexibility and Damping and Aerodynamic Cross-Coupling", (with R. E. Warner), presented at ASME Lubrication Conference, Toronto (October 1974), and published in the ASME Journal of Lubrication Technology (July 1975) pp. 461-472.

29. "Tubesheet Design in U-Tube Heat Exchangers Including the Effect of Tube Rotational Restraint", published in Journal of Engineering for Industry 98, 4 (November 1976) pp. 1157-1160 and presented at Design Engineering Conference, Chicago, IL (April 1976).

30. "Effective Bending Properties for Stress Analysis of Rectangular Tubesheets", (with W. Hill), published in ASME Journal for Power 99, 3 (July 1977) pp. 365-370, presented at 1976 ASME Annual Meeting.

31. "Stress Analysis of a U-Tube Heat Exchanger Tubesheet with an Integral Channel and an Unperforated Rim", presented by Pressure Vessel and Piping Division, ASME Mexico City Conference (September 1976) (76-PV-58).

32. "Analysis of Beam Columns on Elastic Plastic Foundations with Application to Power Plant Condenser Support Plate Design", (with C. Shahravan), published in ASME Journal of Engineering for Power, 100 (January 1978) pp. 182-188.

33. "Analysis of Closely Spaced Double Tubesheets under Mechanical and Thermal Loading", presented at 1977 Joint Power Generation Conference, ASME, Los Angles, California (77-JPGC-NE-21).

34. "The Tubesheet Analysis Method in the New HEI Condenser Standards", (with M.D. Bernstein), presented at the 1977 Joint Power Generation Conference, ASME, Los Angeles, California, published in ASME Journal for Power 100 (April 1978) pp. 363-368.

35. "Design Curves for Stress Analysis of U-Tube Heat Exchanger Tubesheet with Integral Channel and Head", (with J. E. Soehrens) Journal of Pressure Vessel Technology 100 (May 1978) pp. 221-233.

36. "Design of Condenser Hotwell Floor for Pressure Loading", presented at ASME 1978 Annual Meeting, ASME Advances in Reliability and Stress Analysis H00119 (1979) pp. 203-215.

37. "A Preliminary Assessment of the HEI Tubesheet Design Method - Comparison with a Finite Element Solution", presented at ASME 1978 Winter Annual Meeting, ASME Advances in Reliability and Stress Analysis H00119 (1979) pp. 127-146.

38. "Analysis of Bolted Joints with Nonlinear Gasket Behavior", ASME Journal of Pressure Vessels 102 (August 1980) pp. 249-256.

39. "Stress Analysis of Rectangular Tubesheets for Condensers", Paper 80-C2/NE-14 presented at ASME Nuclear Engineering Conference, San Francisco, California (August 1980).

40. "A Finite Element Model for Thick Beams", (with D. Barrett) Computer Methods in Applied Mechanics and Engineering 25 (1981) pp. 299-313.

41. "A Design Concept for Minimizing Tubesheet Stress and Tubejoint Load in Fixed Heat Exchangers", (with K. P. Singh) 1982 ASME Pressure Vessel and Piping Conference, Orlando, Florida; Int. Journal for Pressure Vessel Technology, Trans. ASME (c. 1982).

42. "Dynamic Coupling in a Closely Spaced Two Body System Vibrating in a Liquid Medium: The Case of Fuel Racks", (with K. P. Singh) 1982 SMIRT Conference, Keswick, England (May 1982).

43. "A Finite Element Model for Thickwalled Axisymmetric Shell", (with D. J. Barrett), ASME Journal of Pressure Vessel Technology 104, (August 1982) pp. 215-222.

44. "Design Parameters Affecting Bolt Load in Ring Type Gasketed Joints", (with K. P. Singh), Journal of Pressure Vessel Technology, Trans. ASME (1984).

45. "Effect of Non-Uniform Inlet Air Flow on Air-Cooled Heat Exchanger Performance", (with K. P. Singh and T. L. Ng) presented at Joint ASME-JSME Transfer Conference, Hawaii (March 1983) and published in Conference Proceedings.

46. "A Method for Computing Maximum Water Temperature in a Fuel Pool Containing Spent Nuclear Fuel", (with K. P. Singh) presented at Fourth International Conference on Pressure Vessels and Piping, Portland, Oregon (June 1983), Nuclear Technology, ANS (c. 1984).

47. "Seismic Response of Free Standing Fuel Rack Constructions to 3-D Floor Motions", (with K. P. Singh) presented at the Fourth International Conference on Pressure Vessels and Piping, Portland, Oregon (June 1983) and published in Nuclear Engineering and Design 80, (1984) pp. 315-329.

48. "Analysis of Tube-Tubesheet Joint loading Including Thermal Loading", (with Xu Hong) published in Journal of Applied Mechanics (June 1984), and presented at 1984 Pressure Vessels and Piping Conference.

49. "Analysis and Design of Pressure Vessel Bolted Flanges with Non Linear Gasket Materials", 11th Conference on Production Research and Technology - Computer Based Factory Automation, Conference Proceedings, Carnegie Mellon University, Pittsburgh, PA (May 1984).

50. "Foundation Stresses under Support of Freestanding Equipment Subjected to External Loads", (with K. P. Singh and I. Gottesman), International Journal of Pressure Vessels and Piping, Vol. 20, No. 2 (1985) pp. 127-138.

51. "Finite Elements for Thick 3-D Shells", (with A. Khaskia), International Journal of Pressure Vessel Technology, 1985.

52. "Tube-to-Tubesheet Rolled Joints: Part I - Analysis Including Strain Hardening and Temperature Dependent Properties", (with S. Weinstock), Proceedings of ASME 1985 Pressure Vessel and Piping Conference H00329, New Orleans, LA.

53. "Tube-to-Tubesheets Rolled Joints: Part II - Experimental Analysis", (with K. Reinis), Proceedings of ASME 1985 Pressure Vessel and Piping Conference H00329, New Orleans, LA.

54. "An Elastic Plastic Analysis of the Integral Tubesheet in U-Tube Heat Exchangers - Towards an ASME Code Oriented Approach", (with K. P. Singh), Proceedings of ASME 1985 Pressure Vessel and Piping Conference H00329, New Orleans, LA.

55. "A Design Procedure for Evaluating the Tube Axial Load due to Thermal Effects in Multi-Pass Fixed Tubesheet Exchangers", (with K. P. Singh), ASME Journal of Pressure Vessel Technology (c. 1986).

56. "Tubesheet Analysis - A Proposed ASME Design Procedure" (with S. Caldwell and K. P. Singh), ASME Karl Gardner Memorial Symposium Proceedings (c. 1986). Channel and an Unperforated Rim, presented by Pressure Vessel and Piping Division, ASME.

57. "Some Results From Simultaneous Seismic Simulations of all Racks in a Fuel Pool", with K.P. Singh, INMM Spent Fuel Management Seminar X, Washington, D.C., January, 1993.

58. Application of Transient Analysis Methodology to Quantify Thermal Performance of Heat Exchangers, I. Rampall, K.P. Singh, A. Soler, and B. Scott, Heat Transfer Engineering, 1997.

59. "Seismic Response Characteristics of HI-STAR 100 Cask System on Storage Pads", with K.P. Singh and Mark G. Smith, INMM Conference, Washington, DC, January, 1998.

Resume of
Kiat Lilhanand

EDUCATION:

Ph.D. - Civil Engineering, Rice University, 1974
M.S. - Civil Engineering, University of California, Berkeley, 1970
B.S. - Civil Engineering, University of California, Berkeley, 1969

SUMMARY:

Dr. Lilhanand has over 20 years of professional experience in the specialty areas of seismic analysis, simulation of seismic ground motions, random vibration analysis, probabilistic approach to civil engineering structures, and computer applications on structural analysis programs. During the last 15 years, he actively participated in research, development and applications of seismic soil-structure interaction (SSI) analysis methodologies, development of a new method for generating synthetic time histories compatible with multiple-damping design response spectra, and providing support on computer applications to nuclear, bridge, transportation, and pipeline projects.

EMPLOYMENT HISTORY:

1990-present - Principal Engineer, International Civil Engineering Consultants, Inc., Berkeley
1988-90 - Engineering Group Supervisor, Special Structures Group, Bechtel Power Corporation, San Francisco
1980-88 - Engineering Specialist, Special Structures Group, Bechtel Power Corporation, San Francisco
1978-80 - Senior Engineer, Tsuruga Project, Bechtel Power Corporation, San Francisco
1977-78 - Senior Professional Services Analyst, Control Data Corporation, Sunnyvale
1976-77 - Senior Engineer, CAL Consulting Engineers, Berkeley
1975-76 - Structural Engineer, Valentine, Laurie and Davies Consulting Engineers, Thailand
1974-75 - Research Engineer, Earl & Wright Consulting Engineers, San Francisco

PROFESSIONAL SOCIETY:

American Society of Civil Engineers, Member

AWARDS:

1988 - Bechtel Outstanding Technical Paper Award
1989 - Bechtel Outstanding Technical Paper Award

PUBLICATIONS:

15 technical papers and over 30 technical/project reports.

SUMMARY OF EXPERIENCE:

During the past 10 years, he has participated in a leading role in performing the following activities for the engineered facilities:

(1) Diablo Canyon Nuclear Power Plant, developing 3-D SSI models and performing seismic SSI analysis of containment, auxiliary building, and turbine building structures, developing a new stochastic SSI method for incorporating incoherent ground input motions, generating synthetic time histories compatible with site-specific ground motion response spectra, performing data reduction analysis of recorded earthquake motions to identify the structural dynamic model parameters.

