Rethinking Capstone Courses in Civil Engineering: A Response to ABET 2003-2004 Criteria for Accrediting Engineering Programs

W.J. Davis[1], T.W. Mays[2], J.K. Plemmons[3]

Abstract

ABET 2003-2004 Criteria for Accrediting Engineering Programs [ABET, 1] requires that all engineering students participate in a "Major Design Experience" based on prior course work, engineering standards, and realistic constraints. Some schools are attempting to satisfy this criterion within the context of conventional junior and senior level design classes (e.g., concrete, steel, and environmental design), while other programs are electing to provide a Capstone Course focused largely on accomplishing objectives listed in ABET Criterion 4. This paper presents results of a survey aimed at determining how different schools are addressing ABET capstone criteria within their curriculum. Only civil engineering programs located in the southeastern United States were asked to participate in the survey. Project types, instructional approaches, teaching methods, organization of student teams, assessment of individual student effort, and involvement of practicing professionals are tabulated, discussed, and compared. Criteria definitions formulated by faculty at The Citadel for ABET terms such as economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political are presented. Improvements and curriculum changes adopted for existing capstone courses in structural engineering, subdivisions, transportation engineering, and environmental engineering as a result of this assessment are presented and discussed.

Introduction

A civil engineering program seeking ABET accreditation is required to clearly demonstrate that the program meets all criteria as set forth in *ABET 2003-2004 Criteria for Accrediting Engineering Programs* [ABET, 1]. Criterion 1, 2, and 3 are related to overall student performance, program educational objectives, and program outcomes and assessment. These criteria are directly related to capstone courses in civil engineering, but most of the criteria are also satisfied in numerous other courses taken prior to enrollment in a capstone course. Criterion 5 through Criterion 8 are also indirectly related to capstone courses, but are primarily concerned with the overall makeup of the program and not any one particular course. Conversely, Criterion 4 is tagged the "Professional Component" and it contains requirements specifically geared towards a capstone course. ABET does not require capstone course offerings, but schools that do not offer capstone courses are still required to satisfy this criterion in portions of other courses. All students are required to participate in ". . . a major design experience based on knowledge and skills acquired in earlier course work and incorporating standards and realistic constraints" [ABET,1]. Realistic constraints are required to include most of the following considerations:

1) Economic

---

[1] Associate Professor, The Citadel, Department of Civil & Environmental Engineering, 171 Moultrie Street, Charleston, SC, 29409.

[2] Assistant Professor, The Citadel, Department of Civil & Environmental Engineering, 171 Moultrie Street, Charleston, SC, 29409.

[3] Assistant Professor, The Citadel, Department of Civil & Environmental Engineering, 171 Moultrie Street, Charleston, SC, 29409.

2) Environmental
3) Sustainability
4) Manufacturability
5) Ethical
6) Health & Safety
7) Social
8) Political

No guidance or commentary is provided with the *ABET 2003-2004 Criteria for Accrediting Engineering Programs* [ABET, 1] and educators are left to determine discipline specific definitions for the terms stated above. The American Society of Civil Engineers (ASCE) is the lead society for civil engineering programs as identified in the *ABET 2003-2004 Criteria for Accrediting Engineering Programs* [ABET, 1]. ASCE has drafted a Commentary [ASCE, 2] to the *ABET 2003-2004 Criteria for Accrediting Engineering Programs* [ABET, 1], but the document is still in the review process. The Commentary provides detailed definitions of the terms "proficiency" and "engineering design" and thoroughly addresses the organization's judgment as to what a major design experience should entail.

In general, the Commentary [ASCE, 2] presents design as a "process of analysis and synthesis." In other words, there could be multiple correct solutions to a design problem. Design is not simply a set of plans and specifications, but evidence of "conceptualizing, testing, and proving the solution to a problem." The Commentary recognizes time constraints on students and faculty members and for academic purposes, states that elements of the design project must be constrained at reasonable levels in order to ensure that student designs are all within some narrow range of acceptable solutions. On the other hand, the Commentary recommends that the ABET evaluator search all design class files to ensure that some of the course design projects require iterative solutions that result from realistic constraints.

