ENCLOSURE 1

Stephen W. Verigin, P.E., G.E., Senior Principal Consultant

GEI Consultants

Education
B.S., Civil Engineering, University of California, Davis, 1978
M.S., Civil Engineering, California State University, Sacramento, 1986

Registration
Registered Geotechnical Engineer, California, GE 2048
Registered Civil Engineer, California, CE 33664

Background

Stephen W. Verigin is a Senior Vice President and Senior Consulting Geotechnical Engineer specializing in dam safety and dam design and construction. He managed the GEI dam and levee safety practice west of the Rocky Mountains for the past ten years. GEI has major dam engineering offices in Sacramento, Oakland, San Diego and Denver.

Prior to joining GEI Consultants, Mr. Verigin worked at numerous engineering and management levels for the California Department of Water Resources (DWR) as Chief of the Division of Safety of Dams, Deputy Director and Acting Chief Deputy Director. As a deputy director he provided policy direction for the divisions of Flood Management and Safety of Dams and ran the day-to-day operations of the 2,500 employee agency.

Mr. Verigin has more than 40 years of experience in nearly all aspects of water resources engineering with an emphasis on design and construction. He is nationally recognized as an expert and leader in dam safety engineering with extensive project, program and executive management experience.

Recent Projects

DWR Oroville Dam Spillways Recovery and CNA Projects. Served as Deputy Project Manager, highest level consultant position, on both the Oroville Emergency Recovery – Spillways and Comprehensive Needs Assessment (CNA) projects from February 2017 through present. Managed the geology, geotechnical, hydrology, hydraulics and constructability disciplines for the spillways recovery design and design assistance during construction. Assisted the Project Manager with day-to-day project management tasks and overall project management responsibilities. In coordination with DWR Executive Managers, developed the project scope, project management and project execution plans for the risk-based CNA planning study. Project deliverables are six task level reports, one publicly released project report and one CEII protected project report, over 1000 pages total, due in August 2020. The CNA project scope was to develop and recommend facility enhancements necessary to ensure dam safety and system reliability in conformance with modern engineering standards.

DWR PFMA Workshops. Facilitator for 2-day long PFMA workshops for DWR's Upper Feather River Dams. Prepared workshop background and documentation materials, lead group of approximately 20 dam safety professionals through seepage and piping, seismic and extreme hydrologic loading potential failure modes. Prepared a written report following the workshop. More recently also facilitated PFMA update workshops for Castaic, Dyer, Pyramid, Quail Lake, and Quail Diversion dams. Written reports were also prepared for each of those dams following the workshops.

DWR Part 12 Inspections. Co-independent Consultant for approximately 10 DWR owned dams in 2009 and 2010. Projects included the Oroville-Thermalito and Southern Hydro complexes including the following major dams: Oroville, Thermalito Forebay, Thermalito Afterbay, Pyramid and Cedar Springs. Conducted

inspections, prepared reports and participated in PFMA update workshops to comply with FERC and State of California five-year inspection requirements.

PFMA Workshop Facilitation. Facilitated PFMA workshops for a number of California dams with a variety of clients. Clients have included Yuba County Water Agency (New Bullards Bar, Our House and Log Cabin), El Dorado Irrigation District (Silver Lake, Caples Lake, Echo Lake and Lake Aloha), Jackson Valley Irrigation District (Jackson Creek Dam), PG&E (more than 10 dams), SMUD (more than 5 dams), LADWP (Elderberry Dam) and Santa Clara Valley Water District (Uvas, Chesbro and Coyote). Most of these workshops were to perform PFMA updates, but a number of them had been done so long ago that a substantial number of additional failure modes with far greater detailed failure sequences were developed.

PG&E Owners Dam Safety Review (Audit) Report. As a member of PG&E's Dam Safety Advisory Board, conducted interviews and prepared review (audit) report of PG&E's Owner's Dam Safety Program (ODSP) as required by FERC. This report is one of the first of its kind in California for the largest dam owner (64 jurisdictional dams) in the state.

Turlock Irrigation District (TID) Dam Safety Review (Audit) Report. Completed the first FERC required audit report for TID, owner of the Extremely High Hazard - Don Pedro Dam, a nearly 600-foot high multi-purpose earth embankment dam.

ASDSO Peer Review Committee. Served on ASDSO Peer Review Committee for approximately twenty years, serving as committee chair for five of those years. Chaired the revision of the ASDSO Peer Review Manual and updated report template. Objective of committee is review the subject's dam safety program to the program's statutory authorities and present results in a written report. Participated in reviews of the states of Wisconsin, Minnesota, Iowa, Hawaii and Nevada dam safety programs.

USBR Dam Safety Independent Review Panel (IRP). Member of Reclamation's IRP dam safety program reviews in 2014, 2015 and 2016. The IRP is required annually to independently review Reclamation's dam safety program to evaluate how the organization is performing with respect to its required dam safety function. Past reviews have included travel and interviews of Reclamation staff in Denver, Billings and Boise. The IRP provides a verbal report-out at the conclusion of the in-field visits, a written report of findings and recommendations and a follow-up report-out pending completion of the report.

El Dorado Forebay Dam. Project Engineer for seismic stability reanalysis of 85-foot high earth embankment dam. Managed field exploration, laboratory testing, foundation characterization and stability calculations. Participated in regular meetings with owners engineering and management team to discuss project progress. Submitted report to FERC and California DSOD for review and approval.

Lake Isabella Dam. Project Manager and consultant to Kern River Interests, the local agency water user group, for this Corps of Engineers dam and reservoir. The Corps has identified foundation seepage, seismic stability and spillway capacity dam safety deficiencies and subsequently ranked this dam the number one national priority Corps of Engineers dam safety project. GEI tasks include independent engineering analyses to confirm deficiencies and working with the Corps staff and management to expediently return the reservoir to full operation.

Sly Park Reservoir Dam. Project Engineer and Analyst. Prepared an engineering report for El Dorado Irrigation District with findings that dam meets required design, construction, stability, spillway capacity, outlet capacity and performance requirements of California DSOD. Report was required by DSOD when dam ownership and title transferred from federal to local government.

Crane Valley Dam. Regulatory Process Consultant. Worked with PG&E staff, consultants and consulting board in review and advisory capacity to facilitate meeting California DSOD seismic stability analysis

requirements. Reviewed technical reports and attended meetings to make recommendations to client and consultants for moving past impasse with DSOD.

Caples Lake and Silver Lake dams. Project Engineer for seismic stability and spillway hydrology studies for two High Sierra dam and reservoir complexes. Compliance with California DSOD and FERC regulations required new studies to evaluate adequacy to meet regulatory requirements. Required working closely with dam owner and regulatory agencies.

Terminus Dam. Project Manager representing Kaweah Delta Irrigation District in dam safety evaluation project by Corps of Engineers. Terminus Dam was in the group of dams undergoing a comprehensive review by the Corps to investigate and rank dam safety deficiencies nationwide. Foundation seepage and seismic stability were priority issues for the Corps. Responsibilities included reviewing work by Corps, performing independent engineering evaluations, attending meetings and advising District of actions recommended to achieve a complete and efficient evaluation.

State of Hawaii Dam Safety Project. Project Manager for providing dam safety engineering services to state. Conducted over 50 Phase I dam safety inspections/evaluations. Included dam and reservoir inspections, background review, dam safety evaluations and preparation of Phase I reports. Prepared emergency action plan templates and conducted workshops and EAP exercises on the four Hawaiian Islands with jurisdictional reservoirs. Managed and performed design reviews for approval of applications for design, construction, remediation and repair of dams.

Boards, Committees and Workshops

B. F. Sisk Consulting Board. Member of five-person Independent Consulting Board for USBR and DWR jointly owned 300 foot high B. F. Sisk Dam. Facility is under seismic reevaluation and will require remedial design and construction measures to meet current dam safety standards.

