CONNOR P. HAYDEN, PH.D.

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EDUCATION

University of California, Berkeley — Berkeley, CA

Ph.D., Civil Engineering, Minors: Risk Analysis and Seismology — December 2014
Dissertation: *Liquefaction-Induced Building Performance and Near-Fault Ground Motions*
Advisor: Dr. Jonathan D. Bray

University of California, Berkeley — Berkeley, CA

M.S., Civil Engineering — May 2010

University of Vermont (UVM) — Burlington, VT

B.S., Civil Engineering, Minor: Biology — May 2009

HONORS AND AWARDS

- National Science Foundation Graduate Research Fellowship (UC Berkeley) — 2010–2013
- H. Bolton Seed Outstanding Graduate Student Award (UC Berkeley) — 2010
- ENGEO Graduate Fellowship (UC Berkeley) — 2010
- Phelps Award for Highest Academics and Character (UVM) — 2009
- Magna Cum Laude with Honors and Research Thesis (UVM) — 2009
- Helix Research Fellowship (UVM) — 2008
- Tau Beta Pi and Chi Epsilon Honor Societies (UVM) — 2008

EXPERIENCE

Fugro Earthquake Engineering Group, Walnut Creek, CA — 2014–Present

Performed a variety of geotechnical earthquake engineering analyses, including site characterization, dynamic site response, liquefaction assessment, dynamic slope stability, probabilistic seismic hazard analyses, ground motion selection, spectral matching, and analyses of piles and pile groups. Example projects include the following:

- 3-D Seismic Site Response for Diablo Canyon Nuclear Power Plant, USA—Assessment of highly variable shear wave velocity and inclined shear waves at the plant using FLAC^{3D};
- New Bridge over the Saint Lawrence, Montreal, Canada—Pile foundation design and extensive liquefaction assessments, including 2-D, effective-stress, dynamic slope stability analyses in FLAC with UBCSAND and PM4SAND;
- PEMEX Offshore Platforms, Gulf of Mexico—Site characterization, site response, liquefaction triggering, and dynamic soil-pile interaction assessments for eight offshore platforms; and
- Sonata Premier PSHA, Metro Manilla, Philippines—Probabilistic seismic hazard analysis, design spectra development, ground motion selection, and spectral matching for a 50-storey tower.

Centrifuge Test of Adjacent Buildings Affected by Liquefaction, UC Berkeley 2013–2014

- Led the planning, execution, and analysis of results for final UC Davis centrifuge test as part the NEES City Block series
- Examined structure-soil-structure interaction of adjacent buildings during liquefaction
- Coordinated with collaborators from five universities and supervised undergraduate assistant
- Synthesized results with previous centrifuge test into journal article and also included results in second database journal article

Post-Earthquake Liquefaction Damage Case Histories in Chile, UC Berkeley 2012–2014

- Led site investigations, including SPT and CPT, at key bridges and a hospital affected by liquefaction during the 2010 Chile Earthquake
- Developed case histories of structure-foundation-soil interaction for buildings and bridges
- Worked with US and Chilean collaborators from several universities

Near-Fault Ground Motions, UC Berkeley 2011–2014

- Developed automated method to classify near-fault records in NGA-West2 database as pulse or non-pulse motions
- Provided simplified approach to select pulse motions for a suite used in time history analysis
- Results included in NIST ATC-82 report, presented talks, conference paper, and journal article

Graduate Student Instructor, UC Berkeley Spring 2010

- Assisted Prof. J. Bray with CE175, Geotechnical and Geoenvironmental Engineering
- Held weekly discussion sessions, office hours, and assisted with weekly laboratory exercises

Geotechnical Laboratory Research, UVM 2008–2009

- Helix Summer Internship (2008)—University-wide competitive research internship
- Tested 25 shale samples for Atterberg limits, clay fraction, and mineralogy (X-ray diffraction)
- Assembled and employed a newly acquired ring shear apparatus for improved residual strength testing of the shale specimens

NSF Interdisciplinary Training in Mathematics and Biology, UVM 2005–2007

- Performed research on fire ant ecology including modeling and lab work
- Presented findings at conference and published journal article

JOURNAL ARTICLES

Allmond, J., Kutter, B. L., Bray, J., and **Hayden, C.** (2015). "A new database for foundation and ground performance in liquefaction experiments." *Earthquake Spectra*, 31(4), 2485–2509.