The Commentary makes several other major points, which should be noted. The course syllabus should manifest various standards and constraints used in design courses and should also indicate when, during the design process, the constraints were installed. Open-ended design problems should be used for some design problems, but not for all. Constraints that recognize the education and experience level of the students should be utilized to create practical yet realistic design projects.

Multidisciplinary teams are required to be used in Criterion 3 from the *ABET 2003-2004 Criteria for Accrediting Engineering Programs* [ABET, 1]. The Commentary [ASCE, 2] helps clarify the intent of the ABET requirement by stating that team members can include only students from different areas of civil engineering or additional team members (e.g., other students, practitioners, other faculty) from other areas of engineering or non-engineering disciplines.

The Commentary states that the major design experience should be clearly identified in the curriculum with example design projects available to the ABET evaluator. The major design experience should include both technical and non-technical issues and is not required to cover all of the civil engineering disciplines. The Commentary suggests that capstone courses be used in civil engineering curriculums in lieu of major design experiences only in the individual design classes by stating that "ASCE believes it is preferable to integrate the learning of the design process throughout the professional component of the curriculum, and then to culminate in a major design experience which draws upon and pulls together that which has been learned in previous classes" [ASCE, 2].

Review of Relevant Literature

An investigation of relevant literature reveals a diverse grouping of capstone design course activity within engineering curricula of numerous universities and colleges. A significant number of capstone activities, documented over the past several years, highlight the role that capstone education methods play in the education of engineers. Mechanical, manufacturing, chemical, electrical, civil, and environmental engineering programs with capstone courses are all addressed in the literature. Identified capstone activities tend to focus primarily on senior or upper-level courses and reflect a response to constituent input and awareness of ABET criteria. For examples, see [Gierke 1998], [Todd 1997], and [Gorman 2001]. The heightened level of interest in this topic prompted at least two prominent journal articles that reviewed literature on teaching engineering design through project-oriented capstone courses [Dutson 1997, Todd 1995].

Identified capstone activities range from single courses to multi-year programs. Several documented capstone activities occur within a single quarter or semester, while others are linear and cover a much longer time period [Bazlamit 2002, Bielefeldt 2003]. One capstone activity with an extended timeframe is the comprehensive, multiyear Sooner City project employed by the School of Civil Engineering and Environmental Science at the University of Oklahoma [Kolar 2000].

Based on this literature review, the level of interest and involvement in capstone learning activities appears to be significant and reflects a broad spectrum of assigned problems. From discipline-centered to multidiscipline approaches, many capstone courses apply a design problem approach within a practical, client-based or business-oriented context. [Bazlamit 2002, Welch 2003].

Methodology of Capstone Course Survey

To determine how other schools in the southeastern United States are attempting to meet Criterion 4 in the *ABET 2003-2004 Criteria for Accrediting Engineering Programs* [ABET, 1], a faculty committee at The Citadel performed surveys of faculty responsible for capstone courses at 12 universities across the southeastern United States. All of the surveys were based on a standard survey form, and were conducted using phone interviews, e-mail contact, and personal conversations. All schools asked to participate responded to the survey. Participating schools included the University of Alabama, Auburn University, Christian Brothers University, Clemson University, University of Florida, Georgia Tech, The University of Memphis, University of North Carolina at Charlotte, North Carolina State University, University of South Carolina, Virginia Military Institute, and Virginia Polytechnic Institute and State University.

In lieu of attaching the survey form used for the study, the general topics from the survey form are listed below.