Anderson Dam Consulting Board. Member of five person Independent Consulting Board for Santa Clara Valley Water District. Dam is under reevaluation to address seismic stability, inadequate spillway capacity and deficient low-level outlet works caused by fault rupture. Project has progressed through problem identification, remedial alternatives planning with final design in progress.

National Committee on Levee Safety. Member of national committee, appointed by the Assistant Secretary of the Army, Civil Works, in response to Congress passing WRDA 2007 Section 9003, "National Levee Safety Act of 2007". Committee wrote and submitted to Congress the strategic document, "Recommendations for a National Levee Safety Program", January 15, 2009.

Lake Wohlford Dam. Member of Consulting Board to review work and advise on results of seismic stability analysis and remediation alternatives.

Pit 3, Pit 4 and Pit 5 dams. Member of PG&E Consulting Board required by FERC for outlet works modification for three hydroelectric generation dams on the Pit River.

B. F. Sisk Dam. Conducted workshop for DWR and USBR to resolve impasse issues regarding seismic stability of joint use facility dam. Worked with agencies technical and management staff to reach agreement for exploration, testing and foundation characterization requirements for interpreting geologic conditions. Foundation characterization will be used to construct model for seismic stability analysis.

San Clemente Dam. Advisory Board member of the California Coastal Commission for the removal of San Clemente Dam. Advised on engineering design aspects of dam removal project. Dam removal was a remediation alternative under consideration to respond to seismic stability deficiency.

Statement of Qualifications for

Pacific Gas and Electric Dam Safety Advisory Board

Stephen J. Rigbey M.A.Sc., P. Eng

The Position and Purpose: to be a member of an expert team tasked to conduct periodic external reviews and provide expertise and guidance to support Pacific Gas & Electric Company's Dam Safety Program (DSP). Work is to include reviews of the DSP's performance, organization, processes, and technically challenging or high priority projects to determine whether the DSP is meeting its objectives and effectively managing and reducing the risk of a dam failure.

Stephen Rigbey has 40 years experience in the hydro industry and is well suited to provide the above services through his solely owned company, SJR Consulting Inc.

Technical Experience: After an education in geological engineering, Stephen spent 30 years with Acres International (now Hatch), working in more than 15 countries and following numerous projects through investigations, design, construction and remediation. Projects included concrete and earthfill dams, instrumentation, dam safety and seismicity assessments, underground powerhouse complexes, and tunnels. He co-developed a systematic approach to the evaluation of shear strength parameters for stability analyses, which is now quoted in the Canadian Dam Association Guidelines.

Owner's Dam Safety Perspective: Stephen then joined BC Hydro in 2008, and for the next 10 years was responsible for ensuring safe reservoir retention and water passage at 41 hydro sites throughout British Columbia. BC Hydro's dam portfolio includes some of the largest and tallest hydro dams in North America. As Director of Dam Safety, he was responsible for maintaining a world-class dam safety management program, including monitoring and surveillance, the identification and prioritization of all associated risks, initiating Investigation and Capital projects, and providing technical oversight to these projects. As such, he is well acquainted with the necessity of making tough decisions; decisions that must balance cost, risk and acceptability in dam safety matters; decisions that must then be explained to the Board of Directors and in some cases, the public. He had a staff of about 35 professionals, technologists and support staff, working on a 10-yr Capital Plan totalling $1.9B in dam safety projects.

Dam Safety Reviews and Risk: Stephen left BC Hydro in 2018, and now continues to consult to the hydro community. He has been a member of Advisory Boards for various projects, and has conducted in-depth audits of dam safety management programs in Sweden and Turkey. He is currently on the Board of Consultants for TransAlta's dams in Alberta. Prior to joining BC Hydro, Stephen performed numerous dam safety assessments of various earth and concrete structures within Canada. Internationally, Stephen has performed Dam Safety Reviews and seismic hazard

assessments for high-risk dams in Iran, El Salvador and Panama. Stephen has presented at, and also facilitated, workshops on failure mode identification and analyses.

Dam Safety Forensics: Stephen was a member of the Independent Forensics Engineering Team investigating the February 2017 spillway incidents at the Oroville Dam in California, which resulted in significant damage and the precautionary evacuation of almost 200,000 downstream residents. In particular, he investigated how dam safety organization and management practices contributed to the incident.

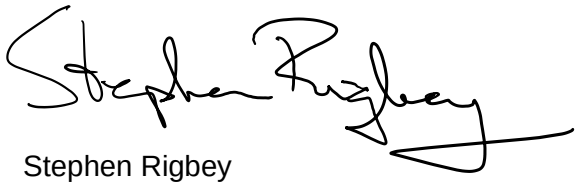
Continued Professional Involvement: Stephen is a licenced professional engineer in both British Columbia and Ontario. As a member of the Canadian Dam Association (CDA) Dam Safety committee, Stephen was heavily involved with the 2013 review and updating of the Dam Safety Guidelines, and continues to be involved with ongoing reviews and updates.

Stephen has been an invited speaker at numerous events, sponsored by the US National Academy of Sciences, Stanford University, ANCOLD (Brisbane), NZCOLD (Christchurch), ICOLD-INCA (Mexico City) and others.

A list of some 24 publications and major presentations is given in Stephen's full Curriculum Vitae. His latest paper, presented at the 2019 International Congress on Large Dams, argues for significant changes in the dam safety industry in view of the findings of the Independent Forensics Team report on the Oroville spillway incidents.

Recognition: Stephen was given the 2017 INGE ANDERSON AWARD by the Canadian Dam Association, in recognition of his "significant contributions to the advancement of knowledge and practices related to dams in Canada." The Association of State Dam Safety Officials recently gave the JOSEPH J. ELLAM PRESIDENT'S AWARD, to members of the Oroville Spillway Incident Independent Forensics Team for "making exemplary contributions to the improvement of dam safety in the U.S."

Submitted by:



Stephen Rigbey

Curriculum Vitae - Stephen James Rigbey

POSITION

Director, SJR Consulting Inc., Canada

EDUCATION

B.A.Sc., and M.A.SC., Geological Engineering,

University of Windsor, Canada, 1975, 1980

PROFESSIONAL ASSOCIATIONS

Association of Professional Engineers and Geoscientists of the Province of British Columbia

Professional Engineers of Ontario

Canadian Dam Association (CDA) – member Dam Safety Committee

RECENT AWARDS

2017 INGE ANDERSON AWARD

Canadian Dam Association, in recognition of his "significant contributions to the advancement of knowledge and practices related to dams in Canada."

2018 JOSEPH J. ELLAM PRESIDENT'S AWARD

Association of State Dam Safety Officials, to members of the Oroville Spillway Incident Independent Forensics Team for "making exemplary contributions to the improvement of dam safety in the U.S."

SUMMARY OF EXPERIENCE

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Stephen left BC Hydro in 2018, and now continues to consult to the hydro community. He has been a member of Advisory Boards for various projects, and has conducted in-depth audits of dam safety management programs in Sweden and Turkey. He is currently on the Board of Consultants for TransAlta's dams in Alberta. He was a member of the Independent Forensics Engineering Team investigating the February 2017 spillway incidents at the Oroville Dam in California, which resulted in significant damage and the precautionary evacuation of almost 200,000 downstream residents. In particular, he investigated how dam safety organization and management practices contributed to the incident.

As a member of the Canadian Dam Association (CDA) Dam Safety committee, Stephen was heavily involved with the 2013 review and updating of the Dam Safety Guidelines, and continues to be involved with ongoing reviews and updates.

Stephen has been an invited speaker at numerous events, sponsored by the US National Academy of Sciences, Stanford University, ANCOLD (Brisbane), NZCOLD (Christchurch), ICOLD-INCA (Mexico City) and others.