(2) Sequoyah Nuclear Power Plant Unit 2, developing seismic acceleration response spectra for diesel generator building, and auxiliary building essential raw cooling water (ERCW) pipe tunnel, performing nonlinear time history seismic response analysis of ERCW cells to determine seismic displacements of the cell for use in assessing the piping stresses.

(3) Watts Bar Nuclear Power Plant Unit 1, developing seismic models and performing SSI analyses of containment reactor building, diesel generator building, new steam valve room, and refueling water storage tank to develop acceleration response spectra, generating synthetic time histories compatible with site-specific ground motion response spectra.

(4) Benicia-Martinez Bridge, performing seismic SSI analyses of as-built and retrofitted caisson deep foundation systems for the bridge's main-span piers to obtain the impedance functions and scattered seismic response motions at the pier caps using the SASSI SSI methodology, and performing the feed-back foundation response analyses to determine the seismic demands on the caissons for use in seismic adequacy evaluation of these pier foundations.

(5) East Bay Municipal Utility District (EBMUD) Mokelumne Aqueduct Seismic Upgrade Study Project, performing seismic soil-structure interaction analyses for the elevated segment/battered-pile foundation systems and the buried underground segment of the aqueduct system.

(6) Richmond-San Rafael Bridge, generating response-spectrum-and-coherency-compatible time histories for multiple pier supports, and developing the equivalent linear impedance functions and scattered response motions at the pilecaps of bridge's pile-group foundation systems for use in super-structural response analyses.

(7) Lafayette Reservoir Outlet Tower, performing seismic analyses of the tower's foundation/ structure/conduits system under the maximum credible earthquake, evaluating structural performance of the tower, and developing seismic upgrade strategies for retrofitting the tower.

(8) San Mateo-Hayward Bridge, conducting soil-structure interaction analyses to determine the foundation impedance functions and scattered foundation input motions at the pilecaps of bridge's pile-group foundation systems.

(9) Posey and Webster Street Tubes Seismic Retrofit Project, developing spatially varying rock motion time histories along the tube, performing calibration of seismic model parameters using the Loma Prieta earthquake recordings, developing soil spring stiffnesses for the tube foundation, and performing seismic analysis and evaluation of retrofitted Alameda Portal building.

(10) Lungmen Nuclear Power Plant Units 1 & 2, conducting site response analyses and soil-structure interaction analyses of Category I nuclear-island structures and major systems.

(11) Valley View Water Storage Reservoir, EBMUD, developing simplified dynamic model of the water-tank-soil-coupled interaction system of existing and retrofitted tanks, performing 3-D finite-element static and dynamic analyses of the tank-foundation system to determine seismic demands on the tanks, and evaluating seismic vulnerabilities of the existing tank.

(12) Taiwan High Speed Rail Project, performing dynamic analysis and evaluation of ground vibrations caused by moving high speed train loads.

Recent Technical Papers **K. Lilhanand**

1. "Development of Power Spectral Density Functions Consistent with Design Response Spectra," (with W. S. Tseng), *Proc.*, 11th International Conference on Structural Mechanics in Reactor Technology (SMiRT-11), Tokyo, Japan, August 1991.

2. "Post-Prediction Analyses and Parametric Studies for the Lotung Soil-Structure Interaction Experiment," (with W. S. Tseng, Y. K. Tang, and H. T. Tang), *Proc.*, 11th International Conference on Structural Mechanics in Reactor Technology (SMiRT-11), Tokyo, Japan, August 1991.

3. "Utilization of Advanced Engineering Theories and Modern Computer Technology for Solving Modern Structural Engineering Problems," Proceeding of Second International Workshop on Advanced Science and Technology Transfer to Thailand, Bangkok, Thailand, August 1992.

4. "Soil-Structure Interaction Analysis Incorporating Three-Dimensional Spatial Incoherency of Ground Motions," (with W. S. Tseng and D. Hamasaki), Proc., 12th International Conference on Structural Mechanics in Reactor Technology (SMiRT-12), Stuttgart, Germany, August 1993.

5. "Development of Multiple-Support Ground Motions for Seismic Vulnerability Evaluations of Major Bridges in Northern California," (with W. S. Tseng, N. A. Abrahamson, and C.-Y. Chang) Proc., 5th U.S. National Conference on Earthquake Engineering, Chicago, July 10-14, 1994.

6. "Seismic Evaluation of Benicia-Martinez Bridge," (with W. D. Liu, W. S. Tseng, C.-Y. Chang, R. A. Imbsen, and F. Li), Proc., 5th U.S. National Conference on Earthquake Engineering, Chicago, July 10-14, 1994.

7. "Generation of Multiple-Station Response-Spectrum-and-Coherency-Compatible Earthquake Ground Motions for Engineering Applications," (with W.S. Tseng, and M.S. Yang), *Proc.*, 12th International Conference on Structural Mechanics in Reactor Technology (SmiRT-12), Stuttgart, Germany, August 1993.

8. "Seismic Response Analysis of Nuclear Power Plant Structures Considering Spatial Incoherency of Ground Motions," (with W. S. Tseng, D. Hamasaki, H. T. Tang, and Y. B. Tsai), Nuclear Science Journal, Vol. 32, No. 2, April 1995.

Resume of
C. Y. Chang

C.-Y. CHANG

Foundation Engineering
Earthquake Engineering
Numerical Analysis and
Computer Applications

EDUCATION

University of California, Berkeley: Ph.D., Geotechnical Engineering, 1969
University of California, Berkeley: M.S., Geotechnical Engineering, 1966
National Cheng-kung University, Taiwan: B.S., Civil Engineering, 1962

REGISTRATION

Civil Engineer: California No. C21708, 1972
Geotechnical Engineer: California No. GE202, 1987

PROFESSIONAL HISTORY

Geomatrix Consultants, Inc., Principal Engineer and Vice President, 1986 to date
Woodward-Clyde Consultants, Senior Project Engineer, 1969-1986
University of California, Berkeley, Research Assistant, 1964-1969
National Cheng-Kung University, Research Engineer, 1963-1964
Republic of China, Chinese Air Force, Civil Engineer, 1962-1963

REPRESENTATIVE SKILLS AND EXPERIENCE

Dr. Chang has 30 years of experience in geotechnical and earthquake engineering. He has been responsible for geotechnical and seismic investigations for highway bridges, dam projects, nuclear power plant sites, high-rise buildings, offshore platforms, and nuclear waste repository facilities. These studies include development of site-specific earthquake ground motions, seismic soil-structure and soil-pile interaction analyses, evaluations of liquefaction potential and consequence of liquefaction, evaluations of foundation capacity and deformations for seismic loading conditions, and evaluations of seismic stability and deformation potential of dams and embankments. Representative project experience includes:

- *Highway Bridges:* Task Leader for seismic ground motion studies conducted for Caltrans for major Northern California bridges, including West San Francisco Bay Bridge, San Mateo-Hayward Bridge, Richmond-San Rafael Bridge, San Joaquin River-Antioch Bridge, Dumbarton Bridge, and Humboldt Bay bridges; seismic ground response studies for the proposed Benecia-Martinez Bridge and Carquinez Bridge; site-specific ground motion studies for the Central Freeway, San Francisco; site-specific ground motion studies and development of soil spring parameters for the 13th Street Bridge, Richmond; Project Manager for geotechnical studies for the seismic retrofit analysis of the 24/580/980 route interchange, Oakland; for the seismic vulnerability

evaluation of the Benecia-Martinez Bridge, Contra Costa-Solano Counties, and the San Mateo-Hayward Bridge, San Mateo County, the West San Francisco Bay Bridge, San Francisco, the Richmond-San Rafael Bridge, Marin-Contra Costa Counties, and the Port Mann Bridge, Vancouver, British Columbia; and for seismic design of the Water Street Bridge in Santa Cruz, California; Project Manager for seismic retrofit design and preparation of PS &E for the Benicia-Martinez Bridge, Richmond-San Rafael Bridge and San Mateo-Hayward Bridge; Geotechnical Task Leader for design and preparation of PS&E for the new Carquinez Strait Suspension Bridge. For these projects, he characterized subsurface soil conditions using available data and developed lateral and axial load-deflection relationships and foundation capacities for pile and caisson groups. For the West San Francisco-Oakland Bay Bridge, he has conducted a series of 3-dimensional soil-structure interaction analyses of caisson foundations to develop foundation stiffness functions and input motions at each pier and anchorages and to evaluate demands on the caisson foundations.

- *Dams:* Responsible for static analyses and involved in seismic analyses of the Aswan High Dam in Egypt in connection with an evaluation of earthquake activity and stability evaluation of the dam. Participated in static and dynamic finite-element analyses and seismic stability evaluations of San Pablo Dam and Seven Oaks Dam, in evaluation of the recorded response of Lexington Dam during various levels of ground shaking, and in a research study on earthquake induced deformations of earth dams. Directed static and seismic stability analyses of the emergency stabilization works and definitive design for an 8-million-cubic yard landslide behind Tablachaca Dam in Peru. The study included extensive subsurface field investigations and remedial treatments of the reservoir sediments.

- *Nuclear Power Plants:* Project Manager and Task Leader of a U.S. Nuclear Regulatory Commission research study on engineering characterization of ground motions for design of nuclear power plant structures. The study included two general considerations: the inelastic response and performance of structures, and spatial variations of ground motion and soil-structure interaction. Performed extensive series of soil-structure analyses of the South Texas and General Electric Standard plants and the General Electric conceptual design. Generated artificial time histories to match the design spectra for the Washington Public Power Supply System Nuclear Power Plant site and the TVA's X24-X25 Nuclear Plant Yellow Creek site in Mississippi. Conducted evaluations of liquefaction potential at the Watts Bar Nuclear Power Plant site, Sequoyah Nuclear Power Plant site, Clinton Nuclear Plant site, and San Onofre Nuclear Plant site. Participated in ground motion characterization for the Diablo Canyon nuclear power plant site.