1. Capstone Design courses offered
2. Project types and disciplines covered
3. Projects, real or fictitious?
4. Project materials
5. Credit hours
6. Instructional approach
7. Involvement of outside professionals
8. Course pre-requisites
9. Student teams
10. Assessment of individual effort
11. Basis of grade determination
12. Final presentation
13. ABET requirement for multi-disciplined teams
14. Ethical aspects, ABET requirement
15. Social and political considerations, ABET requirement
16. Sustainability, ABET requirement
17. Computer programs used
18. Capstone syllabus/materials

To respect the privacy of participating schools and to use the information entrusted to The Citadel faculty committee responsibly, individual responses of the participating school's faculty members to the list above are not revealed in this paper. The schools will henceforth be referred to as School 1 through School 12 so that overall results of the study may be presented. There is no particular order to the schools and the numbers 1 through 12 do not directly refer to the alphabetical listing of schools above.

Results of Capstone Course Survey

Table 1 shows a summary of the survey responses for the 12 schools participating in this study. General trends and findings from the capstone course survey pertaining to major instructional components are summarized in the listing below.

Instructional Approach

4 schools offer discipline specific senior design classes rather than capstone design.
2 schools have a 2-semester sequence.
3 schools use a team teaching approach.
3 large schools do not offer capstone design courses.

Student Teams

All 11 schools use student teams, varying in size from 3 to 8 students.
2 schools have students work on one big project with teams conducting discipline specific work.
3 schools have teams work on different projects promoting interaction between teams.
6 schools have teams work competitively against one another in parallel on the same project.
2 schools designate a student leader for each team.

Individual Student Assessment

5 schools use individual exams/quizzes.
4 schools use individual presentations.
4 schools have an individual serve as leader of intermediate team submittal.
6 schools use peer/self evaluations.
4 schools use individual assignments.

Miscellaneous

Use of real projects is helpful in engaging outside professionals.
3 schools have students meet with practitioner advisers.
5 schools have outside professionals serve on jury panel for final presentations.
1 school has established relationship with project sponsors.
3 schools indicated difficulty in dealing with ABET's multi-disciplinary teams criterion.

Table 1 (a). Summary of survey responses for schools 1 through 3.

ID	Course(s)	Project Types	Student Teams	Class Organization	Individual Student Assessment	Professional Involvement	Comments
1	Senior design (2 semesters)	Revolving, e.g., construction over landfill, force protection, retaining wall	Yes, 3-4 per team	Teams all design same project in parallel effort	Based on peer evaluations and comments from faculty	Yes, serve as guest speakers	NA
2	6 – Senior design	One for each area: water, structural, transportation, soils, construction, and environmental	Yes, structural; 2-4 per team, transportation 6-8 per team	Teams all design same project in parallel effort	Individual assignments, and final oral exam during presentation	Yes, NC PE Board member on ethics/ professionalism and practicing engineer on professional issues	Professor acts as owner and architect, practitioner has input and evaluation role
3	1 – Capstone	All major CE areas including stormwater, highway, industrial park, habitat, etc	Yes, typically 8, sometimes reduced to 6 or 7 based on class size	Teams work on different projects, promotes interaction between teams	Individual oral presentation, mid-term exam, self-evaluation questionnaire	Yes, numerous guest lectures including lawyer, regulatory agency, also students meet weekly with engineer	Has established on-going relationships with regulatory agencies and local consulting firms

Table 1 (b). Summary of survey responses for schools 4 through 6.

ID	Course(s)	Project Types	Student Teams	Class Organization	Individual Student Assessment	Professional Involvement	Comments
4	4 – Senior design	All major CE areas	Yes, e.g., structural, typically 8 per team with 4 subgroups of 2. Class conducts one big project	Subgroups produce products used sequentially by other subgroups	Final exam and small subgroup work	No	Has experienced difficulty in trying to address multi-disciplinary teams
5	None	NA	NA	NA	NA	NA	Conceded difficulty in formulating capstone curriculum
6	None	Building design in steel/concrete, similar projects in constr.uction, soils and environmental	Yes, typically 4, team leader assigns work	Teams work on different projects, promotes interaction between teams	Individual assignments and peer evaluations	No	Faculty has elected to install major design experiences into core design classes

Table 1 (c). Summary of survey responses for schools 7 through 9.