- **Dam Safety Assessments and Risk**: Prior to joining BC Hydro, Stephen performed numerous dam safety assessments of various earth and concrete structures within Canada, including detailed foundation condition investigations, coordination of laboratory work, and assessment of rock/concrete shear strengths. A systematic approach to the evaluation of parameters for stability analyses was developed for this work, and is quoted in the Canadian Dam Association Guidelines. Internationally, Stephen has performed Dam Safety Reviews and seismic hazard assessments for high-risk dams in Iran, El Salvador and Panama. Stephen has presented at, and also facilitated, workshops on failure mode identification and analyses.

- **Operational Safety and Quality Control**: At BC Hydro, Stephen was responsible for initiating and reviewing all major projects involving water passages and dams, and for initiating changes to spillway and reservoir operations as necessary for interim risk management. At Acres, he was responsible for the administration and technical coordination of all geotechnical work on hydro projects, including seismicity assessments. Stephen also has significant experience in quality control reviews, and has acted as Lender's Engineer in the review of designs and construction of dams in Panama and India.

- **Dam Investigations and Design** : Stephen has been the Project Manager for the design of a 35-m high, 500-m long embankment dam founded on sands and gravels, including a 65-m deep plastic concrete cutoff wall. He had previously managed an investigations and monitoring program for the original dam, which included an extensive remote automated instrumentation system, development of a detailed Emergency Preparedness and Response Plans, infilling of sinkholes, geophysical surveys, exploratory boreholes through the damaged core of the dam, and sonar surveys of the headpond. A methodology for precise sonar surveying of the sinkholes was developed under Stephen's supervision as part of the work for this project.

- **Rock Mechanics and Geological Engineering** : Stephen has designed layouts and support for underground powerhouses and tunnels under various conditions, including extremely high horizontal in situ stresses and time dependent deformations. Design studies have included the development of specialty laboratory tests to investigate swelling rock pressures. He also has experience in the laboratory and field identification of alkali-aggregate reactions. Stephen spent 2 years on-site in India during the construction of a major underground power facility, and was also Resident Site Engineer during the construction of a 600-m long, 3.5-m dia adit and a 13.5 m dia trial excavation chamber in shales. He was involved onsite at the Karun III project in Iran during the construction of a 200-m

concrete arch dam and underground powerhouse complex. He also worked for a number of years on the Niagara Diversion Tunnel project, a10-km long, 14.4-m diameter rock TBM drive, including investigations, design, and the development of the project Geotechnical Baseline Report.

CAREER CHRONOLOGY

SJR Consulting Inc – Vancouver, 2013 to present

- Facilitator for CEATI's 2019 workshop on Failure Mode identification and analyses,
- Consultant to Vale for overview of the design for the Nairn dam and powerplant replacement project in Ontario, Canada
- Member of Board of Consultants to TransAlta for the annual review of their dam safety program, involving both management and technical aspects.
- Member of the Independent Forensics Engineering Team for the 2017 spillway incidents at the Oroville Dam in California.
- Audits of Dam Safety Programs: extensive audit of management and technical processes and procedures against ICOLD Bulletin B154 - Dam Safety Management: Operational Phase of the Dam Life Cycle, for Vattenfall Vattencraft (Sweden) and EnerjiSA (Turkey), resulting in 40 to 50 specific recommendations for consideration in each case.
- Advisory Board member, Muskrat Fall Hydroelectric Project, Newfoundland (Nalcor) : project involves RCC and embankment dams about 20 to 40 m high, and a unique abutment issue where a meta-stable landform needed to be transformed into a robust reservoir retaining structure.

BC Hydro – Vancouver : Manager and Director of Dam Safety, 2008 to 2018

- Responsible for all aspects of safety involved with water retention and water passage structures at 41 separate hydroelectric sites, developing the appropriate scope and initiating all major studies, investigations and civil projects associated with dam safety, and for providing technical guidance throughout the execution of these projects.
- Reporting directly to the Deputy CEO, and to the Board of Directors on a quarterly basis

Hatch Energy – Vancouver : Principal Geotechnical Engineer & Project Manager, 2006 to 2008

- Comprehensive review of shear strength parameters for the Ruskin Dam, including investigations for basic resistance of the bedrock-concrete contact.
- Forrest Kerr Hydroelectric Project Feasibility Study —Responsible for geotechnical investigations and feasibility level designs for a 190 MW underground powerhouse scheme and 3.4 km tunnel in Northern British Columbia.
- Risk Study for Kemano Tunnel, including investigation of submersible inspection techniques. This partially-lined rock tunnel has a history of rock collapses, and is critical to the supply of power for Alcan's aluminum smelter at Kitimat. Various alternatives to reduce failure risk were compared on a Net Present Value Basis.
- Project Manager for various detailed sonar bathymetry studies for BC Hydro and TransAlta.

- Dam Safety Review Engineer for various large dams, including BC Hydro's extreme consequence category Mica Dam, a 240-m high earthfill structure, and the 120 m high Wood Creek Suncor tailings dams.
- External consultant to BC Hydro for an audit of monitoring and surveillance practices within the Dam Safety Group.

Acres International (later Hatch Energy),* Niagara Falls: Principal Geotechnical Engineer, *2001 to 2006

Responsible for quality control of geotechnical work and mentoring/guidance of geotechnical staff within the hydro division. Continued in previous role as Department Head.

Development of the Geotechnical Baseline Report (GBR) for the Niagara Diversion tunnel project (14.4-m excavated dia., 10 km long). Participated in technical evaluation of the bids and contract negotiations.

Seismic hazard assessments and dam safety reviews for high-risk dams, including regional seismicity reviews, deterministic and probabilistic hazard analyses, selection of design events for:

- Dez dam, Iran
- four dams in El Salvador
- Fortuna dam, Panama.

Due diligence studies and site visits as Lender's Engineer for hydroelectric projects during construction:

- Está project in Panama, a 120-MW scheme involving an earth dam, 6-km canal, 50-m high concrete-face rockfill dam, 4.8-km, 7-m dia tunnel and surface powerhouse
- Vishnuprayag project in India, involving 11-km, 4-m dia tunnel and 400-MW underground powerhouse.

Onsite review of abutment stability safety for a 140-m high, concrete gravity arch dam at the Chamera project, northern India, following a massive downstream landslide.

Project Manager for the design of the 35-m high, 500-m long Shikwamwka Replacement embankment dam, founded on sands and gravels, and incorporating a 65-m deep plastic concrete cutoff wall. Also acted as Project Manager for the monitoring and investigations program involving the original dam.

Numerous dam safety assessments of various earth and concrete structures in Ontario and New Brunswick, including detailed foundation condition investigations, coordination of laboratory work and assessment of rock/concrete shear strengths for the stability analyses. A systematic approach to the evaluation of parameters for stability analyses was developed for this work.

Acres International, Niagara Falls, Geotechnical Department Head - 1996—2001

Responsible for the administration and technical coordination of all geotechnical work on all projects involving geology, soil and rock mechanics, and seismicity. The department had a staff of 12-15 engineers and technologists.

Acting Geotechnical Site Engineer, Karun III hydroelectric project, Iran. Responsibilities included

- supervision of foundation preparation in a faulted area for a 205-m concrete arch dam

- providing advice on major ground movements experienced during excavation of the 26-m span underground powerhouse; review of all instrumentation results
- development of 3D numerical rock mechanics models for the underground complex
- development of 2D seepage models for the arch dam abutment

Project Manager responsible for a study to examine possible causes of, and to develop alternative remedial options for, significant leakage at the Old Mill Station subway tunnel portal, Toronto, Ontario. The study included geotechnical investigations, conditional surveys and a full-scale pump test.

Inspection and interpretation of monitoring data, detailed hydrogeological site assessment, and detailed analysis of groundwater chemistry for the Irving Paper aeration and stabilization basin. The basin containment dike is constructed on a soft marine clay deposit, Saint John, New Brunswick. Preparation of yearly monitoring reports are issued for the New Brunswick Ministry of the Environment.

