

**Teaming "Design of Small Earth Dams" –
A Practitioner/Professor Collaboration**

Thomas V. Edgar, P.E., Ph.D. and Joel Farber, P.E., P.G.

**Department of Civil and Architectural Engineering
University of Wyoming
Laramie, WY 82071/
TriHydro Corporation
Laramie, WY 82070**

Abstract

The course "Design of Small Earth Dams" is sufficiently broad and involved that the University of Wyoming has taught it for almost 20 years using both a practicing professional engineer and a professor. The arrangement has worked out very well for a variety of reasons and with several practitioners. This paper will focus on the way in which the two instructors team together to develop the course and set up schedules for teaching, assignments, tests and projects.

Introduction

One of the more complex of all structures in civil engineering practice is a moderately high, zoned earth-filled dam. Its design requires a substantial knowledge of hydrology, hydraulics, geotechnical engineering, groundwater hydrology, seismology, economics and construction practice. The pieces are sufficiently difficult that a single, non-practicing professor probably is not an appropriate choice to teach the course individually. In fact, at this level of practice, it may not even be appropriate for the student to believe that the design of a sizeable dam should be undertaken by one person.

Aware of the difficulties and shortcomings, the "Design of Small Earth Dams" course at the University of Wyoming has been team taught with practicing engineers for almost twenty years. This team approach has made this course one of the most highly regarded courses taught in the department by the consulting engineers of the state. It is one of several senior and graduate level courses offered in the civil engineering program having some degree of practitioner involvement, but is currently the only one in which the consultant is a part of the day to day teaching team.

The primary focus of this paper is of the teaming aspect of the shared professor/practitioner roles in teaching this class. The paper will look at the background and nature of the course, the instructors, course structure and scheduling, practitioner's responsibilities and perks, the course as part of the comprehensive design experience (CDE)

*Proceedings of the 2004 American Society of Engineering Education Annual Conference and Exposition
Copyright ©2004 American Society of Engineering Education*

requirements for ABET and finally, individual comments about teaming by the professor and the practitioner.

Course Background

CE 5830 “Design of Small Earth Dams” is a graduate level course, but seniors often take it. By the end of the course, the students should be able to:

- Describe the basic dam types and the hazards associated with them
- Determine the appropriate Maximum Probable Storm and its characteristics,
- Route the storm down the watercourse and through the reservoir,
- Select an appropriate dam for a given geographic site including material borrow sites,
- Design primary and emergency spillways for the dam and operational outflow works, and
- Present their design to the owner or appropriate state or federal regulators.

The workload is extensive, with the final product being a design notebook and set of drawings for a proposed dam or for a rehabilitation of an existing dam. The students work in three- or four-person teams and use the checklist given in the 2nd edition of the US Bureau of Reclamation's "Design of Small Dams" (1973) as an index of material to be considered.

The course is a 3-hour course taught two days a week, representing about 30 classes of 75-minute duration. The professor and the practitioner divide up the class according to their expertise and time. (A bi-weekly course outline is presented in Appendix A showing instructor and topic areas.) It is offered on a three-semester rotation to insure that graduate students will have an opportunity to take it during their program of study. The prerequisite courses are “Surface Water Hydrology” and “Introductory Soil Mechanics”, however, as most of the students taking the course are interested in either the Water Resources or Geotechnical Engineering areas, they will have often had or would currently be taking courses on “Design of Hydraulic Structures”, “Geotechnical Engineering” and/or “Groundwater Hydrology”.

Teams are self-selected, but are required to have a blend of graduate and undergraduate students working together. In that way, more experience is placed in the team and the graduate students are able to provide some mentoring to the undergraduates. This sometimes creates a problem in that the graduate students believe they could learn more if not restricted by the undergraduates, but usually by the end of the semester, they learn that everyone can bring value to a team. A far worse problem is the nonproductive team members that commonly create problems in teams. At the end of the semester, everyone is given a team review sheet in which they estimate the percentage of time each person contributed to the project and can make comments about how the team worked together.

Projects are normally selected at one of several local sites that have the potential for a dam to be built on them. Alternatively, sometimes a knowledgeable owner will have the class inspect an existing dam and provide recommendations for modifications to improve stability, storage capacity and/or safety. A knowledgeable owner is one who understands the complexity of a dam and understands that the designs developed in the class are of a preliminary nature. For

example, one current owner has a PE in petroleum engineering and understands the limits of professional responsibility that would be associated with the students' designs. Students are encouraged to meet with the owner and walk the site whenever they have specific questions concerning the owner or the property.

One or two field trips are made during the semester. The first field trip is three dams located about 30 miles east of Laramie. The first is a zoned-earth dam which has been recently reconstructed. The second is an old (1903) block granite dam located in a hard rock canyon. The emergency spillway for this dam was recently reconstructed with a fuse plug spillway in a natural spillway. The third dam is a thin arch concrete dam. The emergency spillway is off-channel and is also a fuse-plug design in a spillway constructed of driven sheet piling. A second field trip is made to the course's project site. The students can walk the site with topographic maps and get an understanding of the area and its strength and weaknesses which will influence their final design.

