

U.S. NUCLEAR REGULATORY COMMISSION

In the Matter of System Energy Resources

Docket No. 52-009-ESP Official Exhibit No. Staff 14 **CARL J. COSTANTINO**

OFFERED by: Applicant/Licensee Intervenor \_\_\_\_\_ Consulting Engineer  
 NRC Staff Other \_\_\_\_\_ Professor Emeritus  
 IDENTIFIED on 1/15/02 Witness/Panel \_\_\_\_\_ Department of Civil Engineering  
 Action Taken: **ADMITTED** **REJECTED** **WITHDRAWN** The City College of the  
 Reported On: \_\_\_\_\_ City University of New York

**EDUCATION**

BCE	1956	City College of New York
MSCE	1958	Columbia University, majoring in Soil Mechanics and Foundations with Prof. D.M. Burmister
PhD	1966	Illinois Institute of Technology, majoring in Soil Mechanics and Foundations with Prof. E. Vey

**REGISTRATION**

Registered Professional Engineer, New York State

**EXPERIENCE**

1967 - 1996 Department of Civil Engineering, City College of New York  
 Conducted research on stress wave propagation through soil and rock materials primarily associated with the seismic response of structures, with special emphasis on evaluation of critical facilities. Problems centered on the study of large strain and nonlinear effects on wave propagation, soil-structure interaction, and the influence of pore water on dynamic response. Directed the activities of Doctoral and Masters candidates. Co-Director of CUNY Center for Earthquake Engineering.

1975 - Present Seismic Consultant, Nuclear Regulatory Commission  
 Perform seismic studies of nuclear reactor facilities for various divisions of NRC at both the design and review stages; assist NRR with evaluation of advanced reactor facilities and audits of existing plant facilities; develop computer programs to assist NRC Staff in their review of facility designs; perform geotechnical site evaluations and liquefaction assessments; testify as expert witness before various licensing hearings.

1985 - Present Seismic Consultant, Department of Energy  
 Assist various divisions of the DOE in geotechnical and seismic evaluations of critical facilities at both the design and review stage; perform safety evaluations for the underground storage facility (WIPP and Yucca Mountain); perform detailed site and liquefaction evaluations for critical facility sites; assist in the development of DOE safety assessment criteria; evaluate seismic safety of critical facilities at Savannah River Plant, Los Alamos National Laboratory, Rocky Flats, Lawrence Livermore National Laboratory; present results to Defense Nuclear Facilities Safety Board.

1971 - Present Soils Consultant, New York City Transit Authority  
 Provide consulting services to NYCTA Engineers on all geotechnical issues at both the design and construction stages; assist Staff to generate criteria and incorporate modern foundation developments into projects (jet grouting, soil stabilization via sand/wick drains, grout curtains, grout cutoff walls, etc); direct development of project criteria for seismic design; assist in the

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development of Standards for Structural Design, Field Designs, and Soil Exploration; direct the planning and conduct of field exploratory programs; conduct laboratory testing of samples from various projects sites; develop and inspect field monitoring programs; perform studies for dewatering programs, settlement analyses, pile foundation designs, loads on buried structures, soil stabilization projects.

1959 - 1967            Mgr, Structural Dynamics, IIT Research Institute, Chicago, Illinois  
Conducting research studies involving site hardening of missile systems; Principal Engineer on programs involving site hardening of missile and missile guidance systems, theoretical and experimental studies of soil-structure interaction; development of large finite element programs to study wave propagation through nonlinear soil/rock systems; design and analysis of hardened command/control/silo systems; studies of reactor containment shell structures subjected to static and dynamic loadings; large strain plasticity analyses.

1956 - 1958            Geotechnical Engineer, Tippetts, Abbott, McCarthy, Stratton  
Resident Engineer on earth moving project involving soil stabilization and compaction; field supervision of soils exploration programs for earth dam sites, flood control structures and river erosion projects.