Project Manager for potential rockfall studies on 48 highway rockcuts in eastern Ontario. Report included recommendations for remediation, cost estimates and benefits.

On-site consultation for remediation of a collapsed 3.5-m dia tunnel in overburden in Bolivia.

Design of remedial works for a 100+ m slope undergoing long-term creep in weathered rock over a water tunnel intake for the Cañon del Pato project in Peru. On-site consultations and construction reviews.

Provided on-site technical advice for the Second Power Reconstruction project, Bosnia and Herzegovina, in the planning for re-instrumentation of the Bocac and Trebinje dams following damage during the war. Developed specifications for international tendering through the World Bank. Instrumentation included precise survey equipment for geodetic monitoring, regional seismicity monitoring and local accelerometer networks, automatic weather stations, and various geotechnical instrumentation systems, including telependula, vibrating wire piezometers, strain gauges, tiltmeters, and ADAS systems.

Vibrating wire piezometer design and installation in boreholes in Welland, Ontario, to measure uplift pressures on tunnel portal structures for the Ministry of Transportation, Ontario. Readings were data logged and alarm software developed for notification via a remote communications link.

Pre-bid and final designs of underground excavations for the Western Beaches combined sewer outfall storage tunnel (3 m dia, 4 km long) in Toronto, Ontario. The project also included excavation of 30-m dia. shafts through rock to tunnel elevation. Ongoing site visits and consultation during construction.

Design of bar anchor and lining support for two 9-m dia. mine shafts in Wyoming for use as storage bins.

Coordination of tender preparation and pre-bid design of underground support, including large bar anchors and shotcrete for the Nam Ngum III project in Laos (involving a 440-MW underground powerhouse scheme and 10 km of 5-m dia. tunnels).

Project Manager for the Welland River shoreline rehabilitation project, involving the stability assessment of natural, concrete wall and other shoreline types along an unused ship canal and the development of remedial recommendations and cost estimates.

Tunnel inspections and stability reviews for two 4- to 6-m dia. power tunnels in northern Ontario. Review of existing bar anchor and shotcrete support and design of remedial measures.

Acres International **Senior Geological Engineer** ***1990—1996***

Design of layout and support for an underground powerhouse and water transfer tunnels for the Alto Cachapoal project, Chile, including excavation design and sequencing, bar anchor and shotcrete support design for both drill and blast and TBM excavation.

Site reconnaissance and project layout review for the Upper Marsyangdi hydroelectric project, Nepal.

Review of alkali-aggregate reactivity (AAR) in the concrete of three locks in the St. Lawrence Seaway system, including the preparation of instrumentation plans for long-term monitoring of concrete growth.

Assessment of rock/concrete shear strengths for the stability analyses of a number of concrete gravity structures in northern Ontario.

Review of conceptual plans for the underground storage of low-level radioactive waste in Ontario. Assisted in the preparation of tenders and contract awards.

Responsible for the long-term automation planning for geotechnical instrumentation at a number of hydroelectric plants in northern Ontario, and the design and installation of remote monitoring systems.

Project Engineer for the Malvern remedial project, involving site preparation for the sorting and storage facilities for 9000 m3 of mildly radioactive contaminated soils. Responsible for detailed final designs, contract preparation, construction supervision and contract closeouts.

Resident Site Engineer during the Stage 3 geotechnical investigations for the Niagara River hydroelectric development. These investigations included the construction of a 600-m long, 3.5-m dia. adit and a 13.5-m dia. trial excavation chamber in the Queenston shale by means of roadheader. The site was affected by high in situ stresses, highly corrosive groundwaters and swelling rock conditions. The program also included various instrumented arrays, measurement of in situ stresses, borehole dilatometer and geophysics testing, and the development of special in situ and laboratory testing for rock swell.

Geotechnical coordination for the definition phase design of the generation facilities for the Niagara River hydroelectric development. These facilities included a proposed 26-m wide powerhouse cavern, transformer gallery, 12.5-m dia. penstock and tailrace tunnels, and associated access tunnels. Design studies included 3D boundary and finite element analyses of the underground complex, and preliminary support design. The work was superseded by the Niagara Diversion Tunnel project.

Coordination of geotechnical and geophysical field investigations for feasibility and final design of a proposed extension to the Owen Falls generating station, Uganda. Responsible for overall review of project seismicity. The project involves a 20-m deep cut in residual soils for a 1-km long power canal and an intake structure on very weak bedrock foundations.

Coordination of investigations for feasibility of siting a health center on an existing landfill in Toronto, Canada. Specific concerns included methane gas control and excavation/redisposal of solid wastes.

Acres International **Geological Engineer** ***1978—1990***

Resident geotechnical representative at the construction site of the 540-MW Chamera hydroelectric generating station in Himachal Pradesh for National Hydro Power Corporation of India. Work included

- supervision of rock excavation, rock support and quality control for 9.5-m dia, 6.5-km long power tunnel, underground powerhouse complex and tailrace tunnel. Installation of 10.5-m long, 52-mm high tensile hollow core bar anchors in crown, and 13-m long, 36-mm dia anchors in walls

- training and transfer of technology to a group of local engineers and geologists
- geotechnical instrumentation.

Planning and supervision of drilling, testing and instrumentation at the Mactaquac generating station, New Brunswick. Investigation of structures and their foundations included determination of concrete characteristics of, and defining the cause of movements within, a concrete gravity intake/spillway and powerhouse. Fieldwork involved a study of concrete cracking and construction joint conditions by borehole photography and ultrasonic methods. Instrumentation installations included tape and borehole extensometers, normal and inverted plumb lines, various deformation and strain gauges, pneumatic piezometers and thermocouples. Concrete tests included direct shear, strength and index properties, thermal properties and both standard and non-standard tests for potential AAR.

Involved in geological investigations for a major project in the Middle East including in situ stress measurements in deep boreholes and core orientation studies.

Development of stereographic projection, statistical analysis and other computer program packages for general use in interpretation of geological field data.

Feasibility site reconnaissance and geologic interpretation of general site conditions for the Sentani hydroelectric project in Irian Jaya, Indonesia. Project involved 4-m dia. tunnels through karstic limestone ridges and 20-m deep channel excavations in weak soils. Evaluation of bids for field explorations.

Detailed dam abutment geologic mapping and assessment for the proposed Granite Canyon hydroelectric development, Yukon.

Development of a computer aided borehole photography interpretation system for use in a foundation investigation program for the spillway at the Limestone generating station, Manitoba.

Prefeasibility site reconnaissance for the Yom-Nan diversion project in Thailand. Responsible for interpretation of general site conditions for determination of project feasibility. Project involved a 25-km long, 8-m dia. tunnel in rock and 48-km of canal excavation in residual soils.

Responsible for geological mapping, core logging, borehole photography and geological interpretation of site conditions for the Upper Salmon hydroelectric development, Newfoundland. Project involved excavations up to 25 m in vertically fissile rock, greater than 5 km of earth-fill dams and dikes up to 25 m high, and overburden excavation for diversion channels. Preparation of data for tenderers and technical specifications for contract purposes. Calculations of rock slope stability and support requirements on site during part of the construction period to review the rock excavations and performance of bar anchors. Responsible for installation of dam instrumentation and supervision of post-impounding monitoring program. Instrumentation included inclinometers, hydrostatic settlement profile gauge, tape extensometer and pneumatic piezometers.

Layout, field supervision and report on an exploratory drilling program related to the stability of a powerhouse rock intake tunnel near Wawa, Ontario.

Responsible for geological mapping, core logging and geological interpretation of site conditions during a major investigation program for a thermal power generating station at Atikokan, Ontario. Project involved dam rehabilitation, construction of rock tunnels, deep excavations in rock and overburden, and heavy structure foundations.