ID							
7	1 – Capstone	Revolving comprehensive project covering all major CE disciplines	Yes, 3-6 per team, teams organized according to discipline, class conducts one big project	Team leaders form coordination committee, work is coordinated between teams sequentially	Authorship of team submittals, self evaluation, time sheets, peer evaluations	Yes, to discuss environmental permits and technical aspects	Use overlapping team teaching approach
8	4 – Senior design	e.g., structural, 7-story office building using reinforced concrete	Yes, e.g., structural, 4 per team	Teams all design same project in parallel effort	4 extensive home-work assignments, mid-term exam and peer evaluations	Yes, to discuss ethics and technical aspects; also, serve as jury members for final presentation	Course previously taught for 10 years by practicing engineer
9	Senior design (2 semesters)	Typically interchange design covering all major CE areas	Yes, 3-4 per team	Teams all design same project in parallel effort	Determined by advisor and practitioner suggests grade (this doesn't work)	Yes, present on ethics/professional responsibility and meet with student teams every 2 weeks	NA

Table 1 (d). Summary of survey responses for schools 10 through 12.

ID	Course(s)	Project Types	Student Teams	Class Organization	Individual Student Assessment	Professional Involvement	Comments
10	1 – Capstone	Site preparation with open ended building design	Yes, 4-5 per team, never use 3 or 6.	Teams all design same project in parallel effort	Leader of intermediate submittal, peer evaluation, individual presentation	Yes, architect presents lectures and practitioners serve as jury members for final presentation	Support from other faculty for Auto-CAD, Hydro program and architectural aspects
11	1 – Capstone	Chose from extensive list of comprehensive projects	Yes, 4-6 per team, with 5 as optimal for prof. and students	Teams work on different projects, promotes interaction between teams	Team based grade is adjusted up/down based on discretion of professor	Yes, extensive involvement with consultant liaison and agency sponsors	English Department instructor gives lectures on tech writing, informal support from other faculty
12	Seminar, Capstone	Revolving project typically building design, interchange or environmental study	Yes, 3-4 per team	Teams all design same project in parallel effort	13 written assignments, individual project assignments, quizzes, faculty comments	Limited, as guest speakers and sometimes as evaluators	NA

Resulting Curriculum Changes for Capstone Courses at The Citadel

Currently, The Citadel has four unique capstone courses that focus primarily on four major areas of civil engineering. These courses are taught by different faculty who specialize in certain areas. Three of the courses are taught during the daytime and only cadets may choose from these options. One of the courses is taught for the evening program and cadets are not permitted to take this class. The intent of the CEE program at The Citadel is that the overall curriculum for the evening program and the cadet program are similar in content. All capstone courses are taught during the Spring semester and only students that are in their senior year may register for the course. The capstone courses taught at The Citadel are listed below.

Cadet Program

- Civl 422, Comprehensive Design Project in Environmental Engineering
- Civl 423, Comprehensive Design Project in Structural Engineering
- Civl 425, Comprehensive Design Project in Engineering Practice – Land Development

Evening Program

- Civl 425, Comprehensive Design Project in Engineering Practice – Transportation Engineering

The faculty teaching capstone courses at The Citadel agree that there has been difficulty over the past few years in documenting compliance with all of elements of ABET Criterion 4 [ABET, 1]. Specifically, in all classes it has been assumed that realistic constraints have been properly imposed on students, but no definitive definitions for these terms is available in the literature. In addition, although the requirement for multidisciplinary teams may have been met, no real position on this requirement has been consistently formulated by the faculty. Similar to other programs surveyed, each individual professor teaching a capstone course at The Citadel has attempted to meet ABET Criterion 4 and multidisciplinary team requirements based on their own interpretation. To provide congruity across capstone course offerings at The Citadel and to ensure that students in the evening program and the cadet program receive similar education experiences, the faculty at The Citadel decided to conduct the previously addressed survey of schools and to attempt to synthesize the capstone courses by developing definitions for key terms, maintaining similar requirements for students in all capstone courses, and evaluating how the department satisfies requirements for multidisciplinary teams. Also, it was deemed necessary to perform a benchmark capstone study of other universities in order to determine where The Citadel stands in its capstone evolution.

