Project-Based Construction Education

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Introduction

This paper describes project-based education as applied in two construction management courses at the U.S. Air Force Academy. Both courses are for senior-level civil and environmental engineering students. One of the courses is a construction management elective and the other is a required capstone course for students majoring in both civil and environmental engineering.

Construction Management Elective

The elective course fulfills one of two curriculum "senior design options". These design options allow students the opportunity to emphasize structural, geotechnical, environmental and/or construction engineering. *"Construction Project Management"* is taught from the constructor's perspective. Along with traditional topics such as cost estimating, scheduling and safety, the course examines construction methods, materials and famous construction failures.

Students work in teams of two or three on a semester-long project in which they must plan the construction of a real construction project. They find and select projects advertised for bid on the Army Corps of Engineers' Tri-Service Solicitation Network[1] (http://tsn.wes.army.mil/, see Figure 1). The Tri-Service Solicitation Network (TSN) allows the students to choose between hundreds of construction projects advertised for bid by the Army, Navy and Air Force.

The students then request a CD containing project specifications and drawings. Using these documents, the student teams complete a series of four assignments in quantity take-off, cost estimating and scheduling. At the end of the semester, the students correct and compile their work into a project binder and give a final presentation on their results. They also analyze the project design, identifying potential problem areas and opportunities for innovative construction. In the project scenario, each student team is a construction contractor preparing to compete for a contract award.

The first assignment is a quantity take-off of all the concrete in the project, or for large projects, the concrete in one section of the project. Next, the students perform a quantity take-off of all the project's floor finishes. The cost estimate assignment is in two parts. First the teams estimate the overall cost of their projects based on cost per square foot, and adjust it for location and project size. Then using their quantity take-off results, they develop a detailed cost estimate for concrete. In the scheduling assignment, the students use the specifications and drawings to generate a list of 25-30 major construction activities covering the total construction process. They then use project scheduling software to create a critical path method schedule showing relationships between construction activities, activities on the critical path, and activity early and late start and finish dates.