## **SOCIETY MEMBERSHIP**

Member, US National Committee on Tunneling Technology, National Research Council

### **Technical Societies**

American Society of Civil Engineers  
American Society of Mechanical Engineers  
American Institute of Aeronautics and Astronautics  
Transportation Research Board

### **Positions Held:**

Chairman, Applied Mechanics Division, Chicago Section, ASME, 1964 -65  
Member, Education Committee, Soil Mechanics Group, Met Section, ASCE, 1980-81  
Reviewer, Applied Mechanics Reviews, ASME  
Structures Division Journal, ASCE  
Pressure Vessel and Piping Division, ASME

### **Honor Societies:**

Sigma Xi, Chi Epsilon, Tau Beta Pi

## PUBLICATIONS

- "Representative Triaxial Testing", Dept. of Civil Engineering, Columbia University, 1958
- "Stresses in the Vicinity of Deep Underground Shelters", Proceedings, 32nd Symp. on Shock, Vibration and Associated Environments, Part II, Office of DDRE, Bulletin 32, 1962
- "Approximate Burst Strength of Thin Walled Cylinders with Hemispherical End Caps", with NA Weil and MA Salmon, Journal AIAA, vol. 1, no. 9, Sept. 1963
- "Comparison of Approximate Theories for the Burst Strength of Finite Cylinders" with NA Weil and MA Salmon, Transactions of the American Nuclear Society, vol. 6, no. 1, June 1963
- "Effect of End Conditions on the Burst Strength of Finite Cylinders" with NA Weil and MA Salmon, Journal of Applied Mechanics, vol. 31, no. 1, March 1964
- "A Simplified Soil-Structure Interaction Model to Investigate the Response of Buried Silos and Cylinders", with RR Robinson and MA Salmon, Proceedings, Symposium on Soil-Structure Interaction, Univ. of Arizona, Sept. 1964
- "Experiments on Circular Cylinders with Flexible Roof Plates Buried in Sand", with A Longinow, Proceedings, Symposium on Soil-Structure Interaction, Univ. of Arizona, Sept. 1964
- "Theory of Limiting Equilibrium for Axisymmetric Problems: A Comparison with Experiment on Silo Skin Friction", with A Longinow, Proceedings, Symposium on Soil-Structure Interaction, Univ. of Arizona, Sept. 1964
- "Strength of Thin Walled Cylinders Subjected to Dynamic Internal Pressures", Journal of Applied Mechanics, vol. 32, no. 1, March 1965
- "Crushable Materials for Structural Blast Shields", Journal, Structures Division, ASCE, vol. 91, June 1965
- "Response of Buried Silos and Internal Systems to Ground Shock", with A Wachowski, Proceedings, International Symposium on the Use of Electronic Digital Computers in Structural Engineering, Univ. of Newcastle-Upon-Tyne, Sept. 1966
- "Response of Crushable Foam Encased Buried Cylinders", Ph. D Thesis, Illinois Institute of Technology, Dept. of Civil Engineering, June 1966
- "Finite Element Approach to Stress Wave Problems", Journal, Engineering Mechanics Division, ASCE, April, 1967
- "Finite Element Solution for Wave Propagation in Layered Media Caused by a Nuclear Detonation", with A Wachowski, and UL Barnwell, International Symposium on Wave Propagation and Dynamic Properties of Earth Materials, Albuquerque, New Mexico, Sept. 1967
- "Two Dimensional Wave Propagation Through Nonlinear Media", Journal, Computational Physics, vol. 4, no. 2, Aug. 1969

"Response of Crushable Foam Encased Buried Cylinders", with E Vey, Journal, Soil Mechanics Division, ASCE, vol. 95, no. SM5, Sept. 1969

"Structure-Foundation Interaction of a Nuclear Power Plant with a Seismic Disturbance", with CA Miller, Nuclear Engineering and Design, Dec. 1970

"Analysis of Soil-Structure Interaction Effects Under Seismic Excitation", First International Conference on Structural Mechanics in Reactor Technology (SMIRT), Berlin, Sept. 1971