- *Offshore Platform:* Directed evaluations of liquefaction potential at the Maui B offshore platform site. Directed nonlinear ground response analyses and nonlinear dynamic analyses of soil-pile-structure systems for offshore platforms.

- *Excavations:* Responsible for a U.S. Bureau of Mines research project to develop theoretical methods for evaluating the stability of underground excavations. Directed a series of studies to develop analytical techniques in predicting subsidence due to underground mining, including coal and solution mining.

- *Research:* Directed a research project sponsored by the Electric Power Research Institute to evaluate spatial variations in earthquake ground motion and to validate analytical techniques, including nonlinear and equivalent linear idealization for ground response analysis using data from a downhole array. Directed a National Earthquake Hazard Research Project to evaluate site response at a liquefied site using the Port Island downhole array recordings. Directed a research project to assess seismic response of a caisson foundation of long-span bridges sponsored by the Multidisciplinary Center for Earthquake Engineering Research and the Federal Highway Administration.

HONORS

1977 Woodward-Clyde Consultants Innovative Practice Award

AFFILIATIONS

American Society of Civil Engineers
Earthquake Engineering Research Institute

PUBLICATIONS

Evaluation of site response using downhole array data," with Chin Man Mok, and Z.L. Wang, Procs, ASCE 12th Engineering Mechanics Conference, San Diego, California, May 18-20, 1998.

"Seismic analysis of large caisson foundations for long-span bridges," with Chin Man Mok, Z.L. Wang, H. Gonnermann, M.A. Ketchum, and C.C. Chin, Procs., Sixth U.S. National Conference on Earthquake Engineering, Seattle, Washington, May 31-June 4, 1998.

"Evaluation of lateral load capacity of CISS piles," with Chin Man Mok, Dante Legaspi, Jr., Procs., National Seismic Conference on Bridges and Highways, Sacramento, California, July 8-11, 1997.

"Geotechnical considerations for seismic vulnerability study of Port Mann Bridge," with E. Naesgaard, Z.L. Wang, and D. Sin, National Seismic Conference on Bridges and Highways, San Diego, California, December 10-13, 1995.

"Soil-structure interaction effects for deep foundation systems of long span bridges," with W.S. Tseng, W.D. Lin, and R.R. Donikien, National Seismic Conference on Bridges and Highways, San Diego, California, December 10-13, 1995.

"Inference of dynamic shear modulus from Lotung downhole data," with C.M. Mok and H.-T. Tang, Journal of Geotechnical Engineering, ASCE, Vol. 122, No. 8, August 1996, p. 657-665.

"Evaluation of equivalent linear and nonlinear ground response models using Lotung downhole data," with C.M. Mok and H.-T. Tang, to be re-submitted for possible publication in Journal of Geotechnical Engineering, ASCE, 1995.

"The seismic performance evaluation of major steel bridges in California," with R. Donikian and W.S. Tseng, ASCE Structures Congress XIII, Boston, April 1995.

"Analysis of seismic vertical motion using Lotung Downhole Array data," with C.M. Mok, Y.K. Tang, and H.T. Tang, The Fifth U.S. Conference on Earthquake Engineering, Chicago, Illinois, July 10-14, 1994.

"Seismic evaluation of Benicia-Martinez Bridge," with W.D. Liu, W.S. Tseng, R.A. Imbsen, K. Lilhanand, and F. Li, The Fifth U.S. Conference on Earthquake Engineering, Chicago, Illinois, July 10-14, 1994.

"Technical issues associated with the seismic analysis of the San Mateo-Hayward Bridge," with R. Donikian, M. Tabatabaie, and R. Polivka, The Fifth U.S. Conference on Earthquake Engineering, Chicago, Illinois, July 10-14, 1994.

"Development of multiple-support ground motions for seismic vulnerability evaluations of major bridges in northern California," with W.S. Teng, K. Lilhanand, and N. Abrahamson, The Fifth U.S. Conference on Earthquake Engineering, Chicago, Illinois, July 10-14, 1994.

"Analysis of the recorded response of Lexington Dam during various levels of ground shaking," with F. Makdisi, Z. Wang, and C.M. Mok, The Fifth U.S. Conference on Earthquake Engineering, Chicago, Illinois, July 10-14, 1994.

"Development of earthquake ground motion criteria for northern California bridges using combined deterministic and probabilistic approaches," with M. Power, R. Youngs, K. Sadigh, K. Coppersmith, C. Taylor, J. Penzien, W. Tseng, N. Abrahamson, and J. Gates, The Fifth U.S. Conference on Earthquake Engineering, Chicago, Illinois, July 10-14, 1994.

"Development of seismic ground motions for San Francisco Bay bridges," with M. Power, R. Youngs, K. Sadigh, K. Coppersmith, C. Taylor, J. Penzien, W. Tseng, N. Abrahamson, and J.

Gates, Proceedings, First U.S. Seminar on Seismic Evaluation and Retrofit of Steel Bridges, San Francisco, California, October 18, 1993.

"Specification of long-period ground motions: updated attenuation relationships for rock site conditions and adjustment factors for near-fault effects," with K. Sadigh, N.A. Abrahamson, S.J. Chiou, and M.S. Power, ATC-17-1, Technical Papers on Seismic Isolation, p. 59-70.

"Response spectral relationships for rock, deep-stiff soil and soft soil site conditions," with K. Sadigh, Seismological Research Letters, v. 61, no. 1.

"Analysis of ground response data at Lotung large-scale soil-structure interaction experiment site," with C.M. Mok and M.S. Power, Electric Power Research Institute, Palo Alto, California, Report NP-7306-SL, December 1991.

"The learning from the large-scale Lotung soil-structure interaction experiments," with A.H. Hadjian, W.S. Tseng, D. Anderson, N.C. Tsai, Y.K. Tang, H.T. Tang, and J.C. Stepp, Proceedings of the Second International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, v. III, St. Louis, Missouri, March 11-15, 1991.

"Development of shear modulus reduction curves based on Lotung downhole ground motion data," with C.M. Mok, M.S. Power, Y.K. Tang, H.T. Tang, and J.C. Stepp, Proceedings of the Second International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics, v. I, St. Louis, Missouri, March 11-15, 1991.

"Equivalent linear versus nonlinear ground response analyses at Lotung seismic experiment site," with C.M. Mok, M.S. Power, Y.K. Tang, H.T. Tang and J.C. Stepp, Proceedings of the Fourth U.S. National Conference on Earthquake Engineering, v. 1, Palm Springs, California, May 20-24, 1990.

"Analysis of dynamic lateral earth pressures recorded on Lotung reactor containment model structure," with M.S. Power, C.M. Mok, Y.K. Tang, and H.T. Tang, Proceedings of the Fourth U.S National Conference on Earthquake Engineering, v. 3, Palm Springs, California, May 20-24, 1990.

"Variations of earthquake ground motions with depth and its effect on soil structure interaction," with M. S. Power, W.S. Tseng, and Y.K. Tang, Proceedings of the Second Department of Energy (DOE) Natural Phenomenon Hazards Mitigation Conference, Knoxville, Tennessee, October 3-5, 1989.

"Assessment of theoretical models for ground response using downhole array data," with M.S. Power, Y.K. Tang, and C.M. Mok, Proceedings of the 10th International Conference on

Structural Mechanics in Reactor Technology (SMiRT), Anaheim, California, August 14-18, 1989.

"Evidence of nonlinear soil response during a moderate earthquake," with M.S. Power, Y.K. Tang, and C.M. Mok, Proceedings of Twelfth International Conference on Soil Mechanics and Foundation Engineering, Rio de Janeiro, Brazil, August 13-18, 1989.

"Attenuation relationships for horizontal peak ground acceleration and response spectral accelerations for rock sites," with K. Sadigh, F. Makdisi, and J.A. Egan, Abstract, Seismological Research Letters, v. 60, n. 1 (January-March 1989) p. 19. Victoria, British Columbia; Seismological Society of America Annual Meeting, April, 1989.

"A methodology for assessment of nuclear power plant seismic margin," with R.D. Campbell and others, Electric Power Research Institute, Palo Alto, California, Report NP-6041, October 1988.

"Use of observational data in evaluating theoretical models of ground response," with M.S. Power, Proceedings of the Workshop of Earthquake Ground Motions in the Eastern U.S., March 31 - April 2, 1987, Electric Power Research Institute, Palo Alto, California.

"Ground motion considerations for nuclear power plant design with emphasis on soil-structure interaction aspects," with R.P. Kennedy, Proceedings of the Workshop on Soil-Structure Interaction, June 16-18, 1986, Bethesda, Maryland, NUREG/CP-0054, U.S. Nuclear Regulatory Commission.

"Engineering characterization of ground motion, Task II: Summary report," with M.S. Power and others, Report NUREG/CR-3805, prepared for U.S. Nuclear Regulatory Commission, v. 5, 1986.

"Engineering characterization of ground motion, Task II: Observational data on spatial variations of earthquake ground motion," with M.S. Power and others, Report NUREG/CR-3805, prepared for U.S. Nuclear Regulatory Commission, v. 3, 1986.

"Engineering characterization of ground motion, Task II: Soil-structure interaction effects on structural response," with J.E. Luco and others, Report NUREG/CR-3805, prepared for U.S. Nuclear Regulatory Commission, v. 4, 1986.

"Variation of earthquake ground motion with depth," with M.S. Power and I.M. Idriss, Proceedings of the Third U.S. National Conference on Earthquake Engineering, Charleston, South Carolina, August 1986.

