

Integrating Construction Engineering Planning Into a Structural Civil Engineering Program

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Abstract

This paper describes the planning, design, and teaching of a new course in entitled “Construction Engineering Planning,” developed to augment the civil engineering curriculum at the US Military Academy with related topics in construction. This course effectively blended construction management principles – planning, organizing, staffing, directing, and controlling – with project engineering tenets of scope definition, budget development, and scheduling.

Introduction

This paper describes the development and implementation of a new course in construction engineering planning designed to augment the structural Civil Engineering program at the United States Military Academy at West Point. At USMA, all students take 31 common core courses, 16 of which are in the humanities. This substantial core curriculum leaves little room for the critical engineering topics necessary for maintaining viable, ABET-accredited engineering programs. In addition, students do not select their academic major until their sophomore year and generally are not able to take *any* engineering courses until the second semester of that year as shown in Figure 1. Thus addition of a construction management course was not generally considered a pragmatic option, although the educational benefit represented a potentially high dividend. The robust engineering program at West Point was superb in developing structural design engineers, but the practical side of civil engineering, defining the “how” in constructed facilities, was not part of the curriculum. This course in construction engineering planning aimed directly at producing construction management skills in the student that would reinforce the leadership and engineering instruction from other courses and subsequently prepare him for service as a civil engineer.

The Course Description, Implementation, and Student Response

This academic experiment ultimately resulted in a 3.0 credit hours course for senior engineering students dealing with the particulars of project management. The underlying foundation for the course grew from the premise that civil construction projects are essentially unique with each project engineer applying his or her own style of management.

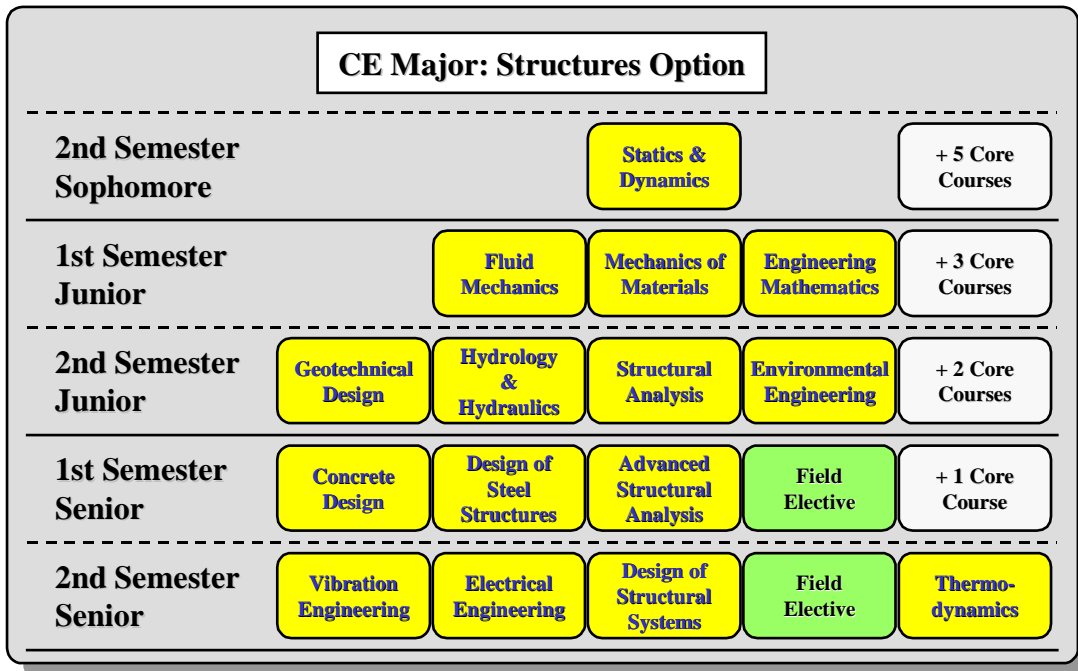


Figure 1. Civil Engineering Major Course Template (Structures Option)

Nevertheless, the course presented a set of fundamental principles that apply equally to all project managers and projects alike.