TECHNICAL PAPERS AND MAJOR PRESENTATIONS

Oroville in Retrospect: What needs to change?, 2019 ICOLD Conference, Ottawa, co-author with D. Harford

Looking Beyond Oroville : Where to from here? Keynote presentation at 2018 CDA Conference, Quebec City, and article in CDA Magazine, Winter 2018

Lessons to be Learned from the Oroville Spillway Incident, March 2018, Committee on Geological and Geotechnical Engineering of the National Academies of Sciences, Engineering, and Medicine, https://www.youtube.com/watch?v=YjgugkIfwWQ

Dam Safety Risk – Canadian and BC Hydro Perspectives, ICOLD-INCA Symposium on Dam Safety for the Americas, Mexico City, October 2016

Next Steps in BC Hydro's Risk Informed Decision Making, keynote presentation at ANCOLD Annual Conference, Brisbane, November 2015

BC Hydro Seismic Hazard Model, presentation at Emergency Preparedness and Business Continuity Conference, Vancouver, November 2014

Reframing Risk Informed Decision Making at BC Hydro, Canadian Dam Association Conference, October 2014 and keynote speech, 2013 HG Acres Seminar, Niagara Falls.

Why Every Owner Needs Risk Informed Decision Making, presentation at CEATI Dam Safety Interest Group meeting, Vancouver, October 2013

Assessment of Extreme Flood Hazard, Series of articles for CDA Newsletter, 2011-2013, that led to the 2013 revision of the CDA Guidelines

Assessment of Shear Resistance for Blasted Rock Foundations, Canadian Dam Association Conference, September 2007.

The Design and Construction of the Shikwamkwa Replacement Dam, Canadian Dam Association Conference, September 2007. (Coauthor)

Accounting for Time-Dependent Deformation in the Niagara Diversion Tunnel Design, Proc. 1st Canada-US Rock Mechanics Symposium, Vancouver, May 2007

Concepts of Shear Resistance and Practical Applications. Dam Engineering, Volume XVI, Issue 3, November 2005. (Coauthor)

Monitoring Sinkhole Development by Detailed Sonar Profiling. Proceedings; Association of State Dam Safety Officials Annual Conference, September 2005, and Proceedings; Canadian Dam Association Conference, October 2005. **Best Paper Award**

The Assessment of Sliding Resistance Beneath Concrete Structures. WaterPower XIII, July 2003. (Coauthor)

Grouting of a Karstic Arch Dam Foundation. 55th Canadian Geotechnical Society Conference, Niagara Falls, Ontario, October 2002. (Coauthor)

A Phased Approach to the Rehabilitation of an Aging Northern Dam. HydroVision 2000 Conference, August 2000. (Coauthor)

Exploratory Adit Program for the Niagara River Hydroelectric Development. 12th Annual Canadian Tunneling Conference, Vancouver, BC, October 1994.

Design of Underground Powerhouse Complex, Niagara River Hydroelectric Development. 45th Canadian Geotechnical Conference, Toronto, Ontario, October, 1992.

Placement and Performance of Impervious Fill Blankets on Slopes. 44th Canadian Geotechnical Conference, Calgary, Alberta, 1991. (Coauthor)

Rock Support for a Large Underground Cavern at Chamera. All India Conference on Underground Engineering, Lucknow, India, February, 1989.

Engineering and Construction Options for the Management of Slow/Late Alkali-Aggregate Reactive Concrete. Proceedings, 16th International Congress on Large Dams, San Francisco, 1988. (Coauthor)

Laser Strain Measurement System. Paper presented at Annual Meeting, Association of Engineering Geologists, Hershey, Pennsylvania, 1978.

The Effect of Sodium Chloride on Water Sorption Characteristics of Rock Aggregate. Bulletin, Association of Engineering Geologists, Vol XIII, No. 3, 1976. (Coauthor)

LANGUAGES

English

Ross William Boulanger

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Education

Ph.D. Geotechnical Engineering, University of California, Berkeley, CA (November 1990)
M.S. Geotechnical Engineering, University of California, Berkeley, CA (May 1987)
B.A.Sc. Civil Engineering, University of British Columbia, Vancouver, B. C., Canada (May 1986)

Registration

Registered Professional Civil Engineer in the State of California (since June 1992)

Professional History

Director, Center for Geotechnical Modeling, Department of Civil and Environmental Engineering, University of California, Davis, CA (2009 - present)
Professor (2002 - present), Vice-Chair (1998 - 2001), Associate Professor (1998 - 2002) and Assistant Professor (1992 - 1998), Department of Civil and Environmental Engineering, University of California, Davis, CA
Senior Staff Engineer, Woodward-Clyde Consultants, Oakland, CA (1990 - 1992)
Lecturer, University of California, Berkeley, CA (January 1992 - May 1992)
Lecturer, University of California, Davis, CA (September 1991 - December 1991)
Staff Engineer, Woodward-Clyde Consultants, Oakland, CA (May 1987 - August 1987)

Awards and Honors

Distinguished Lecture Award, Earthquake Engineering Research Institute (2019)
ISET Shamsher Prakash Award, Indian Society of Earthquake Technology (ISET), India (2018)
Member, National Academy of Engineering (elected 2017)
Cross Canada Lecturer, Fall 2016 Tour, Canadian Geotechnical Society (2016)
Ralph B. Peck Award, American Society of Civil Engineers (2016)
TK Hsieh Award, Institution of Civil Engineers, UK (2014)
Fellow, American Society of Civil Engineers (2012)
Norman Medal, American Society of Civil Engineers (2006)
Outstanding Paper Award, United States Society on Dams, 25th Annual Conference (2005)
Walter L. Huber Civil Engineering Research Prize, American Society of Civil Engineers (2002)
Shamsher Prakash Research Award, SP Foundation (2001)
Arthur Casagrande Professional Development Award, American Society of Civil Engineers (1998)
Distinguished Alumni Award, University College of the Cariboo, BC, Canada (1998)
National Science Foundation CAREER Award (1995)
Parker Davies Trask Fellowship, University of California, Berkeley (1986)
Industrial Liaison Program Fellowship, University of California, Berkeley (1986)
N. M. Skalbania Limited Prize, University of British Columbia (1986)

Professional Affiliations

Member, US National Academy of Engineering (NAE)
Fellow, American Society of Civil Engineers (ASCE)
Member, International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE)
Member, Earthquake Engineering Research Institute (EERI)
Member, United States Society on Dams (USSD)
Member, Association of State Dam Safety Officials (ASDSO)
Member, Geoprofessional Business Association (GBA)