"Empirical data on spatial variations of earthquake ground motion," with M.S. Power, Proceedings of the Second International Conference on Soil Dynamics and Earthquake Engineering, June/July 1985.

"Three-dimensional soil-structure interaction analysis of an offshore gravity platform," with J.E. Luco and others, Proceedings of the Second International Conference on Soil Dynamics and Earthquake Engineering, June/July 1985.

"Earthquake induced deformations of earth dams," with N. Serff, H.B. Seed, and F.I. Makdisi, Earthquake Engineering Research Center Report No. EERC76-4, University of California, Berkeley, September, 1976.

"Finite element methods for the nonlinear and time-dependent analysis of geotechnical problems, with K. Nair and R.D. Singh, Proceedings of ASCE Specialty Conference on Analysis and Design in Geotechnical Engineering, Austin, Texas, 1974.

Resume of
Anwar E. Z. Wissa

ANWAR E. Z. WISSA, Sc.D., P.E.

President/Senior Consultant
Ardaman & Associates, Inc.

EDUCATION:

Bachelor of Arts, Engineering Science, Oxford University, Oxford, England, 1957.

Master of Science, Civil Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1961.

Master of Arts, Oxford University, Oxford, England, 1962.

Doctor of Science, Geotechnical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, 1965.

PROFESSIONAL HISTORY:

1975 to Present	President and Chairman of the Board of Directors Ardaman & Associates, Inc., Orlando, Florida
	Responsible for the overall engineering and business activities of twelve offices in Florida and the Middle East with a staff of over four hundred. International consultant on earthen dams, industrial and mining waste disposal facilities, pavements, soil stabilization, geosynthetics, and construction materials. Guest lecturer at leading universities.
1977 to Present	Director and Senior Consultant Ardaman-ACE, S.A.E., Cairo, Egypt
1961 to Present	Principal and Chairman of the Board of Directors Geotechniques International, Inc., Middleton, Massachusetts
	Responsible for the design and development of geotechnical field instrumentation and specialized soil testing equipment.
1978 to 1983	Director and Senior Consultant, Saudi Geotechnical Services, Ltd., Jubail, Saudi Arabia
1973 to 1975	Senior Vice President and Chief Engineer Ardaman & Associates, Inc., Orlando, Florida
1965 to 1973	Principal Wissa Associates, Marblehead, Massachusetts
	Independent consultant on foundations, pavements, earthen dams, soil stabilization, and construction materials.

1969 to 1972 — Associate Professor of Civil Engineering, Dept. of Civil Engring.
Massachusetts Institute of Technology, Cambridge, Massachusetts

Taught graduate and undergraduate courses and conducted seminars in soil mechanics, soil behavior, pavements, soil stabilization, experimental soil mechanics, and instrumentation. Director of soils research laboratory. Supervised doctoral and master student theses and several $100,000.00 of sponsored research per year on soil behavior, soil stabilization and frost action. Developed and holds a patent on laboratory and field instrumentation.

1965 to 1969 — Assistant Professor of Civil Engineering, Dept. of Civil Engring.
Massachusetts Institute of Technology, Cambridge, Massachusetts

Taught graduate and undergraduate courses in soil stabilization, instrumentation, civil engineering materials, asphalt and Portland cement concrete, soil and materials testing. Director of soil stabilization laboratory. Supervised graduate thesis students and sponsored research in soil stabilization, asphaltic concrete, pavements and experimental soil mechanics.

1962 to 1965 — Instructor of Civil Engineering, Department of Civil Engineering
Massachusetts Institute of Technology, Cambridge, Massachusetts

Taught undergraduate and graduate course in experimental soil mechanics. Supervised research in soil stabilization.

1959 to 1962 — Research Assistant in Soil Engineering, Dept. of Civil Engineering
Massachusetts Institute of Technology, Cambridge, Massachusetts

Conducted research in soil stabilization, soil technology, and soil behavior.

1957 to 1958 — Junior Civil Engineer
Richard Costain, Ltd., London, England

Designed prestress concrete bridge deck, supervised subsurface investigations and worked in soil testing laboratory.

PROFESSIONAL REGISTRATION:

Reg. Professional Engineer, Massachusetts No. 22816.
Reg. Professional Engineer, Florida No. 52326

PROFESSIONAL AFFILIATIONS:

Fellow, American Society of Civil Engineers	Present
Member, Committee on Placement and Improvement of Soil	1969-1978
American Society of Testing and Materials	1966 - present
Member, Committee D-18 on Soil and Rock	
Association of Soil and Foundation Engineers	1978 - present
Boston Society of Civil Engineering	1968 - 1972
Member, Executive Committee, Geotechnical Section	
International Society of Soil Mechanics and Foundation Engineering, Member	1966 - present
Transportation Research Board, Member	1965 - 1994
Member, Committee on Soil-Bituminous Stabilization	1965 - 1978
Chairman, Committee on Soil-Bituminous Stabilization	1966 - 1975
Member, Committee on Soil-Cement Stabilization	1965 - 1975
Member, Committee on Flexible Pavement Design	1970 - 1973
Member, Committee on Soil and Rock Instrumentation	1976 - 1991
Member, Committee on Physicochemical Phenomena in Soils	1982 - 1994
Florida Engineering Society	1974 - Present
National Society of Professional Engineers	1974 - Present
Society of Mining Engineers of AIME	1975 - Present
American Concrete Institute	1985 - 2000
Member, Committee 230, Soil-Cement Stabilization	
Florida Institute of Phosphate Research	1985 - Present
Member, Technical Advisory Committee on Beneficiation	1985 - 1989
Chi Espilon	1965 - Present
Sigma Xi	1965 - Present

ANWAR E. Z. WISSA, Sc.D., P.E. *(continued)*

American Society of Civil Engineers	1985 - Present
National Task Committee on Response to Disaster Situations	1985-1987
International Geosynthetics Society	Present

FOREIGN LANGUAGES:

Arabic and French

PROFESSIONAL PUBLICATIONS:

Author or co-author of over 50 professional papers and publications.

Publications

ANWAR E. Z. WISSA, Sc.D., P.E.

Wissa, A. E. Z. (1963). "Triaxial Equipment and Computer Program for Measuring the Strength Behavior of Stabilized Soils".

Wissa, A. E. Z. and Ladd, C. C. (1964). "Effective Stress-Strength Behavior of Compacted Stabilized Soil".

Wissa, A. E. Z. and Halaby, R. (1964). "Chemical Stabilization of Selected Tropical Soils from Puerto Rico and Panama".

Wissa, A. E. Z. and Ladd, C. C. (1965). "Shear Strength Generation in Stabilized Soils".

Wissa, A. E. Z. (1965). "Preliminary Investigation of the Mechanical Behavior of Idealized Aggregate-Asphalt Composites".

Wissa, A. E. Z., Lambe, T. W., and Ladd, C. C. (1965). "Effective Stress Strength Parameters of Stabilized Soil", 6th International Conference on Soil Mechanics and Foundation Engineering, Montreal.

Wissa, A. E. Z., Moavensadeh, F., and Williamson, R. B. (1966). "Rock Fracture Research".

Wissa, A. E. Z. and Blouin, S. E. (1967). "Report on the Influence of Asphalt Properties on the Behavior of Bituminous Concrete".

Wissa, A. E. Z. and Ho, K. N. (1967). "Up-grading of Marginal Granular Materials for Highway Construction".

Wissa, A. E. Z. and Martin, R. T. (1968). "Development of Rapid Frost Susceptibility Tests".

Wissa, A. E. Z. and Monti, R. P. (1968). "Compressibility-Permeability Behavior of Untreated and Cement Stabilized Clayey Silt".

Wissa, A. E. Z., Blouin, S. E. (1968). "Strength Behavior of Selected Asphalt Aggregate Systems in Triaxial Compression", presented at the 47th Annual Meeting, Highway Research Board, Washington, D.C., Highway Research Record No. 256.

Wissa, A. E. Z. (1969). "Pore Pressure Measurement in Stiff Soils", American Society of Civil Engineers, Journal of Soil Mechanics and Foundations Division, Vol. 95, SM4.

Wissa, A. E. Z. and Heiberg, S. (1969). "A One-Dimensional Consolidation Test".

Wissa, A. E. Z. and Paniagua, J. G. (1969). "A Durability Test for Stabilized Soils".

Wissa, A. E. Z., Feferbaum-Zyto, S., and Paniagua, J. G. (1969). "Effect of Molding Conditions on the Effective Stress-Strength Behavior of a Stabilized Clayey Silt".

Wissa, A. E. Z. (1969). "Discussion on Roads and Pavements", presented at Specialty Session 18, Proceedings of 7th International Conference on Soil Mechanics and Foundation Engineering, Vol. 3, pp. 550, Mexico City.

Wissa, A. E. Z. (1969). "A New One-Dimensional Consolidation Test", presented at Specialty Session 16, Proceedings of 7th International Conference on Soil Mechanics and Foundation Engineering, Vol. 3, pp. 524, Mexico City.

Wissa, A. E. Z. (1969). "Discussion on Pore Pressure Response", presented at Specialty Session 4, Proceedings of 7th International Conference on Soil Mechanics and Foundation Engineering, Vol. 3, pp 438-439, Mexico City.

Wissa, A. E. Z. (1969). "Discussion on Pore Pressure Measurements in the Laboratory", written discussion, Specialty Session 4, Proceedings of 7th International Conference on Soil Mechanics and Foundation Engineering, Vol. 3, pp. 440-441, Mexico City.

Wissa, A. E. Z. and Ladd, C. C. (1970). "Geology and Engineering Properties of Connecticut Valley Varved Clays with Special Reference to Embankment Construction".