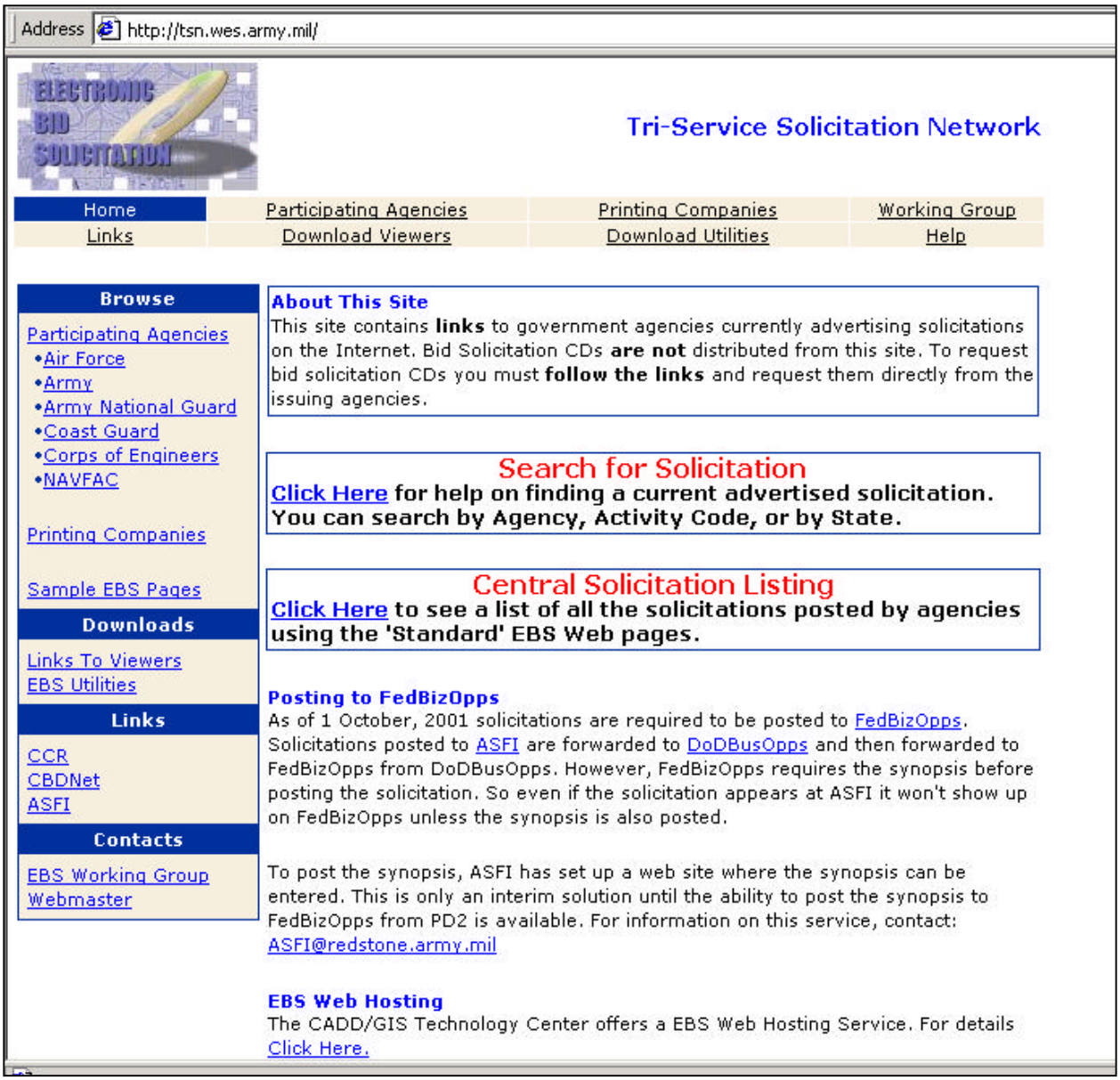

Figure 1. Tri-Service Solicitation Network website

The Final Report includes:

1. A description of the project scope (location, owner, type of facility, size, rough idea of the overall time and cost to build, etc.)
2. A written discussion of the most challenging aspects of the construction and possible problems they anticipate
3. How they would propose to deal with the problems and ensure things go smoothly
4. Ideas for possible innovation (construction techniques, equipment or management)
5. Appendices consisting of corrected:
   - Concrete take-off
   - Floor Finish take-off
   - Concrete cost estimate

- Schedule

During the final presentation, the students must convince the owner's team (portrayed by faculty) that they have studied their projects thoroughly and should be awarded the construction contract.

Capstone Course

After required freshman and sophomore "core" courses, the Air Force Academy's civil and environmental engineering curricula begin with a hands-on "Field Engineering and Readiness Laboratory" (FERL) course between the sophomore and junior years. During this three-week course students complete 22 hands-on construction activities under the supervision of faculty and Air Force construction craftsmen. A sampling of the activities includes wood-frame construction, heavy equipment operation, concrete placement, and asphalt paving, as shown in Figure 2. Each activity integrates with one or more later major's courses and with the capstone construction course[2].

Figure2. FERL Construction Activities.

In the required capstone course, *"Construction Management and Administration"*, student project teams integrate structural, geotechnical and environmental disciplines as a culmination of their civil or environmental engineering curriculum. The course is taught from the owner's point of view and emphasizes construction project administration. The semester project constitutes the "major design experience" required for ABET accreditation[3]. It makes use of designs the students have previously produced in earlier courses, such as foundations,

structural frames and landfills. Over the course of the semester, the students, working in teams of three or four, plan, estimate and schedule the construction phase of their project. The student teams are chosen to be multi-disciplinary within the limits of their limited background. As the students learn about construction management topics in the classroom, such as economic feasibility, environmental considerations, cost estimating, scheduling, safety, constructability and ethical issues, they apply them to the previously-designed project. They will also identify changes to the design that could improve the project's constructability.

In the capstone course project scenario, the teams play the role of design-build firms. Each team plans the construction of a technical design, using real sites in the local area. Planning construction forces the students to take a new look at their designs[4]. They must ask themselves, "How am I going to build this thing"? The assignments in the project consist of a Project Proposal, two Status Reports, a Final Project Report and a Final Briefing, as listed in Table 1.

Submittal Item
Project Proposal & Justification
Team Member Assignments
Progress Schedule
Project Status Report No. 1
Approved Project Proposal
Economic Feasibility Analysis
Manpower & Equipment Needs
Constructability Review
Project Status Report No. 2
Site Access Plan
Safety and Quality Plans
Work Breakdown Structure
Funding Plan and Detailed Cost Estimate
Construction Schedule
Constructability Review
Final Project Report
Site Layout and Utilization Plan
Final Cost Estimate
Bonds and Insurance Certificates
Special Conditions of Construction Contract
Analysis & Evaluation of Performance
Constructability Review
Briefing

Table 1. Project Submittal Items.

Each design-build team's task in the Final Briefing is to convince a panel of faculty "owners" that their proposal is the best and that they are ready to begin construction. Students take the capstone course with its semester project in their final undergraduate semester. It culminates their curriculum as shown in Figure 3.

Figure 3. Air Force Academy Civil and Environmental Engineering Curriculum

Conclusion

This paper has presented two project-based approaches to teaching construction management. The first is from an elective course and gives students working in teams the opportunity to plan the construction of real projects. The second is a capstone course for all seniors in the civil and environmental engineering majors. The students plan the construction of a project they have already designed. They work in small teams to integrate the structural, geotechnical and environmental disciplines in a major design experience.

These two courses and their use of projects to teach construction management are presented in the hope that they may provide useful ideas to other engineering educators and programs.

Bibliography

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Biography

JAMES B. POCOCK is an assistant professor in the Department of Civil and Environmental Engineering at the U.S. Air Force Academy. Dr. Pocock has an undergraduate degree in architecture from the University of Michigan, a master's degree in architectural engineering from the Pennsylvania State University and a PhD. in civil engineering from the University of Illinois. He is a retired Air Force civil engineering officer and a registered architect.

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