Based on the results of the survey of schools, The Citadel faculty committee made several observations and suggested actions for The Citadel's capstone courses. These are presented in the following listing of observation and action items.

Observations and Suggested Course of Action for CEE Department

- Overall findings of this undertaking generally indicate that The Citadel capstone courses are keeping pace with those offered at other schools and meeting most of the ABET criteria.

- CEE curriculum offers a broad array of capstone courses for Cadet students. Most schools surveyed only offer one capstone course.

- Consensus on curriculum issues such as sustainability and multi-disciplinary teams appears difficult to achieve.

- None of the 12 schools included in the survey are conducting multidisciplinary capstone projects in association with other engineering disciplines such as electrical, mechanical, chemical, etc.

- In reviewing pertinent literature, it is obvious that views and approaches to capstone design are continuously changing. The Citadel's capstone courses will need continual tweaking, updating and reformulation for these courses to keep pace with the current best practices.

- The faculty suggests an ongoing effort be made by CEE capstone course instructors to work together to accomplish the following:

    1. continually improve content,
    2. better address central ABET criteria,
    3. incorporate feedback,
    4. develop criteria definitions,
    5. and, ensure consistency across all Departmental offerings.

Although the faculty teaching capstone courses have begun to address all of the points identified above, the remainder of this paper is limited to a discussion of criteria definitions developed by the faculty and means and methods that will be used in the Spring of 2004 to ensure consistency across all four capstone courses offered at The Citadel.

As mentioned in the introduction to this paper, realistic constraints described in the ABET Criterion 4 [ABET, 1] are not formally defined and their use and subsequent assessment are left up to the program seeking accreditation. It was discovered throughout the survey process that each school had its own definition or understanding of the realistic constraint terms and these definitions varied considerably. This is not entirely true since the actual definitions are the opinion of ABET as enforced by the ABET evaluator. In any event, the faculty at The Citadel believe that it is important that all capstone courses use consistent definitions for the project constraints and course criteria. More specific definitions and their actual use will remain up to the discretion of the professors teaching each particular course. Definitions developed by faculty at The Citadel for the realistic constraint terms are considered a work in progress and are presented below.

1) Economic - Economic considerations in civil engineering design includes efficient use of materials and labor, careful management of time and other resources, and the development of an overall budget for design, construction, and maintenance, or any part thereof. Economic, commercial, social, or environmental benefits or dis-benefits that would result from project implementation are also covered.

2) Environmental - Environmental considerations in civil engineering design includes analyzing, assessing, mitigating and/or correcting the impact of altering the natural or existing environment.

3) Sustainability - Sustainability focuses on the social/cultural and environmental impact of a project on the widest scale. This includes, but is not limited to, the concepts of life cycle analysis, reuse/recycling, industrial ecology, and assessment of social cultural impact. Sustainability considerations in civil engineering design ensure the following: (1) A project meets or exceeds its intended design life by incorporating appropriate details to result in minimal maintenance and replacement requirements over time, (2) that the design does not utilize and excessive amount of materials which currently are or could be harmful to the environment, and (3) that the design minimizes any adverse effects on individual cultures or society over a long term basis as best determined at the time of construction.

4) Manufacturability - Manufacturability considerations in civil engineering design refers more appropriately to constructability. In accordance with good engineering practice, the completed design project should be presented in a logical fashion where all elements of the project are either independent of or in harmony with all other components.

5) Ethical - Ethical considerations in civil engineering design should directly reflect accepted practice as detailed in the *ASCE Code of Ethics* and South Carolina's Engineering and Land Surveying Regulations and Engineering and Land Surveying Code of Laws.

6) Health & Safety - Health and safety considerations in civil engineering design ensures the overall health, welfare, and well being of the general public. Design projects must directly account for the health and safety of the contractor(s), owner, occupants, users, and those that are also affected indirectly by the project.