Wissa, A. E. Z., Christian, J. T., Davis, E. H., and Heiberg, S. (1971). "Consolidation at Constant Rate of Strain", Journal of Soil Mechanics and Foundation Division, ASCE, Vol. 97, No. SM10, pp. 1393-1413.

Wissa, A. E. Z., McGillivray, R. T., and Paniaqua, J. G. (1971). "The Effect of Mixing Conditions, Method of Compaction and Curing Conditions on the Effective Stress-Strength Behavior of a Stabilized Soil".

Wissa, A. E. Z. and Garcia, L. O. (1972). "Marshall Tests of Bituminous Concrete Mixes".

Wissa, A. E. Z. and Martin, R. T. (1972). "Operation Manual for Permeability Systems".

Wissa, A. E. Z. and Paniagua, J. G. (1972). "Equipment for Studying the Effect of Repeated Loading on the Stress-Strength Behavior of Stabilized Soils".

Wissa, A. E. Z., Martin, R. T., and Koutsoftas, D. (1972). "Equipment for Measuring the Water Permeability as a Function of Degree of Saturation for Frost Susceptible Soils".

Wissa, A. E. Z. and Martin,R. T. (1973). "Frost Susceptibility of Massachusetts Soils-Evaluation of Rapid Frost Susceptibility Tests".

Wissa, A. E. Z. and Garcia, L. O. (1973). "Statistical Evaluation of the Marshall Test for Bituminous Concrete".

Wissa, A. E. Z., Krizek, R. J., Farzin, N. H. and Martin, R. T. (1974). "Evaluation of Stress Cell Performance", Journal of Geotechnical Engineering Division, ASCE, Vol. 100, No. GT12, pp. 1275-1295.

Wissa, A. E. Z., Olsen, J. M., and Martin, R. T. (1974). "Use of the Freezing Soil Heave Stress to Evaluate Frost Susceptibility of Soils".

Wissa, A. E. Z., Suh, N. P., Martin, R. T., and Fuleihan, N. F. (1974). "New Concepts in Soil Stabilization Mixing", TR-74-114, AD-A007-887, U.S. Air Force, Kirtland Base, New Mexico.

Wissa, A. E. Z. (1974). "Gypsum Stacks", Canadian Phosphate Producers, Montreal, Canada.

Wissa, A. E. Z., Martin, R. T., and Garlanger, J. E., (1975). "The Piezometer Probe", Proceedings of the Conference on In-situ Measurement of Soil Properties, Specialty Conference of the Geotechnical Engineering Division, ASCE, North Carolina State University, pp. 536-545.

Wissa, A. E. Z. (1975). "Design of Secondary Pavement Systems", Engineering Laboratories Forum, Florida Engineering Society, Orlando.

Wissa, A. E. Z., Martin, R. T., Garlanger, J. E. (1975). "The Piezometer Probe," Proceedings of the Conference on In-Situ Measurement of Soil Properties, ASCE, Volume I, pp. 536-545.

Wissa, A. E. Z. (1976). "Industrial and Chemical Wastes", University of California, Berkeley, California.

Wissa, A. E. Z. (1977). "Gypsum Stacking Technology", Clearwater, Florida, American Institute of Chemical Engineers, 1977 Annual Technical Meeting.

Wissa, A. E. Z. (1978). "Environmental Engineering of Gypsum Stacking", 85th National Meeting, American Institute of Chemical Engineers, Pennsylvania.

Wissa, A. E. Z. and Palm, Gordon F. (1978). "Environmental Aspects of Waste Disposal in the Phosphate Industry", Proceedings 1978 Environmental Symposium, New Orleans, Louisiana, The Fertilizer Institute.

Wissa, A. E. Z. and Fuleihan, N. F. (1980). "Critique of Proposed Phosphate Industry Waste Storage Regulations", Proceedings 1980 Environmental Symposium, New Orleans, Louisiana, sponsored by The Fertilizer Institute, Washington, D.C.

Wissa, A. E. Z. and Fuleihan, N. F. (1980). "Control of Groundwater Contamination from Phosphogypsum Disposal Sites", 1980 International Symposium on Phosphogypsum, Lake Buena Vista, Florida, sponsored by the Florida Institute of Phosphate Research, Bartow, Florida.

Wissa, A. E. Z. and Fuleihan, N. F. (1981). "Control of Groundwater Pollution from Phosphoric Acid Waste Gypsum Stacks", Proceedings 1981 Annual Meeting, American Institute of Chemical Engineers, Presented at Session on Phosphoric and Sulfuric Acid Pollution Abatement, New Orleans, Louisiana.

Fuleihan, N. F. and Wissa, A. E. Z. (1983). "Piezocone Testing, Research, Theory and Applications", Presented at New Methods in In-Situ Testing Workshop/Seminar, University of Florida, Gainesville, Florida.

Wissa, A. E. Z., Fuleihan, N. F. and Ingra, T. S. (1983). "Evaluation of Phosphatic Clay Disposal and Reclamation Methods", Florida Institue of Phosphate Research, Research Project 80-02-002.

Wissa, A. E. Z. and Garlanger, J. E. (1984). "Impact of Dam Failures on Safety Regulations", 1984 ASCE Convention, Atlanta, Georgia.

Wissa, A. E. Z. (1985). Recent Developments in Measurement and Modeling of Clay Behavior for Foundation Design, M.I.T. Conference, Chairman of Panel on Geotechnical Instrumentation and Testing

Wissa, A. E. Z., Garlanger, J. E. and Ingra, T. (1985) "Engineering Properties of of Phosphogypsum as they relate to Design, Operation & Reclamation of Gypsum Stacks", 3rd Seminar on Phosphogypsum, Fla. Inst. of Phosphate Research)

Wissa, A. E. Z., Fuleihan, Nadim F., (1986) "Impacts of Phosphogypsum Stack Management on Process Water Balance", 1986 Spring National Meeting and Petrochemical and Refining Exposition - American Institute of Chemical Engineers

Wissa, A. E. Z., Fuleihan, Nadim F., Ingra, Thomas S., (1986) "Implications of Phosphogypsum Engineering Properties on Gypsum Stack Management and Reclamation", Second International Symposium on Phosphogypsum - University of Miami, Phosphate Research Institute.

Wissa, A. E. Z., (1989). "Synthetic Liners; An Engineers Perspective", Presented at University of Florida Short Course titled " Design Construction and Performance of Liner Systems for Environmental Protection", TREEO Center, Gainesville, Florida.

Wissa, A. E. Z., (1989). "Liner Case Histories", Presented at University of Florida Short Course titled "Design Construction and Performance of Liner Systems for Environmental Protection", TREEO Center, Gainesville, Florida.

Fuleihan, N. F. and Wissa, A.E.Z. (1992). "Design and Reclamation of Phosphogypsum Disposal Sites", Presented at the 1992 AIChE Spring National Meeting, Symposium on Advances in Phosphate Fertilizer Technology, Environmental Session, New Orleans, Louisiana

Wissa, A. E. Z., (1993). "Closure and Long Term Care Overview of Florida Rules (Effective January 6, 1993)", Presented at University of Florida TREEO Center Landfill Series titled "Landfill Design: Closure and Long Term Care", Orlando, Florida

Publications (continued)

ANWAR E. Z. WISSA, SC.D., P.E.

Wissa, A. E. Z., (1993). "Synthetic Liners - Construction and QA/QC", Presented at University of Florida TREEO Center Landfill Series titled "Landfill Design: Closure and Long Term Care", Orlando, Florida

Wissa, A. E. Z., (1993). "Selection and Design of Landfill Closure Covers", Presented at University of Florida TREEO Center Landfill Series titled "Landfill Design: Closure and Long Term Care", Orlando, Florida

Wissa, A. E. Z., (1994). "Synthetic Liners - Construction and QA/QC", Presented at University of Florida TREEO Center Landfill Series titled "Landfill Design: Closure and Long Term Care", Orlando, Florida

Wissa, A. E. Z., (1994). "Selection and Design of Landfill Closure Covers", Presented at University of Florida TREEO Center Landfill Series titled "Landfill Design: Closure and Long Term Care", Orlando, Florida

Wissa, A. E. Z., (1994). "Landfill Liners - Facts and Fallacies", Presented at "The Robert V. Whitman Symposium: The Earth, Engineers and Education", Massachusetts Institute of Technology, Cambridge, Massachusetts

Wissa, A. E. Z., (1999). "Phosphogypsum Disposal and the Environment", Presented at "International Environmental Workshop", Prague, Czech Republic, International Fertilizer Development Center, Muscle Shoals, Alabama.

Wissa, A. E. Z. and Fuleihan, N. F. (1999). "Phosphogypsum Stacks and Groundwater Protection", Proceedings of 12th International Technical Conference. Sponsored by the Arab Fertilizer Association, October 5-8, 1999, Casablanca, Morocco.

Wissa, A. E. Z. and Fuleihan, N.F. (2000). "Protection of Water Resources Using Natural and Synthetic Liners", Presented at Fourth International Geotechnical Engineering Conference, Cairo University, January 26, 2000, Cairo, Egypt.

Wissa, A.E.Z, Fuleihan, N.F., and Leto, T.J. (2000). "Inspection and Maintenance of Earthen Dikes and Phosphogypsum Stacks", Presented at Fourth Annual Florida Phosphate Council Training Course February 23, 2000, Lakeland, Florida.

Book Reviews

The Penetrometer and Soil Exploration by G. Sanglerat, Elsevier, Amsterdam, 1972, Geoderma, 1975.