Grading for the course includes some initial homework, a midterm exam, more project related homework, and the final project report and drawing and its presentation. The initial homework is primarily used to introduce the types of dams and where they may be used, volume calculations and general information concerning water and soil, i.e., broader knowledge related questions. By the second third of the course, most of the homework is directed to the dam project itself. For example, the hydrologic analysis of storms and runoff is presented as a general topic in the lecture, but the homework is directed to the watershed above the proposed or existing dam site. The midterm exam usually covers the introductory material (which may represent several weeks of class) and the hydrologic analysis. As an in-class exam, each student must show mastery of the basic steps in defining a storm over a watershed to developing the inflow hydrograph into the reservoir.

The final report is a written document and a set of drawings. The document includes the hydrologic analysis performed as the homework assignment, plus evaluation of the dam's building material and its construction (primarily earthfill, rockfill or roller-compacted concrete), designs of the working and emergency spillways, outlet works and instrumentation. Drawings include area maps, greatest cross-section, centerline profile, and details of the intake, outlet and spillway structures. The presentation is a 20-minute timeslot with questions. The designs are presented to the class, the instructor and the practitioner. Occasionally, engineers from the State Engineers Office and/or the owner may be present as well.

The Instructors

Both current instructors are Professional Engineers and the practitioner (Mr. Farber) is a Professional Geologist as well. The practitioner brings many skills to the table. He has a Bachelor of Science in Geology and a BSCE and MSCE. He has over 20 years professional experience in Geology and Civil Engineering, with an emphasis in his consulting practice on a wide variety of water resource development projects. He is a member of State Board of Licensure for Professional Geologists. He has been a private consultant and is currently employed by a local engineering and environmental sciences consulting firm. He has been teaching this course for about nine years. His dedication to the course is demonstrated by the fact that he made being able to continue teaching the course a requirement for his employment.

The professor's expertise is in the areas of geotechnical engineering, groundwater hydrology and construction while the practitioner's expertise is in surface water hydrology, hydraulics and also construction. Together, we provide a sound basis for both theory and practice in small dam design and construction.

Course Scheduling

The structure of the class has been changing over time. In addition to needing to be pedagogically sound and technically accurate, the selection of topic material is influenced by a number of secondary factors. These include: the number of students taking Hydrology during the current semester; the emphasis and depth of material to be presented for the various topics which may vary depending on the project site; the nature of the project selected; the percentage of time to be covered by the practitioner; and, the practitioner's work and travel schedule.

While Hydrology is a prerequisite course, many students cannot take it two or three semesters before the Dams class when it is available. Therefore, we commonly admit students who have not had Hydrology but may have had some other water resources related class and who are taking Hydrology concurrently. Traditionally, storm events are covered early in the course. Therefore, if we delay covering storm events in Dams, then the students will have had the opportunity to learn about that topic in the appropriate class and we can reinforce the material being learned without having to teach it initially.

Often the dam site selected will conducive to several types of small dams, i.e., earthfill, rockfill or roller compacted concrete. If that is the case, more of the course time will be devoted to these areas rather than providing greater depth in just earthfill dams.

Practitioner's Responsibilities

The consultants that have been involved with the course have taken their participation very seriously and professionally. They have developed their own teaching materials, have presented it, have given and graded homework and exam material, and have performed detailed evaluation of the projects and course at the end of the semester. The practitioners are hired as part-time adjunct faculty members. They are hired on a 0.33 FTE basis, which represents approximately 10 class periods out of the 30. In reality, he normally is there more often and agrees to take on additional responsibilities.

As active professionals, practitioners have to travel, attend meetings, and do their normal jobs in addition to teaching. We meet prior to the semester and set up a tentative schedule. The schedule is flexible and is setup to allow for contingencies, but outlines approximately when the practitioner (and the professor) can teach. Typically, it is best to split his time with usually 4 days during the fourth and fifth week and 6 days starting the tenth week.

One of the most significant problems is to develop a working relationship between the practitioner and the students in the same way in which students have learned to work with professors. This is difficult in that the students do not have the same day-to-day contact with the practitioners as they do with the professors. To overcome this, Mr. Farber has scheduled outside meeting times before and after school and in the evenings for the students to get together with

him when there is more time available. In addition, he provides them with his business and cell phone numbers, his e-mail, and his office address.

In many ways, the practitioner is more exacting and demanding than the professor. From his professional point of view, he believes he should be providing alternatives and the students must determine the optimum solutions. While the graduate students tend to understand this idea, many of the undergraduates do not have an appreciation for the work involved in an open-ended design process. In reality, he is attempting to get the students to think far enough ahead to start asking “why” questions rather than just “how” questions, typical of graduate versus undergraduate understanding. Similarly, this also encourages discussion and counterexamples that one person is not likely to provide.