Hayden, C. P., Zupan, J. D., Bray, J. D., Allmond, J.D., and Kutter, B. L. (2015). "Centrifuge tests of adjacent mat-supported buildings affected by liquefaction." *J. of Geotechnical and Geoenvironmental Engineering*, 141(3), 04014118.

Hayden, C. P., Bray, J. D., and Abrahamson, N. A. (2014). "Selection of near-fault pulse motions." *J. of Geotechnical and Geoenvironmental Engineering*, 140(7), 04014030.

Helms, K. R., **Hayden, C. P.**, and Vinson, S. B. (2011). "Plant-based food resources, trophic interactions among alien species, and the abundance of an invasive ant." *Biological Invasions*, 13(1), 67–79.

Hayden, C. P., Kathryn, P., and Dewoolkar, M. M. “Site-specific drained residual shear strength.” *In preparation.*

CONFERENCE PAPERS AND REPORTS

Hayden, C. P., Bray, J. D., Abrahamson, N. A., and Acevedo-Cabrera, A. L. (2012). “Selection of near-fault pulse motions for use in design.” *Proc., 15th World Conf. on Earthquake Engineering*, Lisbon, Portugal.

Hayden, C. P. (2014). *Liquefaction-Induced Building Performance and Near-Fault Ground Motions.* Ph.D. Thesis. University of California, Berkeley.

Hayden, C. P., Allmond, J. D., Rawlings, I. A., Kutter, B. L., Bray, J. D., Hutchinson, T. C., Fiegel, G. L., Zupan, J. D., and Whittaker, A. S. (2014). “Seismic Performance Assessment in Dense Urban Environments: Centrifuge Data Report for Test-6.” University of California at Davis Center for Geotechnical Modeling Report No. UCD/CGMDR-XX/XX, Davis, CA.

Working group member (Appendix C) of: NIST. (2011). "Selecting and scaling earthquake ground motions for performing response-history analyses." *Prepared by NEHRP Consultants Joint Venture for National Institute of Standards and Technology*, Gaithersburg, MD.

Helms, K. R. and **Hayden, C.P.** Split sex ratio evolution with simple family relatedness structure and facultative worker biasing. Annual Meeting of the Society of Mathematical Biology. San Jose, CA, July 2007.

ACTIVITIES AND SKILLS

- Engineer-in-Training (EIT), License: 017.0053962 (VT) — April 2009
- Earthquake Engineering Research Institute — 2014–Present
- American Society of Civil Engineers — 2009–Present
- Deep Foundations Institute — 2009–Present
- Water Survival/Helicopter Underwater Egress Training Certified — 2014–Present
- Proficient in the following software: MATLAB, FLAC, FLAC^{3D}, PLAXIS, SLOPE/W, AutoCAD, DEEPSOIL, SHAKE, LPILE, GROUP, DYNA6, HAZ, RSPMATCH, Adobe Photoshop, and Microsoft Office

TEACHING STATEMENT

Several of my professors over the years have played critical roles in my development as a researcher and engineer through their teaching, mentorship, and collaboration on research. I hope I can do the same for the undergraduate and graduate students at Iowa State University and thus play an important part in educating tomorrow's engineers, policy makers, researchers, and educators. Given my background, I am most qualified to teach geotechnical courses such as Geotechnical Engineering (CE 360), Foundation Engineering (CE 360), or Dynamics of Soils and Foundations (CE 568). However, I would welcome the opportunity to teach a variety of undergraduate and graduate geotechnical and general civil engineering courses. Depending on the material covered in CE 568 and the demand for it, I would be eager to develop a graduate course on geotechnical earthquake engineering including aspects of ground motion development and probabilistic hazard assessments.