Resume of
Paul J. Trudeau

Paul J. Trudeau

Senior Lead Engineer

Years Experience (as of December 1998)

At Stone & Webster: 26 With other Firms: 0

Department/Division/Location

Geotechnical/Division 50/Boston

Professional History

Stone & Webster Engineering Corporation, Boston, Massachusetts - 1973 to Present
Massachusetts Institute of Technology - Cambridge, Massachusetts - 1971 to 1973
Stone & Webster Engineering Corporation, Boston, Massachusetts - 1971 to 1972
Worcester Polytechnic Institute, Worcester, Massachusetts - 1967 to 1971

Areas of Expertise

- Geotechnical Engineering And Design
- Use of Computers In Geotechnical Analyses and Designs
- Managing Geotechnical Investigations
- Geotechnical Instrumentation
- Performing Cross-Hole Shear Wave Velocity Surveys
- Regulatory Compliance, Review, and Implementation (NRC)

Awards

Desmond Fitzgerald Medal awarded by the Boston Society of Civil Engineers for "Shear Wave Velocity and Modulus of a Marine Clay," Journal of the Boston Society of Civil Engineers, January 1974.

Computer Hardware/Software Capabilities

Mr. Trudeau has considerable experience with PC and mainframe computer programs for performing geotechnical analyses. He is expert in developing spreadsheets using Microsoft Excel and Lotus for solving complex engineering calculations and also is an expert FORTRAN programmer and in programming IBM JCL. He also has considerable experience in using MicroStation for generating report-quality sketches and figures and in using InRoads for plotting contours and determining earthwork quantities.

He is adept at developing batch programs, as well as programming in dBASE, AWK, perl, and developing shell scripts in Unix. He routinely uses these techniques for automatic placement of graphics at correct locations and scales in MicroStation design files for generation of geotechnical figures, such as boring location plans, subsurface profiles, contour maps, and other figures for reports.

Department/Division Assignments

Division Computer Coordinator

Training

40 hours of instruction in Waste Site Worker Protection and 8 hours of instruction in Supervisory Training to comply with OSHA 1910.120(e)(2&3)

Experience Summary

Mr. Trudeau has over 26 years of experience in the engineering industry. Currently, as a Senior Lead Engineer in the Geotechnical Division of Stone & Webster Engineering Corporation, he is designated as the Division Computer Coordinator and as the Division Specialist in cross-hole seismic velocity surveys. As Computer Coordinator, he is responsible for the development, documentation, and maintenance of more than 80 computer programs sponsored by the Geotechnical Division and for providing consulting for Geotechnical Division computer applications. As the Division Specialist in cross-hole seismic velocity surveys, he is responsible for performing the field testing and interpreting the data for use in static and dynamic analyses.

Since joining Stone & Webster Engineering Corporation in 1973, he has served as a Lead Geotechnical Engineer on numerous fossil power plants, Independent Spent Fuel Storage Installations (ISFSI) at Private Fuel Storage Facility in Skull Valley, UT and at Maine Yankee's nuclear plant in Wiscasset, ME, the Bellefonte Nuclear Plant, the Shoreham Nuclear Power Plant, the Falcon Seaboard Gas Pipeline, the TVA Widows Creek Steam Plant, and various projects at the Hanscom Air Force Base. He has also served as a Support Engineer on several nuclear and fossil power plant projects. In these roles, he was responsible for performing geotechnical investigations, preparing geotechnical analyses, developing geotechnical design criteria for other disciplines, such as Structural, Environmental, Engineering Mechanics, and Electrical, and for preparing geotechnical sections of Preliminary and Final Safety Analyses Reports and Environmental Reports. This work was performed in accordance with quality assurance programs that satisfied the quality assurance requirements of Appendix B of 10CFR Part 50 and NQA-1.

He was also responsible for reviewing geotechnical analyses and reports prepared by others on these projects, and for preparing testimony and for testifying at public hearings. He has also completed 40 hours of instruction in Waste Site Worker Protection and 8 hours of instruction in Supervisory Training to comply with OSHA 1910.120(e)(2&3) and is certified to work on hazardous waste sites.

Mr. Trudeau's field experience includes performing cross-hole shear wave velocity tests in Maine, Connecticut, and Texas, geotechnical boring supervision at Jamesport, Shoreham, and Shoreham West on Long Island in New York and at Wards Island in New York, New York, and a compaction control investigation and intake canal revetment repair at Shoreham Unit No. 1. He has performed inspections of the haul road for transport of 300-ton steam generators at the North Anna Nuclear Power Station in Virginia, and has inspected the route proposed by Chem-Nuclear for transport of the 800-ton reactor pressure vessel from the Shoreham Nuclear Power Station to their disposal facility in Barnwell, South Carolina. In addition, he has served as Lead Scientist/Field Supervisor of environmental borings that were drilled for site assessment studies performed for New York City Department of Environmental Protection at their Jamaica, Wards Island, and 26th Ward water pollution control plants.

Mr. Trudeau's laboratory experience includes performing index property tests, consolidation tests, Hardin Oscillator tests, and static and dynamic triaxial tests. He was instrumental in selection, installation, and testing and debugging of Stone & Webster's Geotechnical laboratory data acquisition system. His educational experience encompasses many aspects of civil engineering, including soil mechanics and foundations, computer programming (FORTRAN), soil dynamics, earthquake engineering, geotextiles, and structures.

Education

Master of Science in Civil Engineering, MIT, Cambridge, Massachusetts - 1973
B.S. in Civil Engineering, Worcester Polytechnic Institute, Worcester, Massachusetts - 1971

Licenses, Registrations, and Certifications

Professional Engineer - Massachusetts - 1977

Professional Affiliations

Chi Epsilon: Member - 1969
American Society of Civil Engineers: Member 1971
Boston Society of Civil Engineers Section/ASCE: Member 1971
International Society of Soil Mechanics and Foundation Engineering: Member 1974

BSCES Director
BSCES Awards Committee - Chairman
BSCES Student Chapter Committee - Chairman
BSCES Membership Committee - Member
BSCES Task Force for Younger Members - Member
ASCE National Convention Attendance Committee - Co-Chairman
BSCES Geotechnical Engineering Practice Lecture Series Committee - Member

Publications

Trudeau, P.J., Whitman, R.V., and Christian, J.T., "Shear Wave Velocity and Modulus of a Marine Clay," Journal of the Boston Society of Civil Engineers, January 1974.

Pierce, D.S., and Trudeau, P.J., "Digital and Analog Methods for the Development of Stereoscopic Contour Maps for Geological and Geophysical Analysis," Geological Society of America Abstracts with Programs, Vol. 10, No. 7, 1978.

Experience History

STONE & WEBSTER ENGINEERING CORPORATION, BOSTON, MASSACHUSETTS - 1973 TO PRESENT

Geotechnical Division (Apr 1977 to Present)
Computer Coordinator

Independent Spent Fuel Storage Installation (Sept 1998 to Present)
Maine Yankee Atomic Power Company – Wiscasset, ME
Lead Geotechnical Engineer

VX Full Scale Plant (Mar 1998 to Present)
U.S. Army Program Manager for Chemical Demilitarization, Aberdeen, Maryland
Lead Geotechnical Engineer

Combined-Cycle Power Plant (Feb 1998 to Present)
EMI, Rumford, ME and Tiverton, RI
Lead Geotechnical Engineer

Private Fuel Storage Facility – Skull Valley, UT (Dec 1997 to Present)
Private Fuel Storage, Limited Liability Corporation
Lead Geotechnical Engineer

VX Full Scale Plant (April 1997 to Present)
U.S. Army Program Manager for Chemical Demilitarization, Newport, IN
Lead Geotechnical Engineer

Mystic, Edgar, and Medway Combined Cycle Power Plants (Mar 1998 to Dec 1998)
Sithe Energies, Inc
Geotechnical Engineer

Terminal A Area 8 (Mar 1998 to Oct 1998)
MASSPORT
Geotechnical Engineer

Tapoco Developments (Dec 1997 & July/Aug 1998)
Santeetlah Dam
Geotechnical Engineer

Tapoco Developments (Aug 1997 to Sept 1997)
Cheoah Dam

Big Brown Steam Electric Station, Fairfield, TX (July 1997 to Nov 1998)
TU Electric Company
Geotechnical Engineer

Building 99 Fuel Oil Storage Facility (June 1997 to Aug 1997)
GE River Works Plant – Lynn, MA
Geotechnical Engineer

Private Fuel Storage Facility – Skull Valley, UT (Jan 1997 to Oct 1997)
Private Fuel Storage, Limited Liability Corporation
Geotechnical Engineer

Building 66 G & L G60TX Foundation (Dec 1996 to Jan 1997)
GE River Works Plant – Lynn, MA
Geotechnical Engineer

Tapoco Developments (Nov 1996 to Feb 1997)
Calderwood Dam
Geotechnical Engineer

19th St Substation (Oct 1996 to Jan 1998)
Potomac Electric Power Co, Washington, D. C.
Geotechnical Engineer

Boston Ramps (Feb 1996 to Dec 1996)
Massachusetts Turnpike Authority
Geotechnical Engineer

Goodhue County Independent Spent Fuel Storage Installation (Dec 1995 to Sept 1996)
Northern States Power Company
Geotechnical Engineer

Central Artery/Third Harbor Tunnel Project (Feb 1994 to January 1997)
Mass. Department of Public Works
Manager of Computer Services

Bellefonte Nuclear Plant (Oct 1993 to Mar 1994)
Tennessee Valley Authority
Lead Geotechnical Engineer

Chubb & Son, Incorporated (Sept 1993 to Jan 1994)
Geotechnical Consultant

Granite State Gas Transmission Company (Nov 1993)

Petersburg Generating Station (July 1993 to Sept 1993)
Indianapolis Power and Light Company

