

AC 2010-718: WANTED! MORE DAM ENGINEERS

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Sarah McCubbin-Cain has been the Information Specialist for the Association of State Dam Safety Officials (ASDSO) since 1998. She provides research and reference services for ASDSO, contributes and edits articles in ASDSO's quarterly Journal of Dam Safety and monthly newsletter, and coordinates the activities of ASDSO's Committee on Education Outreach.

Ms. McCubbin-Cain holds Bachelor of Arts degrees in Psychology and Elementary Education from the University of Kentucky and a Masters in Elementary Education from Georgetown College. She has taught in elementary and middle schools in Kentucky and at the Instituto Guatemalteco-Americano in Guatemala City.

Bruce Tschantz, University of Tennessee - Knoxville

Dr. Bruce A. Tschantz served 37 years on the faculty of the University of Tennessee, Civil & Environmental Engineering Department from 1965 until retirement in June 2002. He specializes in water resources engineering in the areas of surface water hydraulics and hydrology, with focus on urban stormwater management, erosion prevention & sediment control, and dam safety engineering. He received his Master (1962) and Doctorate (1965) degrees in Civil Engineering (Water Resources) from New Mexico State University and his B.S. in Civil Engineering from Ohio Northern University (1960). He has over 40 years' experience in civil engineering research, teaching, and practice in dam safety engineering, stormwater modeling and management, flood analysis, sediment transport, erosion prevention & sediment control, open channel hydraulics, and extreme flood event hydrology.

He has served on several national stormwater hydrology and dam safety panels in ASCE, ASDSO, FEMA, National Academy of Sciences, and Executive Office of the President. During the Carter Administration, he coordinated national dam safety programs and established the Federal Office of Dam Safety in FEMA, where he served as the first Chief of Federal Dam Safety in 1980. Dr. Tschantz has authored or co-authored over 100 articles, papers, abstracts, and reports on his research. Over the last 40+ years, he has been in demand as a special consultant to engineering firms on dam safety and drainage matters and as a technical expert by attorneys at local, regional, national & international levels in accidents and issues related to hydrologic and hydraulic engineering projects.

Over the years, Dr. Tschantz has coordinated and remains active in teaching many state, regional and national one- and two-day workshops in the areas of dam safety, stormwater management, and erosion prevention & sediment control. Since 2001, he has assisted in developing and teaching the Tennessee Erosion Prevention & Sediment Control Training and Certification Program workshops for the Tennessee Department of Environment (TDEC), to over 9000 engineers, local & state regulatory officials, contractors & developers, and utilities personnel across Tennessee.

Dr. Tschantz has developed and taught several workshops to hundreds of engineers and dam owners around the U.S., during the period 2001-present, for the Association of State Dam Safety Officials (ASDSO) and FEMA in the areas of Dam Spillway Hydraulics and Plant and Animal Penetrations of Earthen Dams. Venues included Knoxville, North Carolina, Utah, Boston, Chicago, Oregon, and Oklahoma.

Dr. Tschantz currently chairs the Association of State Dam Safety Officials (ASDSO) Committee on Educational Outreach, through which this proposal would be administered. He is a registered professional engineer in Tennessee, Ohio, Virginia and Alabama and has received numerous awards and honors for his teaching, research, and professional service contributions.

PROFESSIONAL EXPERIENCE (current* and past)

Professor of Civil & Environmental Engineering, Department of Civil & Environmental Engineering, University of Tennessee, Knoxville, 1965-2002.

*Senior Research Associate, Tennessee Water Resources Research Center, Univ. of Tenn., Knoxville, program development and instruction of state-sponsored training workshops for engineers, planners, developers, contractors and local and state regulators in areas of (1) Phase II, post-construction development, Stormwater Management for MS4 communities and (2) Construction Site Erosion & Sediment Control (2002-present)

*Private consulting engineering design & analysis and technical expertise in the areas of hydrologic & hydraulic engineering to several engineering firms, attorneys, municipalities, and others. Consultant and advisor on dam safety to Oak Ridge National Laboratory, Oak Ridge, Tennessee (1986-2001).