As a Graduate Student Instructor for an undergraduate geotechnical course at UC Berkeley, I led weekly discussion sessions, held office hours, and assisted with laboratory sessions, which greatly shaped my views on education. Hands-on experience through laboratory sessions, site visits, and in-class demonstrations can be particularly beneficial for learning, especially in geotechnical engineering. Based on my involvement in several collaborative research projects and from my industry experience, I believe that combining team-based projects with real-world engineering problems can be extremely effective. For example, our geotechnical laboratory class at Berkeley consisted of a collaborative, semester-long engineering project. We visited a site, collected soil samples, and performed various lab tests. We then used these data in the analysis and design of a berm documented in an engineering report. My undergraduate senior capstone design course followed a service-learning approach, which involved working with the Vermont Agency of Transportation on a landslide threatening a state highway. Similar approaches excite students, improve understanding, enhance problem solving abilities, and develop transferrable skills less used in traditional course work (e.g., data interpretation, geotechnical software use, report writing, communicating with technical and nontechnical audiences, and other interpersonal skills). Recognizing that all students are different and learn best in different ways, I believe courses should include a mix of teaching and learning approaches.

Close ties to industry have a number of benefits for student teaching, mentorship, and research. At Berkeley, professors' interactions with engineering firms led to a number of opportunities, including field trips (e.g., to see SPT or CPT performed, site visits of important construction projects), internships or full-time positions, and student funding (e.g., an ENGEO fellowship funded my M.S.). Involvement with industry and government also keeps professors aware of current practice and relevant skills, provides consulting opportunities, and can be a source of ideas and funding for research addressing critical engineering issues. For over a year, I have been working in the geotechnical consulting industry. I am scheduled to take the CA PE exam in the spring, which will be helpful in pursuing ties with industry and government as part of my academic career.

Although research is often left to graduate students, it can be invaluable in undergraduate education as well. My experience performing research in a biology lab as part of an NSF program for undergraduates first piqued my interest in research. Later, undergraduate research on residual shear strength of shales solidified my interest in geotechnical engineering and research. Such opportunities are beneficial for the undergraduates, graduate students, and professors involved. As a graduate student, I supervised an undergraduate research assistant who was part of the team assembling the model for the centrifuge test I led at UC Davis. In addition to being a great benefit to the team, I believe this was a valuable experience for her as she went on to obtain a graduate degree in geotechnical engineering.

Research and teaching are even more closely intertwined than may first appear. Performing important research, particularly with open-ended real world application, and sharing it in the classroom, helps students see the importance of our field and enhances enthusiasm about their future profession. Conversely, skills essential for an effective educator, such as conveying new information to a wide audience through a variety of approaches, are also essential in disseminating research findings to have a broad impact on society. I look forward to developing novel approaches combining teaching and research in my future academic career.

RESEARCH STATEMENT

Current research illustrates the importance of the interactions between structures and the soil they are founded on through soil-structure interaction (SSI); however, less is known about the interaction of adjacent structures through structure-soil-structure interaction (SSSI) during an earthquake. The resilience of cities, where neighboring structures are generally quite close, depends on an improved understanding of SSSI. For example, the earthquake performance of systems of adjacent structures on liquefiable soil depends on the ground motion, soil characteristics, and the properties of the structure under consideration as well as adjacent structures. While at Berkeley, I worked on three projects broadly related to SSI, SSSI, liquefaction, and ground motions: 1) geotechnical centrifuge testing of adjacent buildings affected by liquefaction; 2) investigations of critical infrastructure damaged by liquefaction during the 2010 Chile earthquake; and 3) selection of near-fault ground motions. I intend to expand upon this research and branch into new areas including engineering risk assessment, which is an essential component of sustainable and resilient systems.