Working within the framework depicted in Figure 2, the course emphasized the importance of achieving quality to satisfy the owner’s expectations in all aspects of the project including scope definition, scheduling, and budgeting. In fact, quality was presented as an integral part of project management and the ultimate linkage between other major salient parts involved in designing and building a constructive endeavor. Field trips to local construction job sites and guest lecturers from the construction community including contractors and project managers supplemented course material with real world examples of project management challenges

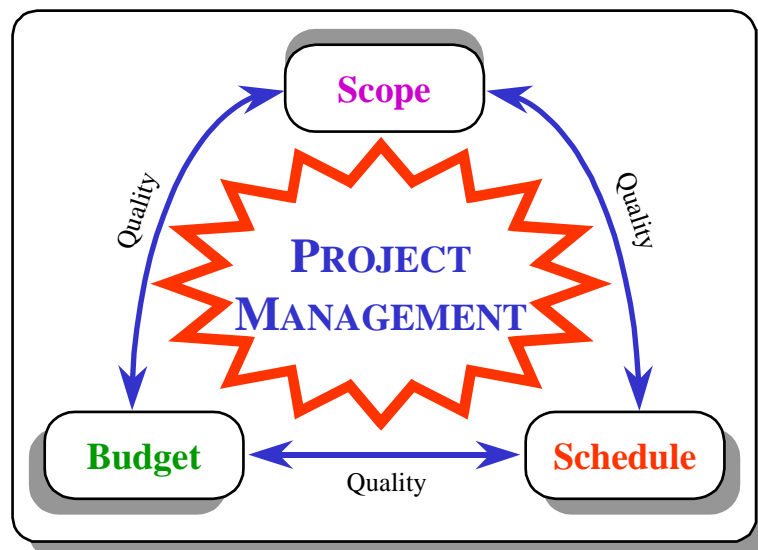


Figure 2. The Basic Course Framework

and initiatives and effectively echoed this endorsement of the importance of quality. Trips included overview briefings from project managers on project scope, budget, schedule, and the methods employed to plan, organize, staff, direct, and control the project. The course presented guidelines for the practicing civil engineer for managing the following three basic components of a project:

- Scope definition based on the owner's need.
- Scheduling via network analysis systems such as CPM, PERT, or Precedence. Primary intermediate learning goals included proper, logical sequencing of work packages as well management of resources – money, manpower, material, and time.
- Budgetary considerations involving not only resource constraints and allocation but also the time value of money dealing with the engineering economy of long term projects.

The course deliberately encouraged experimentation by the student leading to the development of his or her own style of project management. Throughout the course, students developed their abilities in management fundamentals – planning, staffing, organizing, directing, and controlling – through practical exercises, graded homework, actual project analysis and in-class exams. The students examined the basic steps in development of a management work plan for each project phase from conceptual development to completion and close-out. However, just as projects are most often a unique, one-of-a-kind venture, the plans for construction are also distinctive and reflective of the manager's experience, imagination, and creative insight into the needs of the owner.

Figure 3 presents the course academic objectives. These learning goals were inter-related and worked in concert to develop the skills in the student to identify and organize certain critical information unique to a particular project. The course introduced the principal contracting parties integral to successful project: the owner, the designer, and the contractor. On special note, one of the attributes of the course dealt with the specific ties drawn between the time value of money and project budgetary considerations. In fact, this subject area was covered so thoroughly during in-class instruction that students taking this course were pre-empted from enrolling in an engineering economy course.