Professional Service and Special Assignments

Member, Awards Committee, ASCE Geo-Institute (2019 - present)
Member (2016 - present) and Chair (2018 - 2019), NHERI Council, Natural Hazards Engineering Research Infrastructure network for the National Science Foundation
Member, NHERI Science Plan Task Group, Natural Hazards Engineering Research Infrastructure program (2016 - present)
Member, USSD Earthquakes Committee, United States Society on Dams (2010 - present)
Chair (2016 - 2019), Vice-Chair (2009 - 2016, 2019 - present), and Member (2006 - present), Technical Committee No. 203 – Earthquake Geotechnical Engineering, International Society of Soil Mechanics and Geotechnical Engineering
Chair (2004 - 2009), Co-chair (2000 - 2004) and Member (1996 - present), Earthquake Engineering and Soil Dynamics Committee of ASCE's Geo-Institute
Advisory Panel Member, Geo-Engineering Earthquake Reconnaissance Association (2005 - present)
Member, EERI Board of Directors, Earthquake Engineering Research Institute (2016 – 2020)
Member, Organizing Committee, NSF-funded Workshop to Advance the NHERI 5-Year Science Plan, Washington, DC, March 18-19 (2019)
Co-Chair with D. Wijewickreme, 3rd International Conference on Performance-based Design in Earthquake Geotechnical Engineering, ISSMGE Technical Committee TC203 on Earthquake Geotechnical Engineering, Vancouver, B.C., Canada, July 16-19 (2017)
Member, USSD Board of Directors, United States Society on Dams (2009 - 2015)
International Core Member, Center for Urban Earthquake Engineering, Tokyo Institute of Technology, Tokyo, Japan (2007 - 2013)
Chair (2014) and Member (2012-2013), EERI Nominating Committee, Earthquake Engineering Research Institute
Co-lead, Geotechnical Extreme Events Reconnaissance (GEER) team for the March 11, 2011, Tohoku earthquake, Japan (2011 - 2012)
International Observer, ERTC-12 Evaluation Committee for the Application of the Eurocode 8, International Society of Soil Mechanics and Geotechnical Engineering (2006 - 2010)
Member, Research Committee, Pacific Earthquake Engineering Research (PEER) Center (2003 - 2010)
Team Member, International Familiarization of ISO Code for Geotechnical Earthquake Resistant Design, New Energy and Industrial Technology Development Organization, Japan (2005 - 2009)
Chair, Organizing Committee for the ASCE Geo-Institute's Specialty Conference on Geotechnical Earthquake Engineering and Soil Dynamics, Sacramento, CA, May 18-22, 2008 (2004-2008)
Member, Site Operations and Shared Use Committee of NEES (2003 - 2006)
Chair, Proceedings Committee, 100th Anniversary Earthquake Conference – commemorating the 1906 San Francisco earthquake, A joint conference co-convened by EERI, SSA, and OES in San Francisco, CA, April 18-22, 2006 (2004 - 2006)
Organizer, U. S.-Japan Workshop on the Simulation and Performance of Pile Foundations in Liquefied and Laterally Spreading Ground, sponsored by the PEER Center, Davis, CA, March 16-18 (2005)

Member, ISO/TC98/SC3/WG10 Working Group on Draft Standard for Seismic Actions on Geotechnical Works, International Standards Organization (2002 - 2005)
Member, A2K03 Committee on Foundations of Bridges and Other Structures, TRB (2002 - 2004)
Editor, Journal of Geotechnical and Geoenvironmental Engineering, ASCE (2001 - 2004)
Member, Publications Policy Committee of EERI (1999 - 2004)
Organizer, U.S.-Japan Seminar on Seismic Disaster Mitigation in Urban Area by Geotechnical Engineering, Anchorage, AK, June 26-27, sponsored by the National Science Foundation (NSF), East Asia and Pacific Program (2002)
Editorial Board Member, Journal of Geotechnical and Geoenvironmental Engineering, ASCE (2000 - 2001)
Technical Specialist for external review of US Army Corps of Engineers research on liquefaction at high confining stresses, Vicksburg, MS (2000 - 2001)
Member of Geotechnical Reconnaissance Team funded by the National Science Foundation to report on the effects of the 1999 Chi-Chi earthquake in Taiwan (1999)
Member of Geotechnical Reconnaissance Team funded by the National Science Foundation to report on the effects of the 1999 Kocaeli earthquake in Turkey (1999)
Organizing Committee Member, Workshop on the Integration of Engineering Research and Education, sponsored by the National Science Foundation (NSF), Civil and Mechanical Systems Division, Arlington, VA, November 8-10, 1998
Member of Geotechnical Reconnaissance Team funded by the National Science Foundation to report on the effects of the 1995 Hyogoken-Nanbu earthquake near Kobe, Japan (1995)
Organizing Committee Member, Stability and Performance of Slopes and Embankments - II, an ASCE Specialty Conference in Berkeley, CA, June 29 - July 1, 1992

Consulting Activities

Clean Water Services. Member, Consulting Review Board for design alternative studies by CWS and the U.S. Bureau of Reclamation for Scoggins Dam, Tualatin Project, OR (2019 - present)
Metro Vancouver. Member, Technical Review Board for Capilano Main No. 5, Stanley Park Water Supply Tunnel Project, Vancouver, BC, Canada (2019 - present)
Contra Costa Water District. Member, Technical Review Board for Los Vaqueros Reservoir Expansion Project, CA (2019 - present)
U.S. Army Corps of Engineers. Independent External Peer Review (IEPR) Panelist for review of the Isabella Lake Dam Safety Modification Project Construction Phase, CA (2019 - present)
Rio Tinto Kennecott Copper. Member, Independent Technical Review Board for design and evaluation of tailing embankments, UT (2018 - present)
Metro Vancouver. Member, Geotechnical Expert Advisory Panel for Iona Island Wastewater Treatment Plant, Vancouver, BC, Canada (2018 - present)
Santa Clara Valley Water District. Technical review regarding dam safety evaluations of Coyote, Chesbro, and Uvas Dams, CA (2018 - present)
Metro Vancouver. Member, Technical Review Board for Annacis Water Supply Tunnel, Surrey and New Westminster, BC, Canada (2016 - 2019)
Grant County Public Utility District No. 2. Member, Board of Consultants for seismic evaluation and modification of the embankment dam at Priest Rapids on the Columbia River, WA (2015 - present)
Grant County Public Utility District No. 2. Member, Technical Integration Team for seismic risk evaluation of the embankment dam at Wanapum on the Columbia River, WA (2015 - present)
Los Angeles Department of Water and Power. Member, Board of Consultants for seismic assessment and improvement projects: Bouquet Canyon Reservoir Dams No. 1 and 2, Eagle Rock Dam, Ivanhoe Dam, North Haiwee Dam No. 2, South Haiwee Dam, Stone Canyon Dam, Tinemaha Dam, Upper Stone Canyon Dam, and the Van Norman Stormwater Capture project, CA (2013 - present)

GeoPentech. Review of liquefaction evaluations for North Shore Wastewater Treatment Plant, North Vancouver, BC, Canada (2019 - 2020)
California Department of Water Resources, Division of Engineering. Technical support for seismic evaluation of B. F. Sisk Dam, CA (2007 - 2018)
Cotton, Shires and Associates, Inc. Technical review and consultation regarding investigations and analyses of settlement at the Millennium Tower, San Francisco, CA (2016 - 2018)
Pacific Gas and Electric Co. Member, Dam Risk Panel for seismic risk evaluation of hydro generation facilities, San Francisco, CA (2015 - 2017)
Los Angeles Department of Water and Power. Member, Technical Review and Advisory Panel, Headworks Reservoir Project, Los Angeles, CA (2009 - 2016)
U.S. Army Corps of Engineers. Independent Expert Project Review (IEPR) Panelist for review of the Isabella Lake Dam Safety Modification Project, CA (2015 - 2016)
Geosyntec Consultants, Inc. Technical review and consultation regarding seismic deformation analyses of the Blue Ridge Dam, Fannin County, GA (2014 - 2016)
Bechtel Canada Co. Technical review and consultation regarding site characterization and seismic evaluation for a proposed marine facility, BC, Canada (2015 - 2016)
East Bay Municipal Utility District. Member, Technical Review Board for the seismic upgrades of Chabot Dam, San Leandro, CA (2015 - 2016)
Earthquake Commission of New Zealand. Expert panel for peer review of engineering studies regarding increased liquefaction vulnerability of residential land in Christchurch, New Zealand (2015)
Deltares. Workshop to examine seismic evaluation practices and remediation strategies for levees in the Netherlands, Groningen, The Netherlands (2015)
Tennessee Valley Authority. Workshop to develop guidance document regarding liquefaction assessments with emphasis on numerical modeling, Knoxville, TN (2015)
New Zealand Ministry of Business, Innovation, and Employment. Peer review of ground improvement guidelines for Christchurch, New Zealand (2014 - 2015)
Earthquake Commission of New Zealand. Peer review of ground improvement trials and land damage work, Christchurch, New Zealand (2014 - 2015)
U.S. Department of the Interior, Bureau of Reclamation. Technical review of the Bureau of Reclamation's Embankment Dam Seismic Analysis Design Standard, Denver, CO (2014 - 2015)
Shimmick\FCC\Impregilo Joint Venture. Member, Technical Advisory Panel for review of design and construction of the main span bridge and approach bridges of the Gerald Desmond Bridge Project, Port of Long Beach, Los Angeles, CA (2012 - 2015)
U.S. Army Corps of Engineers (via URS). Quality control and consistency (QCC) review panel coordination meeting, Risk Management Center, Lakewood, CO (2014)
Geocomp Corporation. Technical review services for the Tennessee Valley Authority regarding seismic evaluations of Kingston Fossil Plant Stilling Pond, TN (2014)
EBA Engineering Consultants, Ltd. Technical review and consultation regarding seismic design of the Evergreen Line Rapid Transit Project, Vancouver, BC, Canada (2013 - 2014)
U.S. Army Corps of Engineers. Technical Specialist for review of seismic evaluations for Success Dam, CA (1999 - 2014)
GeoPentech. Consultation regarding seismic site characterization and site response analyses for the San Onofre Nuclear Generating Station, San Onofre, CA (2013)
URS Corporation. Technical review of seismic evaluations for Gatun Dam, Panama (2012)
U.S. Department of the Interior, Bureau of Reclamation. Member, Consulting Review Board, Scoggins Dam, Tualatin Project, OR (2011 - 2012)
GEI Consultants, Inc. Member of Technical Expert Panel for review of Delta Seismic Design studies for California Department of Water Resources, CA (2011 - 2012)
Tennessee Valley Authority. Peer review of seismic properties study for Kingston Coal Fly Ash, Kingston Fossil Plant, Harriman, TN (2011)