Chief of Federal Dam Safety Program (on 1-year leave from University of Tennessee), Federal Emergency Management Agency (FEMA), Washington, D.C., 1980.

Consultant and Advisor on Dam Safety to Executive Office of the President, Office of Science and Technology Policy (OSTP), Washington, D.C., 1977-79.

Hydrologist consultant (GS-12) to U.S. Geological Survey, Knoxville, Tennessee Branch, 1973-76.

Sanitary Engineer (GS-11), U.S. Bureau of Indian Affairs, Albuquerque, N.M., Summers 1962-63.

Civil Engineer (GS-11), Engineering Division of White Sands Missile Range, N.M., 1965.

Dam Safety Consultant and Advisor, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 1987-96.

Consultant and Expert Witness, Tennessee Office of Attorney General and Tennessee Department of Transportation, 1975-79.

Director, Tennessee Water Resources Research Center, University of Tennessee, Knoxville, 1991-94.

Advisor and Consultant, Council of State Governments, Lexington, Ky., 1983-84. RESEARCH AREAS

Dr. Tschantz's research experience at the University of Tennessee has included hydrologic modeling of surface waters; hydraulic modeling of open channel flow; sediment transport modeling of open channel flow; dam safety (state policy and regulation assessment, extreme flood event analysis and outlet structure hydraulics); urban stormwater management--best management practice (BMP) studies & development of local regulations; hydrologic modeling; strip mine area water quality analysis, contaminated sediment transport, remote sensing, and soil erosion and sediment control hydrology. During his tenure with the University of Tennessee, he was principal investigator and coordinator of research projects involving major funding.

WANTED! More Dam Engineers

Abstract

This paper will discuss the student outreach initiatives of the Association of State Dam Safety Officials (ASDSO), a national non-profit association of over 2,800 members representing state and federal agencies, consulting firms, dam and levee owners, manufacturers and suppliers, researchers, college faculty, students and others dedicated to ensuring the safety of our nation's dams.

While new dam construction peaked several decades ago, the nation's existing dams require ongoing maintenance, many need extensive rehabilitation, and others will be removed. The American Society of Civil Engineers has consistently assigned dams a grade of 'D' on its Report Card for America's Infrastructure, noting that the number of dams identified as "unsafe" is increasing at a faster rate than those being repaired.

The disastrous levee failures resulting from Hurricane Katrina and a recent report by the National Committee on Levee Safety³ that cited a need for "creating a cadre of national levee experts" also underscore the need to recruit students into careers dedicated to dam and levee safety. In addition to the nearly 90,000 dams listed in the National Inventory of Dams, the U.S. is home to an estimated 114,000 miles of federal and non-federal levees, many of uncertain condition.

According to surveys of association members conducted by the authors in 2004 and 2009, there is an inadequate supply of qualified candidates for jobs relating to dam and levee safety, and the shortage will likely increase as "boomer-era" experts retire. Accordingly, ASDSO is providing incentives to attract students to the field through a Speakers Bureau, a Student Employment Opportunities Clearinghouse, a Student Paper Competition, scholarship awards, and free student admission to the group's national and regional conferences.

Additionally, ASDSO seeks to increase collaboration between its members and universities in the areas of specialized training, research, and development of capstone courses.

This paper will:

- Look at current hiring needs within government and private sector communities;
- Outline how ASDSO's projects are helping to attract students to professions in dam and levee safety; and
- Challenge the engineering education community to foster greater collaboration between universities and practicing engineers who specialize in dam engineering.