Pease Air Force Base (Aug 1993)
United States Air Force
Geotechnical Engineer

Green Mountain Power Corporation (July 1993)
Geotechnical Engineer

E. W. Stout Generating Station (July 1993)
Indianapolis Power and Light Company
Geotechnical Engineer

Hanscom Air Force Base (Apr 1993 to July 1993)
United States Air Force
Lead Geotechnical Engineer

Portland Natural Gas Transmission System (Nov 1992 to Apr 1993)

Maine Low-Level Radioactive Waste Authority (Oct 1992 to May 1993)
Geotechnical Engineer

Afobaka Dam (Oct 1992 to Jan 1993)
Suriname Aluminum Company
Geotechnical Engineer

Widows Creek (Sept 1992 to Feb 1993)
Tennessee Valley Authority
Lead Geotechnical Engineer

General Support Services Contract, Richland Field Office (Sept 1992 to Oct 1992)
U. S. Department of Energy

Patriot Generating Station (June 1992 to Aug 1992)
Indianapolis Power and Light Company
Geotechnical Engineer

Bellefonte Nuclear Plant (Feb 1992 to July 1992)
Tennessee Valley Authority
Lead Geotechnical Engineer

Central Artery/Third Harbor Tunnel Project (Mar 1990 to Feb 1992)
Mass. Department of Public Works
Manager of Computer Services

Petersburg Generating Station (Nov 1991 to Jan 1992)
Indianapolis Power and Light Company
Geotechnical Engineer

Petersburg Generating Station (Sept 1991 to May 1992)
Indianapolis Power and Light Company
Geotechnical Engineer

New Production Reactor (Sept 1991 to Oct 1991)
US Department of Energy
Geotechnical Engineer

New Production Reactor (Feb 1991 to May 1991)
US Department of Energy
Geotechnical Engineer

Widows Creek Steam Plant - Unit 8 (Feb 1991 to June 1991)
Tennessee Valley Authority
Lead Geotechnical Engineer

North Anna Nuclear Power Station (Sept 1991)
Virginia Power Company
Geotechnical Engineer

EG & G Rocky Flats (Sept 1991)
US Department of Energy
Geotechnical Engineer

Hanscom Air Force Base (Jan l991 to Feb l991)
United States Air Force
Lead Geotechnical Engineer

Hanscom Air Force Base (Jan 1990)
United States Air Force
Lead Geotechnical Engineer

Sludge Management Project (Sept 1989 to July 1990)
New York City Department of Environmental Protection
Geotechnical Engineer / Geotechnical Field Inspector / Lead Scientist/Field Supervisor

Plattsburgh 12 In. Diameter Gas Pipeline (Feb 1989 to Apr 1990)
Falcon Seaboard Pipeline Company
Lead Geotechnical Engineer

Great Northern Paper Company (Feb 1989 to May 1989)
Geotechnical Engineer

Shoreham Nuclear Power Station - Unit No. 1 (Jan 1983 to Mar 1992)
Long Island Lighting Company
Lead Geotechnical Engineer

Office of Nuclear Waste Isolation (ONWI) of Battelle Memorial Institute (Jan 1982 to Oct 1987)
U.S. Department of Energy
Geotechnical Computer Consultant

Bradley Lake Project (Feb 1986 to Oct 1986)
Alaska Power Authority
Geotechnical Engineer

Salt Cave Hydroelectric Project (Apr 1986 to May 1986)
City of Klamath Falls, Oregon
Geotechnical Engineer

Beaver Valley Power Station - Unit 2 (Oct 1984 to Aug 1985)
Duquesne Light Company
Geotechnical Engineer

Malakoff Site (Apr 1982 to Dec 1982)
Houston Lighting & Power Company
Geotechnical Engineer

Site X (Aug 1981 to Dec 1981)
Houston Lighting & Power Company
Geotechnical Engineer

Patriot Station (May 1981 to July 1981)
Indiana Power and Light Company
Geotechnical Computer Consultant

Site X (May 1981 to July 1981)
Houston Power and Light Company
Geotechnical Computer Consultant

Site X (Mar 1981 to May 1981)
Houston Lighting & Power Company
Geotechnical Engineer

Western Fuels Association. Inc. (Dec 1980)
Geotechnical Computer Consultant

Patriot Station (Nov 1980 to Dec 1980)
Indiana Power and Light Company
Geotechnical Computer Consultant

Site X (Oct 1980)
Houston Lighting & Power Company
Geotechnical Engineer

Pumped Storage Project (Apr 1980 to July 1980)
Public Service Company of New Mexico
Geotechnical Computer Consultant

Beaver Valley Power Station - Unit No. 2 (Feb 1980 to Mar 1980)
Duquesne Light Company
Geotechnical Computer Consultant

Millstone Unit No. 3 (Feb 1980)
Northeast Utilities Service Company
Geotechnical Engineer

Martin Cooling Dike (Jan 1980)
Florida Power and Light Company
Geotechnical Engineer

Beaver Valley Power Station - Unit No. 1 (Mar 1970 to May 1979)
Duquesne Light Company
Geotechnical Computer Consultant

Haven Nuclear Power Station (Dec 1978 to Jan 1979)
Wisconsin Electric Power Company
Geotechnical Engineer

Office of Nuclear Waste Isolation (ONWI) of Battelle Memorial Institute (Sept 1978 to Nov 1979)
U.S. Department of Energy
Geotechnical Computer Consultant

Stuyvesant & New Haven Sites (Apr 1978 to Sept 1978)
New York State Electric and Gas Corp.
Geotechnical Computer Consultant

Sundesert 500 kV Transmission and Substation Project (Aug 1977 to Dec 1977)
San Diego Gas and Electric Company
Geotechnical Computer Consultant

Jamesport Nuclear Power Station (July 1976 to Apr 1977)
Long Island Lighting Company
Geotechnical Engineer

Shoreham Unit No. 1 (Feb 1976 to June 1976)
Long Island Lighting Company
Geotechnical Engineer

Jamesport Nuclear Power Station (Feb 1975 to Jan 1976)
Long Island Lighting Company
Geotechnical Engineer

Shoreham Unit No. 1 (Sept 1974 to Jan 1975)
Long Island Lighting Company
Geotechnical Engineer

Shoreham Unit No. 1 (June 1974 to Aug 1974)
Long Island Lighting Company
Geotechnical Engineer

Jamesport Nuclear Power Station (Mar 1974 to June 1974)
Long Island Lighting Company
Geotechnical Engineer

Shoreham Unit No. 1 (Oct 1973 to Apr 1974)
Long Island Lighting Company
Geotechnical Engineer

Jamesport and Shoreham West (Sept 1973)
Long Island Lighting Company
Geotechnical Engineer

Northfield Mountain Pumped Storage Project (Aug 1973 to Oct 1973)
Northeast Utilities Service Company
Geotechnical Engineer

Jamesport Nuclear Power Station (Aug 1973)
Long Island Lighting Company
Geotechnical Engineer

Geotechnical Division Computer Coordinator (Mar 1973 to Nov 1973)

North Anna Power Station (Feb 1973)
Virginia Electric and Power Company
Geotechnical Engineer

Massachusetts Institute of Technology - Cambridge, Massachusetts - 1971 to 1973
Graduate Research Assistant

Resume of
Robert R. Youngs

ROBERT R. YOUNGS

PRINCIPAL ENGINEER

EDUCATION

University of California: Ph.D., Geotechnical Engineering, 1982

University of California: M.S., Geotechnical Engineering, 1973

California State Polytechnical University, Pomona: B.S., Civil Engineering, 1969

REGISTRATION

Geotechnical Engineer, California No. 924, 1987
Civil Engineer, California No. 22519, 1973

AFFILIATIONS

American Society of Civil Engineers
American Geophysical Union
Earthquake Engineering Research Institute
Seismological Society of America
Society for Risk Assessment

SKILLS AND EXPERIENCE

Dr. Youngs has 24 years of consulting experience, with primary emphasis in hazard analysis. He has pioneered approaches for incorporating earth sciences data, and their associated uncertainties, into probabilistic hazard analyses; The work has focused on developing quantitative evaluations of hazard by combining statistical data and expert judgment. Within Geomatrix's Decision Analysis (DA) operating unit, Dr. Youngs has helped develop capabilities that integrate the fields of earth sciences, hazard analysis, and risk assessment. Representative project experience includes:

Regional Seismic Hazard Mapping/Microzonation Studies: Ech Cheliff Region, Algeria; San Juan Province, Argentina, PG&E; Mendoza Province, Argentina; Seismic Design Mapping Project, State of Oregon, Oregon Department of Transportation

Seismic Source/Ground Motion Characterization for Hazard Analysis: Diablo Canyon Power Plant, PG&E; WNP-2 Hanford Power Plant, WPPSS; Hanford Reservation, Westinghouse Hanford Co.; Palo Verde Nuclear Generating Station, Arizona Power; Yucca Mountain Nuclear Waste Repository Site, U.S. Department of Energy

Development of Hazard Methodologies/Uncertainty Treatment: Seismic Hazard in the Eastern United States, Electric Power Research Institute (EPRI); Maximum Earthquakes in Eastern United States, EPRI; Expert Elicitation Methodology Demonstration for Yucca Mountain Performance Assessment, EPRI; Characterization of seismic hazard in Southern Ontario, Atomic Energy Control Board, Canada

Hazard Analyses for Performance Assessment of Built Structures: seismic hazard at San Francisco-Bay Area bridges, California Department of Transportation (CDOT); seismic hazard at Humboldt Bay bridges, CDOT ; seismic hazard and site response studies for K-reactor, Westinghouse Savannah River Co.; seismic hazard analysis for operating nuclear power plants in Spain, Westinghouse Energy Systems Europe; seismic hazard analysis and development of earthquake ground motions for Blue River Dam, Oregon, USACOE.