"Dynamic Response of Nonlinear Media at Large Strain", with J Heifitz, Journal, Engineering Mechanics Division, ASCE, vol. 98, no. EM6, Dec. 1972

"Seismic Analysis of Liquid Sodium Storage Tanks", with CA Miller, Fifth World Conference on Earthquake Engineering, Rome, Italy, June, 1973

"Rocking Effects in a Nuclear Power Plant Subjected to a Seismic Disturbance", with CA Miller, Fifth World Conference on Earthquake Engineering, Rome, Italy, June, 1973

"Influence of Soil-Structure Interaction Parameters on Floor Response Spectra", with CA Miller, Second International SMIRT Conference, Berlin, Sept. 1973

"Finite Element Analysis for Soil Amplification Studies", with LA Lufrano, Proceedings, ASCE Specialty Conference on Structural Design of Nuclear Plant Facilities, vol. 2, Chicago, Dec. 1973

"Mesh Size Criteria for Soil Amplification Studies", with LA Lufrano and CA Miller, Third International SMIRT Conference, London, Sept. 1975

"Facility Design Constraints for Combined Seismic and Thermal Loadings", with CA Miller, Third International SMIRT Conference, London, Sept. 1975

"Soil-Structure Interaction Parameters from Finite Element Analyses", with CA Miller and LA Lufrano, Proceedings, Conference on Extreme Load Conditions, Berlin, Sept. 1975

"Seismic Analysis", with CA Miller, Shock and Vibration Computer Programs, Reviews and Summaries, edited by W and B Pilkey, Shock and Vibration Information Center, US DoD, 1975

"Soil-Structure Interaction Methods", volumes I through IV, with CA Miller, US Nuclear Regulatory Commission, Office of Nuclear Regulatory Regulation, NUREG/CR-1717, BNL-NUREG-51263, Sept. 1979

"Seismic and Dynamic Qualification of Safety Related Electrical and Mechanical Equipment in Operating Nuclear Power Plants", with JR Currenri and M Reich, US Nuclear Regulatory Commission, Office of Nuclear Regulatory Regulation, NUREG/CR-3266, BNL/NUREG-51667, Jan. 1983

"High Soil/Structure Interaction Combined with Low Structural Damping", with CA Miller and AJ Philippacopoulos, Seventh International SMIRT Conference, Chicago, Aug. 1983

"Seismic Models for Buried Tanks", with AJ Philippacopoulos and CA Miller, American

Society of Mechanical Engineers, Pressure Vessel and Piping Division, July, 1984

"Upper Bound Floor Response Spectra", with PC Wang, AJ Philippacopoulos and CA Miller, 8th World Conference on Earthquake Engineering, San Francisco, July 1984

"Development of Generic Floor Response Spectra for Equipment Qualification for Seismic Loads", with JR Currerri, Inter. Power Plant Thermal-Hydraulics and Operations Meeting, Chinese Nuclear Energy Society and American Nuclear Society, Taipei, Taiwan, Oct. 1984

"A Method to Generate Generic Floor Response Spectra for Operating Nuclear Power Plants", with JR Currerri, M Subudhi, M Reich, Eighth International SMIRT Conference, Brussels, Belgium, Aug. 1985

"Correlation of Fukushima Data with SSI Models", with CA Miller and AJ Philippacopoulos, Eighth International SMIRT Conference, Brussels, Belgium, Aug., 1985

"Influence of Soil-Structure Interaction on Floor Response Spectra", with CA Miller and JR Currerri, Eighth International SMIRT Conference, Brussels, Belgium, Aug. 1985

"SSI and Structural Benchmarks", with A.J. Philippacopoulos, C.A. Miller and H. Graves, Proceedings of the 14th Water Reactor Safety Meeting, March, 1987

"Soil-Structure Interaction: Influence of Ground Water", US Nuclear Regulatory Commission, Office of Nuclear Regulatory Regulation, NUREG/CR-4588, BNL-NUREG-51983, Volume 3, April, 1986