A Shortage of Engineers: Perceptions and Solutions

Over the past two decades, an apparent decline in the percentage of college students studying engineering led to speculation about its potential effects on the nation's future. According to a 2003 American College Testing (ACT) report², fewer than six percent of seniors who took the ACT examination in 2002 planned to study engineering; a decade earlier, the figure was nearly

nine percent. A 2003 National Science Board report⁴ concluded that declining graduate enrollment in science and engineering “threatens the economic welfare and security of our country.”

Soon after these reports were issued, the Association of State Dam Safety Officials (ASDSO), a national professional association composed primarily of engineers, formed a Committee on Education Outreach (CEO) with the purpose of focusing more attention to one aspect of its strategic plan: promotion of dam safety engineering as a profession in undergraduate and graduate college-level programs.

At its initial meeting in September 2004, the group agreed to assess the need for increasing the number of professionals who specialize in dam engineering and dam safety by conducting a survey of employment opportunities in these fields. Accordingly, the CEO developed and distributed surveys in 2004 and again in 2009.

2004 Survey on Employment Opportunities in Dam Engineering and Dam Safety

In 2004, the CEO developed a 10-item survey designed to collect information on:

- the responding organizations (type, services provided, number of employees involved with dams and number with advanced degrees);
- anticipated attrition rates and hiring needs for dam-related positions;
- problems in attracting new employees and filling dam-related positions;
- awareness of university undergraduate or graduate courses, curricula or degree programs offering specialized training related to dam safety or dam engineering; and
- steps that should be taken to ensure an adequate supply of qualified technical personnel in any area of dam safety or dam engineering.

The CEO distributed its survey to over 2,000 association members, approximately 50 related associations, and about 50 journals and newsletters. A separate set of questions about current university course offerings was sent to more than 100 university civil engineering departments.

Nearly 200 state and federal agencies, consulting firms, owner/operators, and other organizations representing almost 3,700 engineers and technical employees responded to the survey.

<i>Organization Type</i>	<i>Number of Responses</i>	<i>Percentage of Total</i>
State agency personnel	65	33.5
Consulting engineers	57	29.4
Federal agency personnel	33	17.0
Dam owners/operators	32	16.5
Others (suppliers, contractors)	7	3.6
<i>Total</i>	<i>194</i>	<i>100</i>

Survey findings indicated that:

The body of knowledge and experience in dam engineering and dam safety is shrinking. Experienced personnel were retiring at a greater rate than initiates were entering the field.

The employment outlook for dam safety engineers appeared to be optimistic. All categories of dam safety-related employers indicated a short-term need for almost 260 engineers and an estimated a need for about 760 engineers for dam safety work over the next ten years as a result of projected attrition in the profession, primarily due to employee retirement.

The majority of respondents (65%) indicated difficulties in finding qualified candidates for dam-related positions. This percentage was fairly uniform throughout the country. The most commonly noted problems in filling positions included candidates' lack of experience and training and low pay for entry-level positions, particularly in state regulatory programs. Many respondents indicated that state budget constraints significantly hampered their efforts to hire and retain qualified staff. Regarding experience, many respondents said that their employees worked on a variety of projects; thus the best candidates were those with broad knowledge who could be trained for specific duties as needed.

Few respondents were aware of available specialized university courses in dam engineering. Altogether, 46 universities (including one in Australia and one in Canada) were identified as possibly offering such courses. (Appendix 1, Universities Offering Courses Related to Dam Engineering)

There were a variety of comments in response to the survey's final question: *How can this organization best serve your current and future needs for trained engineers?* Responses indicated a need to: (1) Raise awareness of careers in dam safety and engineering; (2) Encourage establishment of more university courses specifically related to dam engineering and dam safety; (3) Promote co-op and internship opportunities for students; and (4) Publicize job opportunities in dam engineering and safety. These suggestions formed the basis for the CEO's ensuing work, described later in this paper.

2009 Employment Opportunities Survey

In December 2009, following the onset of the national economic downturn and the devastating levee failures resulting from Hurricane Katrina, the CEO distributed a follow-up to its 2004 survey to representatives of three segments of ASDSO's membership: company members and state and federal regulatory programs.