Centrifuge Tests of Adjacent Buildings Affected by Liquefaction. When assessing the potential for liquefaction-induced damage, engineers often use models based on free-field observations, which can significantly underestimate demands. Recent studies illustrate the important effects of soil-structure interaction on isolated structures founded on liquefiable soil. However, the lack of research on the interaction of adjacent structures through structure-soil-structure interaction (SSSI) could detrimentally affect the earthquake resilience of urban centers and other areas with closely spaced structures. As part of an effort involving collaborators from many universities, I led the sixth and final City Block centrifuge test performed at UC Davis. This well-instrumented test (over 140 sensors) contained six model structures on liquefiable soil, which allowed a systematic examination of SSI and SSSI (Hayden et al., 2015). I also contributed toward the development of publically available database of liquefaction centrifuge experiments (Allmond et al., 2015). Given the unique and valuable results provided from centrifuge tests, I intend to pursue further research examining the influence of spacing between adjacent structures, mitigation techniques, structure properties, soil stratigraphy, and ground motion characteristics.

Numerical Modeling of SSSI Involving Liquefaction. I have spent much of the last year at Fugro performing numerical analyses for several major projects, including 3-D seismic site response in FLAC^{3D} for the Diablo Canyon Nuclear Power Plant and liquefaction-induced slope instability analyses for a major bridge using the UBCSAND and PM4SAND constitutive models. This experience could be directly applied to my SSSI doctoral research involving liquefaction by first calibrating the UBCSAND and PM4SAND models to the City Block centrifuge tests (Hayden et al., 2015). Next, by performing sensitivity analyses on a wide range of parameters for adjacent structures, input ground motions, and soil profiles, I would develop more comprehensive results. Finally, the most critical parameters could be included in simplified methods for engineering practice, enabling this research to have rapid effects on improving earthquake resilience. Numerical modeling could then be used to analyze case histories such as those developed during the site investigations I performed in Chile following the 2010 earthquake (Hayden, 2014).

Near Fault Pulse Motions. Many earthquake ground motions in the near-fault region contain intense pulses, often attributed to forward-directivity as a fault ruptures toward a site. These pulses can be very damaging to structures, and based on the centrifuge test I performed (Hayden et al., 2015), pulse motions appear more likely to trigger liquefaction and result in larger settlements. However, pulse motions do not always occur, which raises the question of how many pulse motions should be included in a suite of design ground motions. To address this, I developed a new automated pulse classification scheme and applied it to a large database of ground motions to classify each motion. We then developed a simple model to estimate the proportion of pulses as a function of distance and epsilon (Hayden et al., 2014), which can readably used in engineering practice. I intend to continue my research on near fault ground motions. For example, given that pulse motions tend to have short durations and spectral matching tends to remove the pulse-like character of a motion, spectral matching of pulse motions could lead to an underestimate of the demand on non-linear systems. This research would be an excellent opportunity for collaboration with structural engineering faculty.

Future Goals. My doctoral research should provide the foundation for ample opportunities for additional research and to secure funding in the near-term. Over both the near- and long-term, I intend to incorporate probability and engineering risk assessments in the research projects with which I am involved. Given my risk analysis minor, ground motion research, and recent industry experience (e.g., PSHA for a 50-story building), I believe that assessing the significant uncertainties inherent in geotechnical engineering is essential. More reliable quantification of the uncertainty and risk involved in geotechnical projects is a crucial part of sustainability (e.g., efficient allocation of resources throughout construction, life-cycle maintenance, and decommissioning) and resilience (e.g., identification of susceptible components of systems, consequences of failure, or aid in post-disaster recovery). I am also interested in gradually branching out into other interdisciplinary research areas such as multi-hazards, energy applications, or local problems. In particular, I believe that being involved in local geotechnical challenges provides a number of benefits, including identification of important research areas, potential funding sources such as state transportation departments, and opportunities to collaborate with industry.