"Impact Loading on Waste Fuel Shipping Casks", with CA Miller, Ninth International SMIRT Conference, Lausanne, Switzerland, August, 1987

"Influence of Ground Water on Soil Structure Interaction", with RH Lung, H Graves, Ninth International SMIRT Conference, Lausanne, Switzerland, August, 1987

"Geotechnical Properties in the New York City Area and Their Impact on Transit Facilities", with CA Miller, Proceedings, Seismic Hazards, Ground Motions, Soil Liquefaction and Engineering Practice in Eastern North America, Lamont Dougherty Geological Observatory, October, 1987

"NFAP Calculation of Pressure Response of 1/6th Scale Model Containment Structure", with S. Pepper, CUNY Report for Brookhaven National Laboratory, February, 1988

"NFAP Calculation of Pressure Response of 1/6th Scale Model Containment Structure", with S. Pepper, M. Reich, Fourth Workshop on Containment Integrity, Arlington, Virginia, June, 1988

"Prediction of Seismic Response of the Quarter Scale Containment Using a Lumped Parameter Soil/Structure Interaction Model", with CA Miller, A. Zerva, and E. Heymsfield, CUNY Report to Argonne National Laboratory, November, 1988

"Seismic Risk Assessment for Embankments and Small Earth Dams", with CA Miller, AJ Philippacopoulos, N. Simos, Proceedings, 1st Japan-US Workshop on Liquefaction, Large

Ground Deformation and Their Effects on Lifeline Facilities, Assoc for Development of Earthquake Prediction, Tokyo, Nov. 1988.

"NFAP Calculation of the Response of a 1/6th Scale Reinforced Concrete Containment Model", with S. Pepper, M. Reich, 10th International SMIRT Conference, Anaheim, California, August, 1989

"Integrated System for Seismic Evaluations", with J. Xu, A.J. Philippacopoulos, C.A. Miller, H. Graves, 10th International SMIRT Conference, Anaheim, California, August, 1989

"Evaluation of Control Motion Input Location", with C.A. Miller, A. Zerva, E. Heymsfield, 10th International SMIRT Conference, Anaheim, California, August, 1989

"Seismic Effects on Elevated Transit Lines of the New York City Transit Authority", with C.A. Miller, E. Heymsfield, National Center for Earthquake Engineering Research, Report No. NCEER-89-0039, Dept. of Civil Engineering, City College of New York, December, 1989

"Assessment of Thermal Fatigue Crack Propagation in Safety Injection PWR Lines", with N. Simos Structural and Seismic Design Analysis of Structures/Components Systems, Pressure Vessel and Piping Conference, ASME, Nashville, Tenn., June, 1990

"Experience With Rapid Consolidation of Soils Using Sand Drains", Proceedings, ASCE Metropolitan Section Seminar on Tunnels and Underground Construction, February, 1991

"Site Specific Hazard Calculations for Deep Soil Sites", with E. Heymsfield and J. Xu, Symposium on System Interaction with Linear and Nonlinear Characteristics, 1991 ASME Pressure Vessel and Piping Conference, San Diego, CA June, 1991

"Effects of Inclined Seismic Waves on Soil-Fluid-Structure Interaction", with J. Xu, C. A. Miller, Symposium on System Interaction with Linear and Nonlinear Characteristics, 1991 ASME Pressure Vessel and Piping Conference, San Diego, CA June, 1991

"Seismic Response Analyses for Reactor Facilities at Savannah River", with J. Xu, C. A. Miller, Symposium on System Interaction with Linear and Nonlinear Characteristics, 1991 ASME Pressure Vessel and Piping Conference, San Diego, CA June, 1991

"Seismic Risk Assessment of Small Earth Dams", Third US Conference on Lifeline Earthquake Engineering, Los Angeles, CA, August, 1991

"Determination of Seismic Hazard for Soil Sites Given Comparable Data for Rock Sites", with J. Xu, E. Heymsfield, Proceedings SMIRT91, Tokyo, Japan, August, 1991