Again, the survey polled respondents on their organizations' services, technical personnel, anticipated hiring needs, problems in filling positions; their awareness of university courses related to dam and levee engineering; and their thoughts on how to ensure adequate supplies of future qualified professionals dedicated to ensuring the safety of dams and levees. In order to obtain responses representing organizations as a whole, the CEO sent the survey to a targeted segment of ASDSO members—those identified as representatives of large organizations including state and federal agencies and regional and national engineering firms.

Responding to the survey were representatives of 19 ASDSO company members, 43 states, and 21 representatives of two federal agencies—one representative from the Federal Energy

Regulatory Commission (FERC) and representatives of 20 districts of the U.S. Army Corps of Engineers (USACE).

The 2009 survey results confirmed the findings of the 2004 survey:

The outlook for job opportunities in dam and levee engineering is healthy. Respondents reported 85 current openings (including three state positions currently frozen due to budget constraints) for dam and levee engineers and technicians, and anticipate hiring about 275 new employees over the next year. Of these new employees, about 162 will fill replacement positions; nearly as many—123—will fill new positions. Over a three-year period, respondents expect to hire from 190-200 new employees: they anticipate that 41% will fill new positions while 59% will fill existing positions. Anticipated retirement figures over a 10-year period were difficult to gauge due to inconsistencies in responses; however, respondents from the Corps of Engineers indicated that about 36% of Corps technical staff involved with dams and levees were likely to retire within ten years.

Attracting new recruits is less problematic than finding and retaining experienced candidates for technical positions related to dam and levee engineering. Roughly 55% of respondents representing state regulatory programs reported problems in attracting and retaining qualified employees, compared with approximately 50% of federal agency representatives and 47% of company representatives. Over half of all respondents—nearly 69% of company representatives, 60% of state program representatives, and 52% of federal program representatives—perceive a shortage of qualified personnel. The variation in company rankings over the latter two categories is likely due to comparatively attractive pay offered by large engineering firms; attracting large numbers of candidates for positions is a smaller problem than finding qualified candidates.

Recruiting entry-level personnel is primarily a problem for state regulatory programs: about 28% reported problems filling entry-level positions, compared with 8% of company member representatives. Federal agency representatives reported few difficulties here, aside from the reluctance of many candidates to live in remote or rural locations.

According to a representative of a large national engineering firm: “At entry level or [for positions requiring] a couple of year’s experience, there seems to be a growing talent pool. However, very few are trained or have project experience in dam safety engineering.” Another respondent representing a state agency noted that finding candidates at any level is difficult, especially for advanced positions: “Our experience over the last several years has been to find very few qualified candidates on both-entry level and lower-level engineering hiring lists. Finding qualified candidates on experienced-level hiring lists just doesn't happen.”

Technology transfer remains a concern. Current supplies of undergraduates seem to be on the rebound; however, a lapse of new initiates in the field from the late 1990s to present has resulted in a shortage of experienced technical personnel, meaning that fewer experts are available to help ensure the safety and viability of this segment of the nation’s infrastructure and to pass their expertise along to the next generation of dam and levee specialists. A survey respondent from a large national engineering firm employing more than 2,000 engineers with skills applicable to

dams noted, “There is a large and very obvious gap in the labor pool. Specifically, there is a great need for professionals with seven to ten years of experience. Unfortunately, these folks simply do not exist – [this is] an outgrowth of the dot-com era.”

Few respondents were aware of university courses specifically related to dam and levee engineering. A list of those named is provided in Appendix 1. Many expressed opinions consistent with the comment of a state official: “It is probably too much to expect universities to graduate trained dam safety intern engineers. The area is too specialized and too small. Indeed, it would probably be a poor service to graduates to allow them to specialize so precisely. ASDSO’s continuing education opportunities are important tools for turning well qualified civil engineers into dam safety engineers.”