Hazard Analyses for Development of Design Criteria: Seismic hazard assessment for the New Production Reactor at Savannah River Site and Idaho National Engineering Laboratory (DOE); WNP-1, 2,4 Hanford and WNP-3, 5 Satsop, WPPSS; Potential High-Level Radioactive Waste Repository Site, Yucca Mountain, DOE; Waste Tank Sites at Hanford, Washington, Westinghouse Hanford Co.

Performance Assessment of Natural Systems: Demonstration of risk-based total system performance assessment, EPRI, DOE; Earthquakes/tectonics expert elicitation project, EPRI; Probabilistic volcanic hazard analysis, Yucca Mountain, TRW and DOE; Fault displacement hazard analysis for Yucca Mountain, USGS, DOE

ROBERT R. YOUNGS
PRINCIPAL ENGINEER

PUBLICATIONS

"Strong ground motion attenuation relationships for subduction zone earthquakes." Youngs, R.R., Chiou, S.J., Silva, W., and Humphrey, J.: Seismological Research Letters, v. 68, n. 1. January/February 1997.

"Seismic hazard mapping for highway design in the state of Oregon." Youngs, R.R.: Proceedings, Design of Highway Bridges for Extreme Events, Federal Highway Administration, Atlanta, Georgia. December 1996.

"Regional probabilistic seismic hazard mapping with uncertainty: An example from the state of Oregon, USA." Youngs, R.R., Coppersmith, K.J., Hanson, K., DiSilvestro, L., and Wells, D.: Fifth International Conference on Seismic Zonation, Nice, France. October 17-18, 1995.

"Earthquake ground shaking hazard in Utah." Proceedings, Earthquake Engineering Research Institute Wasatch Front Seismic Risk Regional Seminar, v. 1, Salt Lake City, Utah. November 29-30, 1994.

"Magnitude dependent variance of peak ground acceleration." Youngs, R.R., Abrahamson, N., Makdisi, F., and Sadigh, K.: Bulletin, Seismological Society of America, accepted for publication. 1994.

"Computer applications in geotechnical earthquake engineering." Chang, C.-Y., and others: Geotechnical News, v. 12, n. 2, p. 36-38. June 1994.

"Specification of ground motions and response spectra for seismic evaluation of nuclear power plants." Youngs, R.R.: Proceedings, Fourth Symposium on Current Issues Related to Nuclear Power Plant Structures, Equipment, and Piping, Orlando, Florida. December 1993.

"Assessing fault rupture hazard for the proposed repository at Yucca Mountain, Nevada: Demonstration of a methodology using expert judgments." Perman, R.C., Coppersmith, K.J., Youngs, R.R., and Shaw, R.: Proceedings, Fourth Annual International Conference on High Level Radioactive Waste Management, v. 1, p. 2086-2091. 1993.

"Preliminary assessment of fault rupture hazard at the Yucca Mountain site based on expert judgment." Coppersmith, K.J., Youngs, R.R., Perman, R., and Shaw, R.: Proceedings, Fourth Annual International Conference on High Level Radioactive Waste Management, v. 1, p. 6-13. 1993.

"A comprehensive seismic hazard model for the San Francisco bay region." Youngs, R.R., Coppersmith, K.J., Taylor, C., Power, M.S., Di Silvestro, L., Angell, M., Hall, T., Wesling, J., Mualchin, L.: Proceedings, Second Conference on Earthquake Hazards in the Eastern San Francisco Bay Area, California Division of Mines and Geology Special Publication 113, p. 431-441. 1992.

"A stable algorithm for regression analyses using the random effects model." Abrahamson, N.A., and Youngs, R.R.,: Bulletin, Seismological Society of America, v. 82, n.1, p. 505-510. 1992.

PUBLICATIONS (continued)

"Modeling fault rupture hazard for the proposed repository at Yucca Mountain, Nevada." Coppersmith, K.J., Youngs, R.R.: Proceedings, 1992 International High Level Radioactive Waste Management Conference, v. 1, p. 1142-1150. 1992.

"Site specific ground motion assessment for K-Reactor, Savannah River Site." Coppersmith, K.J., and others: Proceedings, Third Department of Energy Natural Phenomena Hazards Mitigation Conference, p. 184-194. 1991.

"Assessment of liquefaction potential in the San Jose, California urban area." Power, M.S., Perman, R., Wesling, J., Youngs, R.R., and Shimamoto, M.: Proceedings, Fourth International Conference on Seismic Micro Zonation, Stanford, California, v. II, p. 677-625. 1991.

"Seismic microzonation of the Ech Cheliff region, Algeria." Power, M.S., and others: Proceedings, Fourth International Conference on Seismic Micro Zonation, invited case study paper, Stanford, California, v. I, p. 539-588. 1991.

"Improved methods for seismic hazard analysis in the western United States." Coppersmith, K.J.: Proceedings, Fourth U.S. National Conference on Earthquake Engineering, v. 1, p. 723-731. 1990.

"Probabilistic seismic hazard analysis using expert opinion: An example from the Pacific Northwest." Coppersmith, K.J., and Youngs, R.R.: Geological Society of America Memoir on Neotectonics in Earthquake Evaluation: The Geological Society of America, v. 8, p. 27-46, Boulder, Colorado. 1990.

"The impact of fault segmentation on estimates of earthquake recurrence and seismic hazard." Youngs, R.R., and Coppersmith, K.J., Proceedings, Fourth International Conference on Seismicity and Seismic Risk, Bechyne Castle, Czechoslovakia, September 4-9, v. II, p. 440-446. 1989.

"Estimating maximum earthquakes for seismic sources in the central and eastern United States: A progress report." Coppersmith, K.J., Youngs, R.R., Johnston, A.C., Kanter, L., Schneider, J., and Arabasz, W.: Proceedings, Fourth International Symposium on Seismicity and Seismic Risk, Bechyne Castle, Czechoslovakia, September 4-9, v. I, p. 115-122. 1989.

"Keeping pace with science: Seismic hazard analysis in the western United States." Youngs, R.R., and Coppersmith, K.J.: Proceedings, Second Department of Energy Natural Phenomena Hazards Mitigation Conference, p. 262-270. October 1989.

"Keeping pace with science: seismic hazard analysis in the central and eastern United States." Coppersmith, K.J., and Youngs, R.R.: Proceedings, Second Department of Energy Natural Phenomena Hazards Mitigation Conference, p. 252-261. October 1989.

PUBLICATIONS (continued)

"Issues regarding earthquake source characterization and seismic hazard analysis within passive margins and stable continental interiors." Coppersmith, K.J. , Youngs, R.R.: Earthquakes at North-Atlantic Passive Margins–Neotectonics and Postglacial Rebound (Gregersen, S. and Basham, P., eds.), NATO ASI Series C, v. 266, p. 601 – 631. 1989.

"Use of detailed geologic data in regional probabilistic seismic hazard analysis: An example from the Wasatch Front, Utah." Youngs, R.R., Swan, F.H., and Power, M.S.: Proceedings, Earthquake Engineering and Soil Dynamics II ASCE, Park City, Utah, p. 156-172. June 27-30.

"Nearfield ground motions for large subduction zone earthquakes." Youngs, R.R., Day, S.M., and Stevens, J.L.: Proceedings, American Society of Civil Engineers–Specialty Conference on Earthquake Engineering and Soil Dynamics II, Park City, Utah, p. 445-462. 1988.

"Probabilistic analysis of earthquake ground shaking hazard along the Wasatch Front, Utah." Youngs, R.R., Swan, F.H., Power, M.S., Schwartz, D., and Green, R.: United States Geological Survey–Professional Paper on Seismic Hazards in Utah (in press). Preprinted and Assessment of Regional Earthquake Hazards and Risk along the Wasatch Front, Utah United States Geological Survey Open File Report 87-585, v. 2, p. M1-110.

"Geotechnical data in seismic risk evaluations." Arango, I.: Proceedings, Eighth Pan American Congress for Soil Mechanics and Foundation Engineering p. 495-506. August 1987.

"Probabilistic assessment of seismic hazards in the Ech Cheliff Region, Algeria and seismic microzonation of urban areas in the Ech Cheliff Region, Algeria." Swan, F.H., and others: Proceedings, Eighth European Conference on Earthquake Engineering, Lisbon, Portugal. September 7-12, 1986.

"Seismic hazard methodology for the central and eastern United States, Volume 1: Methodology." with Risk Engineering, Woodward-Clyde Consultants, and Cygna Corporation. Electric Power Research Institute Publication NP-4726. 1986.

"Capturing uncertainty in probabilistic seismic hazard assessments within intraplate environments." Coppersmith, K., Youngs, R.R.: Proceedings, Third National Conference on Earthquake Engineering, Charleston, South Carolina, v. 1, p. 301-312. August 24-28, 1986.

"Seismic hazard assessment of the Hanford region, eastern Washington State." Coppersmith, K.J., and others: Proceedings, Department Of Energy Natural Phenomena Hazards Mitigation Conference, p. 169-176. October 1985.

"Implications of fault slip rates and earthquake recurrence models to probabilistic seismic hazard estimates." Youngs, R.R., Coppersmith, K.J.: Bulletin, Seismological Society of America v. 75, p. 939-964. 1985.

"Geotechnical features of Fur Seal Island design." Luscher, U., and others: Proceedings, American Society of Civil Engineers Conference on Civil Engineering in the Arctic Offshore, San Francisco. March 25-27, 1985.

PUBLICATIONS (continued)

"Assessment of confidence intervals for results of seismic hazard analysis." Kulkarni, R., Youngs, R.R., and Coppersmith, K.J.: Proceedings, Eighth World Conference on Earthquake Engineering v. 1, p. 263-270. 1984.

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