"Seismic Hazard Studies for the High Flux Beam Reactor at Brookhaven National Laboratory", with E. Heymsfield, Y. J. Park, C. H. Hofmayer, Third DOE Natural Phenomena Hazards Mitigation Conference, St. Louis, Missouri, October, 1991

"Soil Structure Interaction Effects on High Level Waste Tanks", with C.A. Miller, E. Heymsfield, Third DOE Natural Phenomena Hazards Mitigation Conference, St. Louis, Missouri, October, 1991

"Guidelines for Seismic Evaluation of Nuclear Facilities", with C. A. Miller, T. Cheng, G. Bagchi, 10th World Conference on Earthquake Engineering, Madrid, Spain, July, 1992

"Conditions for Which SSI Effects in HLW Tanks Are Small", with C. A. Miller, Fourth DOE Natural Phenomena Hazards Mitigation Conference, Atlanta, Georgia, October, 1993

"Site Specific Seismic Hazard Calculations at Deep Soil Sites", with C. A. Miller, E. Heymsfield, Fourth DOE Natural Phenomena Hazards Mitigation Conference, Atlanta, Georgia, October, 1993

"Comparison of Shaker Predictions with Measured Data from the Hualien Quarter Scale Model Experiment", with C. A. Miller, J. McLean, H. Graves, Fourth DOE Natural Phenomena Hazards Mitigation Conference, Atlanta, Georgia, October, 1993

"On The Liquefaction Failure of an Earth Dam", with N. Simos, M. Reich, Fourth DOE Natural Phenomena Hazards Mitigation Conference, Atlanta, Georgia, October, 1993

"Seismic Safety of Earth Dams: A Probabilistic Approach", with N. Simos, M. Reich, Proceedings, Second Inter. Conf. on Computational Stochastic Mechanics, Athens, Greece, June, 1994

"Spacing Effects on Seismic Responses of Underground Waste Storage Tanks", with J. Xu, K. Bandyopadhyay, S. Shteyngart, C. A. Miller, Proceedings, Pressure Vessels and Piping Conference, American Society of Mechanical Engineers, Minneapolis, Minnesota, June 19, 1994

"Probabilistic Assessment of Soil Liquefaction", with N. Simos, M. Reich, T. McSpadden, U.S.-Japan Panel on Wind and Seismic Effects, May, 1995

"Seismic Induced Earth Pressures in Buried Vaults", with C. A. Miller, Proceedings, Pressure Vessels and Piping Conference, American Society of Mechanical Engineers, Minneapolis, Minnesota, June 19, 1994

"Earthquake Hazard Mitigation in Geotechnical Engineering", with P. Edinger, V. Tirolo, Proceedings, ASCE Met Section Construction Group Seminar, Feb. 1995

"Impact of Seismic Hazard Characterization on Probability of Liquefaction", with C.A. Miller, E. Heymsfield, Proceedings, Pressure Vessel & Piping Division, ASME, Hawaii, July, 1995

"Seismic Capacity of Reinforced Concrete Frames with Insufficient Development Length of Joint Reinforcement", with C.A. Miller, Y. Zhu, Proceedings, Pressure Vessel & Piping Division, ASME, Hawaii, July, 1995

"Seismic Design Evaluation Guidelines for Buried Piping for the DOE HLW Facilities", with C.W. Lin, R. P. Kennedy, G. Antaki, S. Bush, and K. Bandyopadhyay, Proceedings, Pressure Vessel & Piping Division, ASME, Hawaii, July, 1995

"Hualien Experiment: Shaker Tests After Backfill", with C.A. Miller, H. Graves, Fifth DOE Natural Phenomena Hazards Mitigation Symposium, November, 1995



"Reconnaissance Report for the Hyogo-Ken Earthquake", Proceedings, 7th US-Japan Workshop on the Improvement of Structural Design and Construction Practices, Applied Technology Council and the Japanese Structural Consultants Association, Kobe, Japan, January, 1996

"Hualien Experiment: Model Response to Earthquakes; Nonisotropic Site Properties; Forced Vibration Tests", with C. A. Miller, H. L. Graves, 14th International SMIRT Conference, Lyon, France, August, 1997