While this pragmatic viewpoint appeared to be fairly common among respondents, respondents also expressed frustration with the qualifications of job candidates:

- *We have recruited diligently for geotechnical, hydraulic...and civil engineers and have had difficulty attracting the needed talent. Most difficult is geotechnical engineers.*
- *We recently received 22 resumes for engineers experienced in H/H type work, and out of those, only two came close to having the necessary experience. Most appeared to use canned programs for site development work, so they have not fully grasped the need to understand H/H in much detail.*
- *We advertized for a position three years ago and we only had two qualified applicants.*
- *Our experience over the last several years has been to find very few qualified candidates on both-entry level and lower-level engineering hiring lists.*
- *The new Engineering Assistant II position was filled in 2009. Out of 19 applicants, only six met the pre-interview screening.*

Remarking on the difficulties of find qualified candidates for dam safety positions, one state agency respondent remarked, “Lack of undergraduate engineering courses specifically related to dam engineering and lack of awareness among engineering students about dam engineering opportunities and requirements are problems.” Another state respondent reported, “During our last wave of hiring...none of the applicants were aware of our existence and what we do.”

Acknowledging the pragmatic viewpoint that universities cannot be expected to graduate fully trained dam safety engineers, the CEO nevertheless challenges the academic community to expose students to dam and levee engineering as a potential professional field and to provide students with solid fundamentals—including practice and design— in hydrology, hydraulics, structures, and soil mechanics.

A key to inspiring the next generation of engineers to embrace dam and levee safety as a professional practice is in a great part up to educators. It is while future engineers are still in school that they are exposed and enlightened to possible career prospects. As a CEO member

and past ASDSO scholarship recipient remarked, “Students appear to be interested in and concerned about dam and levee engineering, but there is not enough exposure to the topic in the undergraduate curriculum. Some students think that dam engineering is a dying field because not many dams are being built, but it is a great profession and I think the word needs to get out.”

Initiatives of the Committee on Education Outreach

The work of the Committee on Education Outreach sprang from suggestions gleaned from the 2004 survey. Over the past five years, the CEO has worked to enhance the association’s existing scholarship program and has created several new resources for students, all completely supported by the generous donations of Association members:

ASDSO’s Speakers Bureau provides guest speakers for classes and student groups throughout the U.S. The CEO developed several presentations and handouts suitable for use in meetings of student chapters of various engineering organizations. ASDSO members have used these materials for presentations throughout the country, from Hawaii to Maine. According to Speakers Bureau volunteers, the presentations to student groups are effectively raising awareness of careers in dam engineering. As one remarked, "I don't think most people, including engineering students, realize how many dams are out there until they are introduced to them through direct experience or by being educated through a presentation or other medium. These presentations make students aware of different types of disciplines involved with dams and that dams are an option as an area of specialization for them."

“Kids’ Pages” on ASDSO’s website target elementary and secondary students. The CEO also targets younger students by providing guest speakers in elementary and secondary classrooms on request and participating in Engineering Week activities.

ASDSO hosts an online clearinghouse for internships, co-op programs and employment opportunities. ASDSO invites employers to list student opportunities on its website free of charge. The tool currently lists available internships with several state agencies and private consulting firms across the country.

ASDSO holds a student paper competition connected with its annual national conference. In 2009, the association held its first student paper competition, open to undergraduate and graduate students enrolled in U.S. universities. Three winners presented papers at “Dam Safety 2009” and each received a \$500 prize. The CEO is sponsoring its second student paper competition in 2010.

ASDSO offers on-request resources for project assistance with design classes. ASDSO’s membership includes dam and levee safety experts from around the country who are eager to share their expertise with the next generation. The members of its Committee on Education Outreach comprise several well-established and nationally active civil engineering faculty who are well aware of the general and departmental program criteria for accrediting engineering programs.