B.C. Hydro. Technical Specialist for review of seismic evaluations for the John Hart Powerhouse Replacement and Dam Deficiency Investigation Projects, Campbell River, BC, Canada (2009 - 2011)

U.S. Army Corps of Engineers. Technical Panelist for review of seismic evaluations for Isabella Dam, CA (2005 - 2011)

California Department of Water Resources. Independent Review Committee, Delta Habitat Conservation and Conveyance Program, CA (2010)

EBA Engineering Consultants, Ltd. Port Mann Highway Project, Seismic Engineering Review, Category 3 Checking for the Port Mann Bridge, Vancouver, Canada (2009-2010)

Terra / GeoPentech Joint Venture. Member, Technical Review Board for the seismic evaluations of Camanche Dam, CA (2008 - 2009)

Klohn Crippen Berger Ltd. Technical support for seismic testing of tailings samples from Greens Creek project, Canada (2007 - 2009)

URS Corporation. Member, Soil Strength Advisory Panel for the DWR Urban Levee Geotechnical Evaluations Program, Sacramento, CA (2008)

ENGEO Incorporated. Technical Panelist for review of Treasure Island geotechnical conceptual design work, CA (2007 - 2008)

URS Corporation. Member, Seismic Review Panel for the Delta Risk Management Strategy Project's seismic levee vulnerability studies, CA (2007 - 2008)

B.C. Hydro. Member, Technical Review Board for seismic deficiency investigations on Cheakamus Dam, B.C., Canada (2007 - 2008).

Terra / Ninyo & Moore Joint-Venture. Member, Independent Review Board, San Pablo Dam Seismic Upgrading Project, CA (2006 - 2007)

Terrain Engineering. Consultation on the causes of damages to the sewer system at Metro Air Park, Sacramento, CA (2006 - 2007)

GeoPentech. Consultation for seismic evaluation of tailings dam (2005 - 2006)

California Department of Water Resources, Division of Safety of Dams. Member, Consulting Board for Earthquake Analysis (2005)

Harlan Tait Associates. Cyclic triaxial testing of soil samples from Piedmont Reservoir Dam, Piedmont, CA (2002 - 2003)

Farrell Design-Build Companies, Inc. Technical review of rammed aggregate pier technology, Placerville, CA (2002 - 2003)

California Division of Safety of Dams. Technical Specialist for review of seismic evaluations for dams in California (2000 - 2002)

U. S. Army Corps of Engineers. External reviewer of liquefaction research by the Earthquake Research and Development Center (ERDC) (2000 - 2002)

RMC Geoscience. Review panel for liquefaction analyses and ground improvement efforts at the Union Pacific Rail Yard, Sacramento, CA (1998 - 1999)

Sub-consultant to Dr. I. M. Idriss. Dynamic properties for foundation materials along the realignment of the outlet works for Prado Dam, CA (1997 - 1998)

Parsons Brinckerhoff Quade & Douglas, Inc. Study of ground improvement issues for the Posey and Webster Street Tubes Seismic Retrofit Project, Alameda, CA (1996 - 1997)

Sub-consultant to Dr. I. M. Idriss. Review of a soil-structure interaction study for two 15-story structures in Oakland, CA (1995)

Miller Pacific Engineering Group, as retained through the Law Offices of Clinton A. Johnson. Consultation regarding liquefaction hazards and ground improvement by compaction grouting for the Santa Cruz Transit District's Maintenance and Operations Facility, CA (1993 - 1994)

Woodward-Clyde Consultants. Final design, plans and specifications for ground improvement by compaction grouting, stone columns, and a steel-reinforced DSM wall at the California Water Operations Center, Sacramento, CA (1992)

Woodward-Clyde Consultants. Evaluation of compaction grouting effectiveness for ground densification within a test section at the California Water Operations Center, Sacramento, CA (1992)

Contech Construction Products, Inc. Performed finite element analyses of long-span, flexible, metal box culvert structures to evaluate the effects of observed field deformations on load carrying capacity. Compared results with the Simplified Design Procedure in use (1988)

Publications

Monographs

1. Idriss, I. M., and Boulanger, R. W. (2008). *Soil liquefaction during earthquakes*. Monograph MNO-12, Earthquake Engineering Research Institute, Oakland, CA, 261 pp.

Journals

104. Krage, C. P., Price, A. B., Lukas, W. G., DeJong, J. T., DeGroot, D. J., and Boulanger, R. W. (2019). "Slurry deposition method of low plasticity intermediate soils for laboratory element testing." Geotechnical Testing Journal, GTJODJ, ASTM, 10.1520/GTJ20180117.
103. Boulanger, R. W., and Ziotopoulou, K. (2019). "A constitutive model for clays and plastic silts in plane-strain earthquake engineering applications." Soil Dynamics and Earthquake Engineering, 127(2019): 105832, 10.1016/j.soildyn.2019.105832.
102. Boulanger, R. W. (2019). "Nonlinear Dynamic Analyses of Austrian Dam in the 1989 Loma Prieta Earthquake." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 145(11): 05019011, 10.1061/(ASCE)GT.1943-5606.0002156.
101. Price, A. B., Boulanger, R. W., and DeJong, J. T. (2019). "Centrifuge modeling of variable rate cone penetration in low-plasticity silts." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 145(11): 04019098, 10.1061/(ASCE)GT.1943-5606.0002145.
100. Darby, K. M., Boulanger, R. W., and DeJong, J. T. (2019). "Effect of partial drainage on cyclic strengths of saturated sands in dynamic centrifuge tests." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 145(11): 04019089, 10.1061/(ASCE)GT.1943-5606.0002085.
99. Darby, K. M., Hernandez, G. L., DeJong, J. T., Boulanger, R. W., Gomez, M. G., and Wilson, D. W. (2019). "Centrifuge model testing of liquefaction mitigation via microbially induced calcite precipitation." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 145(10): 04019084, 10.1061/(ASCE)GT.1943-5606.0002122.
98. Moug, D. M., Price, A. B., Parra Bastidas, A. M., Darby, K. M., Boulanger, R. W., and DeJong, J. T. (2019). "Mechanistic development of CPT-based cyclic strength correlations for a clean sand." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 145(10): 04019072, 10.1061/(ASCE)GT.1943-5606.0002101.
97. Boulanger, R. W., Munter, S. K., Krage, C. P., and DeJong, J. T. (2019). "Liquefaction evaluation of interbedded soil deposit: Çark Canal in 1999 M7.5 Kocaeli Earthquake." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 145(9): 05019007, 10.1061/(ASCE)GT.1943-5606.0002089.
96. Khosravi, M., Boulanger, R. W., Wilson, D. W., Olgun, C. G., Shao, L., and Tamura, S. (2019). "Stress transfer from rocking shallow foundations on soil-cement reinforced clay." Soils and Foundations, Japanese Geotechnical Society, 59(2019): 966-981, 10.1016/j.sandf.2019.04.003.
95. Moug, D. M., Boulanger, R. W., DeJong, J. T., and Jaeger, R. A. (2019). "Axisymmetric simulations of cone penetration in saturated clay." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 145(4): 04019008, 10.1061/(ASCE)GT.1943-5606.0002024.
94. Darby, K. M., Boulanger, R. W., DeJong, J. T., and Bronner, J. D. (2019). "Progressive changes in liquefaction and cone penetration resistance across multiple shaking events in centrifuge tests." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 140(3): 04018112, 10.1061/(ASCE)GT.1943-5606.0001995.