"Soil Saturation and Water Table Effects on Impedances at the APT Target Facility", with N. Simos and D. Niehoff, Paper K2-C7-US, 15th International SMIRT Conference, Seoul, Korea, August, 1999

"Seismic Analysis of a Fire Loop Piping System", with J. Crawford, L. Goen and D. Volkman, ASME Pressure Vessel and Piping Conference, Boston, MA, August, 1999

"Considerations in the Evaluations of Site Characteristics on Seismic Response"; with W. Silva, OECD Workshop on Engineering Characterization of Seismic Input, Committee on the Safety of Nuclear Installations, OECD Nuclear Energy Agency, Brookhaven National Laboratory, Upton, NY November 15, 1999

"Site Response Functions for the Eastern United States as Compared to NEHRP 97 Recommendations", with J. Kimball, OECD Workshop on Engineering Characterization of Seismic Input, Committee on the Safety of Nuclear Installations, OECD Nuclear Energy Agency, Brookhaven National Laboratory, Upton, NY November 15, 1999

"Technical Basis for Revision of Regulatory Guidance on Design Ground Motions: Hazard- and Risk-Consistent Ground Motion Spectra Guidelines", with R. McGuire, W. Silva, for U.S. Nuclear Regulatory Commission, NUREG/CR-6728, October, 2001

"Probabilistic Site Identification Analysis Using NUPEC Recorded Free-Field Motions", with J. Xu, C. Hofmayer, A. Murphy and Y. Kitada, Pressure Vessels and Piping Conference ASME, Vancouver BC, Canada, August, 2002

"Methodology to Produce Hazard Consistent Free-field and In-structure Design Response Spectra", with W. J. Silva, R. K. McGuire, R. M. Kenneally, A. J. Murphy, Proceedings, Organization for Economic Cooperation and Development (OECD-NEA Workshop), Istanbul Turkey, October, 2002

"BNL Prediction of NUPEC's Field Model Tests of NPP Structures Subject to Small-to-Moderate Magnitude Earthquakes", with J. Xu, C. Hofmayer, A. Murphy and Y. Kitada, , 17th International SMIRT Conference, Prague, Czech Republic, , August, 2003

"River Protection Project – Seismic Analysis of Vitrification Buildings", with F. Ostadan and N. Deng, , 17th International SMIRT Conference, Prague, Czech Republic, , August, 2003

"Liquefaction: Proposed NYC Building Code Revision" with R. Alperstein, P. Edinger, M. Iskander, S. Leifer, S. Nikolaou, T. Thomann, Proceedings of the 5<sup>th</sup> Inter. Conf. On Case Histories in Geotechnical Engineering, April, 2004

“Assessment of Seismic Analysis Methodologies for Deeply Embedded NPP Structures”, with J. Xu, C. Miller, C. Hofmayer and H. Graves, 18<sup>th</sup> International SMIRT Conference, Beijing China, August, 2005

“Evaluation of Seismic Induced Wall Pressures for Deeply Embedded NPP Structures”, with J. Xu, C. Miller, C. Hofmayer and H. Graves, 18<sup>th</sup> International SMIRT Conference, Beijing China, August, 2005

“Assessment of Seismic Analysis Methodologies for Deeply Embedded NPP Structures”, with J. Xu, C. Miller, C. Hofmayer and H. Graves, 18<sup>th</sup> International SMIRT Conference, Beijing China, August, 2005

“Assessment of Analytical Prediction of JNES Seismic Wall Pressure Data for ABWR Model Structures” with J. Xu, C. Hofmayer and H. Graves, Proceedings of International Congress on Advances in Nuclear Power Plants, Reno, NV, June, 2006

“Finite Element Models for Computing Seismic Induced Soil Pressures on Deeply Embedded NPP Structures”, with J. Xu, C. Hofmayer, H. Graves, Proceedings, Pressure Vessel and Piping Division Conference, Vancouver BC, July 2006