The Accrediting Board for Engineering and Technology's (ABET) General Program Outcomes criteria¹ require engineering programs to demonstrate that their students attain an "ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical health and safety, manufacturability (or constructability), and sustainability" and "an ability to use techniques, skills, and modern engineering tools necessary for engineering practice." For organizations responsible for designing, constructing, and maintaining levees and dams, these are two especially important qualifications for apprenticing engineers. Committee members agree that one of the most effective means for achieving these two criteria is through the so-called "capstone" design course experience. Most of the faculty on the Committee have developed and/or taught capstone courses in their respective schools. Those who have used dams as senior or capstone class projects for analysis or design agree that this type of topic offers more opportunities than most other projects because of its unique multi-disciplinary nature (hydrology, geotechnical, structures, economics, environmental, regulatory, risk assessment, project planning and management, teamwork, etc.) in satisfying the ABET General Outcomes and Program criteria for accreditation. Toward this end, the Committee offers volunteers in all regions of the country for working with capstone design course faculty and coordinators to help set up design problems, provide software modeling and reporting assistance, act as project consultants and assist in project evaluations during and after the academic term.

As one of the professors on the CEO noted, "Courses taught at the graduate or undergraduate level are key arenas for development of interest in dam safety engineering. With video/photo examples of catastrophic dam failures such as the Teton Dam or St. Francis Dam, students get excited about dam safety, slope stability, earthquake engineering, seepage issues, and earthwork construction. Promotion of dam safety engineering as a profession can be advanced through these types of courses."

Undergraduate Scholarship Program

The ASDSO Scholarship Program was established in 1992 to award excellence in the study of civil engineering and related fields, and to make students more aware of careers related to dam and levee engineering and safety. Through this program, ASDSO has awarded annual scholarships to forty senior undergraduates.

The CEO was instrumental in enhancing this scholarship program, encouraging ASDSO's Board of Directors to double the total annual scholarship award to \$10,000, provide a free one-year membership to scholarship recipients, and sponsor recipients' attendance at the association's annual national conference, where they are recognized at the annual Awards Banquet. Since 2005, ASDSO has sponsored conference attendance by twelve scholarship winners. These conference sponsorships, as well as the annual scholarship awards, are also provided through donations by Association members.

In early 2009, the authors asked former scholarship winners for their thoughts on how to improve the association's student outreach efforts.

All past recipients who attended the association's national conference said that the experience was extremely valuable and that the CEO should continue to encourage student attendance. In commenting on what they gained from the conferences, the students mentioned networking opportunities, meeting potential employers, opportunities to increase their technical knowledge, and gaining insight into the importance of specific classroom assignments.

As one scholarship recipient remarked, "ASDSO's national conference was a great opportunity to attend seminars and view in greater depth the real-life aspects of engineering. One of the more interesting aspects of ASDSO's conference (as opposed to other engineering conferences) was the emphasis placed on the communities impacted by dams. Civil engineering is a relatively people-oriented field to begin with, but ASDSO interacts with the public in nearly every aspect of dam construction, design, maintenance, and decommission."

Another noted, "As a student I was still unsure of my plans after graduation, but after attending the conference I felt that dam safety was the correct path for me. The scholarship helped to ease the burden of paying for college, but more than that, it exposed me to an organization of people engrossed in helping to make all dams safe."

Students also suggested that ASDSO increase its campus presence by:

- Encouraging practicing engineers to work with professors in their region to arrange talks, lectures, and field trips to nearby dams;
- Participating in on-campus activities, such as Engineers Week and ASCE events;
- Encouraging the creation of student chapters that volunteer with local projects and attend the association's national and regional conferences; and
- Supporting national engineering competitions and creating advertising targeted to universities.

Students also suggested that ASDSO begin a paper competition and create hands-on competitions similar to the ASCE concrete canoe and steel bridge competitions.