93. Boulanger, R. W., Khosravi, M., Khosravi, A., and Wilson, D. W. (2018). "Remediation of liquefaction effects for an embankment using soil-cement walls: Centrifuge and numerical modeling." Soil Dynamics and Earthquake Engineering, 114(2018), 38-50, 10.1016/j.soildyn.2018.07.001.
92. Tamura, S., Khosravi, M., Wilson, D. W., Rayamajhi, D., Boulanger, R. W., Olgun, C. G., and Wang, Y. (2018). "A simple method for detecting cracks in soil-cement reinforcement for centrifuge modeling." International Journal of Physical Modeling in Geotechnics, 18(6): 281-289, 10.1680/jphmg.17.00036.
91. Khosravi, M., Boulanger, R. W., Wilson, D. W., Olgun, C. G., Tamura, S., and Wang, Y. (2017). "Dynamic centrifuge tests of structures with shallow foundations on soft clay reinforced by soil-cement grids." Soils and Foundations, Japanese Geotechnical Society, 57:501-513, 10.1016/j.sandf.2017.06.002.
90. Price, A. B., DeJong, J. T., and Boulanger, R. W. (2017). "Cyclic loading response of silt with multiple loading events." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 143(10): 04017080, 10.1061/(ASCE)GT.1943-5606.0001759.
89. Boulanger, R. W., Moug, D. M., Munter, S. K., Price, A. B., and DeJong, J. T. (2016). "Evaluating liquefaction and lateral spreading in interbedded sand, silt, and clay deposits using the cone penetrometer." Australian Geomechanics, The Australian Geomechanics Society, 51(4), 109-128.
88. Boulanger, R. W., and Montgomery, J. (2016). "Nonlinear deformation analyses of an embankment dam on a spatially variable liquefiable deposit." Soil Dynamics and Earthquake Engineering, 91(2016), 222-233, 10.1016/j.soildyn.2016.07.027.
87. Montgomery, J., and Boulanger, R. W. (2016). "Effects of spatial variability on liquefaction-induced settlement and lateral spreading." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 2017, 143(1), 04016086, 10.1061/(ASCE)GT.1943-5606.0001584.
86. Ziotopoulou, K., and Boulanger, R. W. (2016). "Plasticity modeling of liquefaction effects under sloping ground and irregular cyclic loading conditions." Soil Dynamics and Earthquake Engineering, 84 (2016), 269-283, 10.1016/j.soildyn.2016.02.013.
85. Khosravi, M., Boulanger, R. W., Tamura, S., Wilson, D. W., Olgun, G., and Wang, Y. (2016). "Dynamic centrifuge tests of soft clay reinforced by soil-cement grids." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 142(7), 04016027, 10.1061/(ASCE)GT.1943-5606.0001487.
84. Rayamajhi, D., Boulanger, R. W., Ashford, S. A., and Elgamal, A. (2016). "Dense granular columns in liquefiable ground: Effects on deformations." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 142(7), 04016024, 10.1061/(ASCE)GT.1943-5606.000147.
83. Rayamajhi, D., Ashford, S. A., Boulanger, R. W., and Elgamal, A. (2016). "Dense granular columns in liquefiable ground: Shear reinforcement and cyclic stress ratio reduction." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 142(7), 04016023, 0.1061/(ASCE)GT.1943-5606.0001474.
82. van Ballegooy, S., Wentz, F., and Boulanger, R. W. (2015). "Evaluation of CPT-based liquefaction procedures at regional scale." Soil Dynamics and Earthquake Engineering, 79 (2015), 315-334, 10.1016/j.soildyn.2015.09.016.
81. Boulanger, R. W., and Idriss, I. M. (2015). "CPT-based liquefaction triggering procedure." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 142(2), 04015065, 10.1061/(ASCE)GT.1943-5606.0001388.
80. Boulanger, R. W., and Idriss, I. M. (2015). "Magnitude scaling factors in liquefaction triggering procedures." Soil Dynamics and Earthquake Engineering, 79 (2015), 296-303, 10.1016/j.soildyn.2015.01.004.
79. Idriss, I. M., and Boulanger, R. W. (2015). "2nd Ishihara Lecture: SPT- and CPT-based relationships for the residual shear strength of liquefied soil." Soil Dynamics and Earthquake Engineering, 68, 57-68, 10.1016/j.soildyn.2014.09.010.

78. Rayamajhi, D., Tamura, S., Khosravi, M., Boulanger, R. W., Wilson, D. W., Ashford, S. A., and Olgun, C. G. (2015). "Dynamic centrifuge tests to evaluate reinforcing mechanisms of soil-cement columns in liquefiable sand." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 141(6), 04015015, 10.1061/(ASCE)GT.1943-5606.0001298.
77. Howell, R., Rathje, E. M., and Boulanger, R. W. (2014). "Evaluation of simulation models of lateral spread sites treated with prefabricated vertical drains." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 141(1), 04014076, 10.1061/(ASCE)GT.1943-5606.0001185.
76. Montgomery, J., Boulanger, R. W., and Harder, L. F., Jr. (2014). "Examination of the K_σ overburden correction factor on liquefaction resistance." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 140(12), 04014066, 10.1061/(ASCE)GT.1943-5606.0001172.
75. Armstrong, R. J., Boulanger, R. W., and Beaty, M. H. (2014). "Equivalent static analyses of piled bridge abutments affected by earthquake-induced liquefaction." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 140(8), 04014046, 10.1061/(ASCE)GT.1943-5606.0001152.
74. Khosravifar, A., Boulanger, R. W., and Kunnath, S. K. (2014). "Design of extended pile shafts for the effects of liquefaction." Earthquake Spectra, EERI, 30(4), 1775-1799, 10.1193/032512EQS107M.
73. Khosravifar, A., Boulanger, R. W., and Kunnath, S. K. (2014). "Effects of liquefaction on inelastic demands on extended pile shafts." Earthquake Spectra, EERI, 30(4), 1749-1773, 10.1193/032412EQS105M.
72. Dahl, K, R., DeJong, J. T., Boulanger, R. W., Pyke, R., and Wahl, D. (2014). "Characterization of an alluvial silt and clay deposit for monotonic, cyclic and post-cyclic behavior." Canadian Geotechnical Journal, 51(4): 432-440, 10.1139/cgj-2013-0057.
71. Maki, I. P., Boulanger, R. W., DeJong, J. T., and Jaeger, R. A. (2014). "State-based overburden normalization of cone penetration resistance in clean sand." Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 140(2), 04013006, 10.1061/(ASCE)GT.1943-5606.0001020.
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