Student response before, during, and after the semester was highly favorable to the new course. Enrollment was initially limited to a maximum of 36 students, split evenly between two sections. Within days of opening, the department received over 70 student applications. During their summer prior to their senior year, civil engineering students at the US Military Academy may serve as "acting" project engineers for the US Army Corps of Engineers managing construction projects throughout the United States, Europe, and Asia. With this fresh, first-hand experience in the "how" of civil engineering, the students were primed to augment personal knowledge with formal education. Further, as graduation approached, many realized that their future as a Second Lieutenant in the US Army would very likely involve both construction management and certainly the leadership of men and women that would rely on their ability to plan, organize, direct, and control. These factors

in the US armed forces.

**CE490, Construction Engineering Planning:
Course Objectives**

- Explain the relationship between the three principal components of a construction project: Scope, Budget, and Scheduling.
- Explain the phases of a project from the owner's definition of the need through construction and project close out.
- Explain the uses and relative level of accuracy associated with project estimates developed by the owner, the designer, and the contractor.
- Apply basic economic concepts pertaining to time value of money including: Single payment compound amount and present worth factors; Uniform Series Compound Amount, sinking funds, capital recovery, and present worth factors; Interest factor relationships with linear interpolation; Computing repayment periods and unknown interest rates; Analysis of interest periods with equivalent, smaller, and larger payment periods; Discrete and continuous payments; Comparing economic alternatives; and Compute attractive rate of return.
- Complete benefit-cost analysis for alternative comparison.
- Compare the four primary contractual methods for compensating for design services -- lump sum, salary times a multiplier, cost plus a fixed payment, and percentage of construction.
- Compare two primary contractual methods for compensating for construction services -- fixed price (I.e., lump sum or unit price) and cost reimbursable.
- Explain the roles of the project manager and the owner in reviewing the design and developing the work breakdown structure for a construction project.
- Compare the four basic types of organizational structures: product oriented, functional, discipline, and matrix.
- Develop a work breakdown structure for a project.
- Analyze a project through a network analysis system either CPM, PERT, or Precedence.
- Develop cumulative cost curves to forecast and monitor performance in terms of budgeted cost of work performed (BCWP) and the actual cost of work performed (ACWP).
- Determine project performance descriptives such as percent complete in terms of earned value.
- Explain the significance of integrated resource management of manpower, materials, machines, money, and time.
- Apply the basic tenants of construction engineering management -- planning, organizing, staffing, directing, and controlling.

Figure 3. Course Objectives for CE490, Construction Engineering Planning

contributed directly to a marked motivation and eagerness that was unanticipated but a welcome phenomenon. End of semester course critiques likewise reiterated these favorable responses. Students felt the course was demanding, but they clearly understood what was expected. They felt confident that a good effort resulted in a good grade, but most importantly, the students felt the course was relevant. Written comments testified to the consistency observed between classroom principles and their recent field experience. Additionally, the course philosophy and discourse on principles of management fully matched the truths they had developed during their limited military experience during three years at the Academy as well as the expectations they were developing for their future careers in the US armed forces.

Conclusion

The vast majority of our students found this course interesting, challenging, and enjoyable, but its worth was found in the powerful way it supplemented the already strong and robust program already in practice at the US Military Academy. The Civil Engineering structures program is superb in developing structural design engineers that are well versed in defined the “what” in building endeavors, but this course took their education into a new area effectively dealing with the “how” of construction engineering.

As a result of my experience in developing and implementing this new course in construction engineering planning, I conclude that (1) it is indeed possible to integrate construction management into a strictly structures civil engineering program, and (2) that this course can serve as viable introduction to the management principles inherently required to be a functioning, practicing civil engineer.

LIEUTENANT COLONEL DAVID S. COTTRELL is Chief, US Army Operations Center, Washington, DC. Graduated from the US Military Academy in 1978, his further studies at Texas A&M University culminated in a Masters Degree (1987) and a PhD (1995). He has served as an Assistant Professor in the Department of Civil and Mechanical Engineering at USMA (1995-1998) and is a registered Professional Engineer in Virginia. He has taught courses in statics and dynamics, mechanics of materials, and construction engineering planning.