The ASDSO Technical Training Program

ASDSO is addressing the need for on-the-job training for dam and levee engineers by developing a list of technical topics that should be included in a comprehensive program of study (Appendix 2, ASDSO Technical Training Program of Study). Many of these topics are currently addressed through courses offered by ASDSO and other organizations. ASDSO's Training Committee is conducting a comprehensive update of the Program of Study in 2010.

Within the past three years, ASDSO has begun development of a program of web-based courses designed to meet technical training needs. Now available are four webinars, each approximately 90 minutes in length and easily adapted for use in university classes:

- *Geotechnical Review of Embankment Projects*
- *Internal Erosion and Piping Considerations for Dam Safety*
- *Fundamentals of Hydrology*

- *Applying the Pareto (80/20) Principle to Geotechnical Analyses and Reviews of Embankment Projects*

According to a professor who used the latter webinar with his second course in Geotechnical Engineering, a class of about 30 students, the webinars provide a valuable opportunity for students to learn from experts in the field. “University faculty members can only be up-to-date on a couple of topics,” he remarked. “By bringing nationally recognized experts into the classroom, the webinars are an effective means to introduce students to specialized technical knowledge.”

Conclusion

The nation is facing a “brain drain” in the area of dam and levee engineering as today’s experts retire at an increasingly rapid rate. Attracting young people to the profession of designing, building, maintaining and operating safe dams and levees is essential to protect life, property, and the economic well-being of communities nationwide.

While few new large dam projects are underway in the U.S., a plethora of career opportunities exist in dam removal, dam and levee modification and rehabilitation, risk assessment, failure analysis, emergency action planning and more. In order to attract “new blood” in the form of upcoming undergraduate and graduate students there is a need for financial and mentoring support of this potential workforce. This support goes a long way to enticing students to consider a career in dam safety.

The Association of State Dam Safety Officials urges university professors to make students aware of this specialized niche of engineering and stands ready to assist in the effort by facilitating communication between practicing engineers and universities throughout the U.S. ASDSO’s Committee on Education Outreach is committed to working with college and university departments at undergraduate and graduate levels to assist in developing relevant design and elective courses, assist faculty in teaching capstone courses, help promote curricula that meet the needs of the profession, and provide seminars and student chapter meeting speakers. In addition, the Committee is working to increase national support of students and faculty interested in dam and levee safety related research.

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2. American College Testing. *Maintaining a Strong Engineering Workforce* (2003)
3. National Committee on Levee Safety. *Recommendations for a National Levee Safety Program – A Report to Congress*. (2009)
4. National Science Board. *The Science and Engineering Workforce/Realizing America's Potential* [NSB 03-69, 2003])

Appendix 1

Universities Offering Courses Related to Dam Engineering

Universities identified in 2004 (compiled from 210 survey responses, including responses from 23 universities):

1. Brigham Young University
2. California State University - Sacramento
3. Colorado State University
4. Drexel University
5. Duke University
6. Geneva College
7. Georgia Tech
8. Illinois Institute of Technology - Urbana
9. Michigan Tech University - Houghton
10. Michigan University
11. Mississippi
12. Montana State University - Bozeman
13. North Carolina State University
14. North Carolina A & T State University
15. Ohio State University
16. Pennsylvania State University
17. Rensselaer Institute
18. Rowan University
19. Rutgers University
20. Southern Polytechnic State University
21. Tri-State University
22. University of California – Berkeley
23. University of California - Davis
24. University of California - Los Angeles
25. University of Colorado at Denver
26. University of Connecticut
27. University of Houston
28. University of Illinois
29. University of Kentucky
30. University of Louisville
31. University of Maryland
32. University of Memphis
33. University of Missouri - Rolla
34. University of North Carolina - Charlotte
35. University of South Carolina - Columbia
36. University of Southern California
37. University of Texas
38. University of Wisconsin - Madison

39. University of Wyoming
40. Utah State University
41. Vermont Technical College
42. Villanova
43. Virginia Tech
44. West Virginia University Tech
45. University of Queensland, Brisbane, Australia
46. University of Saskatchewan, Canada