In addition to the responsibilities of teaching the course, there are also some perks. From the practitioner’s viewpoint, it is a chance to get out of the office and into a situation that requires a different thinking process and approach than the daily “routine”. He has an opportunity to work with some of the brightest students in the department and enjoy the intellectual challenge that entails. He gets to have an extended interview with perspective employees, which is also one of the benefits for the company for which he works. Further, the company realizes the valuable public relations that holds for potential employees and for potential clients.

“Design of Small Earth Dams” as a Comprehensive Design Experience

The Design of Small Earth Dams is a graduate level course. The course requirements for the homework and design project have been very consistent over the past 20 years. The students are informed during the first class period to expect between 125 and 175 hours of work in the class. While that is not much beyond the standard heuristic of 3 hours outside to 1 hour inside class, much of the work comes during the last third of class or so as all the elements of the design start to become apparent. While this is a push for the graduate students, it is a difficulty for the seniors who may be taking 16 hours of coursework.

In response to the ABET requirement for a broad capstone design experience, the Department of Civil and Architectural Engineering has recommended that each program area select a course that fulfills those and the departments requirements for a Comprehensive Design Experience (CDE). One of the Department CDE requirements is that there be “... Some level of Practitioner Involvement”. “Dams” is a CDE for both the Geotechnical and the Water Resources Programs. Therefore, the departmental support for the practitioner is justified not just by the broad course requirement for the graduate course but also by the mandate of practitioner involvement for the CDE.

Overall Impression of Practitioner Involvement by the Professor

For the students, having a practitioner involved in the course provides a different and deeper level of validity for the course than they normally may have. He brings in experience and examples from his own projects and others that he has worked on or seen. Hence the students get more than one point of view of the professional practice of consulting engineering which they could not get otherwise.

For me, this is a wonderful and enriching experience, both professionally and personally. Knowing that someone knowledgeable is in the classroom provides an additional incentive for me to remain current. It makes the course more fun and rigorous as well. We have known each other for many years and appreciate our own strengths and weaknesses without any negative or downside.

Overall, this is a win-win situation with little to no downside. All parties, the students, the department, the firm, the practitioner and the professor all gain from the association in the course. I would recommend teaming like this for any senior and/or graduate level design course.

Overall Impression of the Practitioner

Teaching the Small Dams course is an enriching experience for me, in several regards. Firstly, it provides an opportunity for regular contact with Professor Edgar and his associates in Civil and Architectural Engineering Department. These people share an energetic enthusiasm for professional development that derives from the constant and immediate interaction with young people. Their enthusiasm is contagious and rejuvenates me. The opportunity for me to interact directly with students on an ongoing basis is also a source of enrichment. The questions and concerns expressed by the students over the course of the semester serve to reinforce my understanding of the design process and demands that I “stretch” my abilities to communicate effectively, guide and motivate other people.

The course is demanding on the students as well, inasmuch as students are expected to integrate and apply engineering principles learned from a broad spectrum of fundamental course work. The structure of the course also tests the maturity of the students. Students are required to work in teams, and in addition to the significant technical elements of the course material, emphasis is placed on written and verbal communication skills. For these reasons, mature students tend to be most successful in the course.

From the perspective of a practitioner, the Small Dams course provides students with a unique opportunity to gain practical engineering design experience in an academic setting. The students are required to apply their knowledge, work cooperatively and communicate their understanding of a complex design project. On numerous occasions, past students have indicated that the Small Dams course was an invaluable experience to prepare them for the transition from school to engineering practice.

Appendix A – Typical Semester Topic Breakdown

Weeks	Instructor	Topic
1-2	Edgar	Introduction to Course, Dam types and Hazard Ratings and Classifications
2-4	Edgar	Site Investigation, Foundations
5-6	Farber	Storm Hydrology and Stream Routing
7-8	Edgar	Dam Construction and Filters, Alternative Dam Types
9-10	Edgar	Flow Through Dams and Slope Stability
11-12	Farber	Spillway Hydraulics and Design
13-14	Farber	Outlet Works and Control, Downstream Hydraulics
15-16	Edgar/Farber	Final Considerations, Reports and Presentations

THOMAS V. EDGAR – Dr. Edgar has taught at the University of Wyoming for 23 years, specializing in Geotechnical Engineering and Groundwater Hydrology. He won the John P. Ellbogen Excellence in Teaching Award in 2002, the highest teaching honor given by the University and has been named ASCE Top Professor four times. He has been the Faculty Advisor for ASCE for 18 years.

JOEL A. FARBER - Mr. Farber possesses Bachelor of Science degrees in Geology and Civil Engineering and a Master of Science in Civil Engineering in which he studied computer modeling of river systems related to water rights. He is a member of State Board of Licensure for Professional Geologists. He has over twenty years experience including several years as a private consultant. He is currently employed by TriHydro Corporation.