Universities identified in 2009 (compiled from 83 responses):

1. University of California – Davis: Dam design
2. Colorado State University: Graduate courses
3. University of Connecticut: Dam design
4. University of Hawaii
5. University of Evansville: Senior class project
6. Missouri University of Science and Technology
7. University of Maryland at Baltimore: Risk Analysis
8. Rowan University: Dam design (senior project)
9. The College of New Jersey: Dam design (senior project)
10. New Mexico State University
11. Oklahoma State University
12. University of Oklahoma
13. University of Rhode Island: Dam design
14. University of Tennessee: Dam design
15. University of Texas
16. George Mason University
17. Virginia Tech: Hydraulic Structures (CEE 4334); Soil and Site Improvement (CEE 5554); Seepage and Earth Structures (CEE 5564); Geotechnical Aspects of Earthquake Engineering (CEE 5584)

Appendix 2

ASDSO Technical Training Program of Study (To be updated in 2010)

PRIORITY ONE COURSES

Emergency Action Planning

Basic: (1) Teaching Dam Owners How to Design and Implement EAPs (2) Emergency Action Planning for Dam Safety

Geotechnical Issues

Basic: Soil Mechanics for Dam Safety

Advanced: (1) Slope Stability Analysis of Embankment Dams (2) Seepage for Earth Dams

Hydraulics

Basic: (1) Hydraulic Analysis of Spillways (2) Computer Models (HEC-RAS, HEC-2, DAMBRK, FLDWAVE)

Advanced: (1) Dam Failure Analysis (2) Computer Models (HEC-RAS, HEC-2, DAMBRK, FLDWAVE)

Hydrology

Basic: (1) Basic Hydrology for Dams (2) HEC-1, HEC-HMS, WMS

Advanced: (1) HEC-1, HEC-HMS, WMS (2) Statistical Analyses of Design Floods (PMF-PMP)

Inspections

Basic: (1) Construction Inspections for Dams and Ancillary Structures (2) Safety Evaluations of Existing Dams (3) Plant and Animal Impacts on Earthen Dams

Miscellaneous

Basic: (1) Plans and Specifications Review (2) Developing a Dam Security Program

Advanced: Risk Indexing

Seismicity

Basic: Earthquake Engineering for Dams

Advanced: Earthquake Engineering for Dams

Emerging Technologies

Basic: Embankment Armoring (Overtopping Protection)

PRIORITY TWO COURSES

Emerging Technologies

Advanced: RCC Applications

Geotechnical Issues

Basic: (1) Foundation Prepping/Grouting (2) Geosynthetics (3) Geotechnical Review of Embankment Dams

Advanced: (1) Foundation Prepping/ Grouting (2) Dynamic Analysis of Dams

Miscellaneous

Basic: (1) Dam Removal/Decommissioning (2) Concrete Repair (3) Spillway Erodibility

Advanced: Tailing Dams

Instrumentation

Basic: Assessment of Project Requirements

Structural

Basic: (1) Basics of Reinforced Concrete Structures (2) Stability Analysis of Concrete Dams (3) Towers, Outlets and Bridges

Advanced: Stability Analysis of Concrete Dams

PRIORITY THREE COURSES

Hydraulics

Basic: Gates, Valves and Conduits

Advanced: Gates, Valves and Conduits

Instrumentation

Basic: (1) Data Interpretation (2) Design and Installation (3) Emerging Technology (4) Operation, Use and Maintenance

Advanced: Design and Installation

Miscellaneous

Basic: (1) Environmental Issues that Affect Dam Safety (2) Flood Damage Assessment (3) Hazardous Materials (4) Dealing with the Media/ Public Relations (5) Reservoir Sedimentation (6) Risk Analysis (7) Worker Safety

Advanced: Risk Indexing and Potential Failure Mode Analysis

Structural

Basic: (1) Anchors (2) Gates and Rubber Dams