7) Social - Social considerations in civil engineering design should reflect real world interaction between individuals and is typical of all multi-disciplinary teams. Outside practicing engineers, architects, scientists, etc., are an integral part of the real design process and are needed to appropriately address the social constraints of a design project. Team members must learn to recognize the role and importance of other team members and outside professionals.

8) Political - Political considerations in civil engineering design involve both the public and private sectors. Major design projects require public approval and often times require the support of elected officials. Smaller projects require an appropriate hierarchy of command during the design process and some consultation with the client or owner is typically expected. As a minimum, all projects require the approval of smaller agencies via permits.

In addition to establishing CEE Department accepted definitions of realistic constraint terms, the faculty teaching all four capstone courses have attempted to optimize the use of multidisciplinary teams in each course. The faculty teaching the three cadet courses have elected to combine all projects into one project located on a fictitious site. All three classes will meet together for the first two weeks of the course and a guest developer, architect, and permitting agency will present the project scope to the students. The overall project will consist of land development for various residential and commercial areas, structural design of one large building and several individual buildings, and the design of a water treatment facility. All students are considered part of one large team consisting of various civil engineering disciplines and will work together on the project. The majority of the work for each student will remain in the student's discipline of choice. Other team members are to consist of the architect, developer, and permitting agency who will continually introduce realistic constraints each time they visit the class (i.e., once every two weeks). Since the evening course is taught at a different time, it is impractical to have the evening students work with any of the cadet classes. Hence, this class will effectively use students representing various disciplines on a more broad based design assignment. The focus of the project is transportation engineering and it includes bridge design, environmental impact, geotechnical, drainage, traffic engineering and construction management all addressed in a comprehensive format by various teams.

Conclusions and Recommendations

ABET 2003-2004 Criteria for Accrediting Engineering Programs [ABET, 1] requires that all engineering students participate in a "Major Design Experience" based on prior course work, engineering standards, and realistic constraints. Affectively demonstrating that a capstone course experience meets all associated criteria is an arduous task given the lack of clarification by the governing organization. The survey conducted by the CEE faculty at The Citadel revealed that this is not an uncommon conclusion for most CEE faculty at other schools. Although many schools believe they are adequately addressing the majority of ABET requirements, it is interesting to note that if this is true, most are doing so in a somewhat unique way. The Criteria definitions formulated by faculty at The Citadel for ABET terms such as economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political are believed to be the implied intent as related to civil engineering and that future versions of the Commentary [ASCE, 2] might contain similar guidance. Improvements and curriculum changes adopted for existing Capstone Courses in structural engineering, subdivisions, transportation engineering, and environmental engineering as a result of this assessment are provided as ideas that that may be helpful to other programs in addressing similar concerns.

References

1. ABET (2002) *ABET 2003-2004 Criteria for Accrediting Engineering Programs*, Accreditation Board for Engineering and Technology, Baltimore, MD.

2. ASCE (2002) *Commentary to Civil Engineering Program Criteria*, American Society of Civil Engineers, Draft #7 Version of May 2002.

3. Bielefeldt (2003) Bielefeldt, A. R., "Capstone Environmental Design Course Incorporating Sustainable Projects," Proceedings of the 2003 American Society of Engineering Education Annual Conference, June 2003, Session 3251.

4. Dutson (1997) Dutson, A. J., et al, "A Review of Literature on Teaching Engineering Design Through Project-Oriented Capstone Courses," Journal of Engineering Education, January 1997.

5. Gierke (1998) Gierke, J. S.; Mayer, A. S.; Shonnard, D. R.; "Multidisciplinary Subsurface Remediation Courses, Fundamentals, Experiments, and Design Projects," Journal of Engineering Education, 1998 Supplement.

6. Gorman (2001) Gorman, M. E., et al; "Transforming the Engineering Curriculum: Lessons Learned from a Summer at Boeing," Journal of Engineering Education, January 2001.

7. Quadrato (2003) Quadrato, C., et al, "Grading Capstone Design: On Time and On Target," Proceedings of the 2003 American Society of Engineering Education Annual Conference, June 2003, Session 2425.

8. Todd (1995) Todd, R. H.; et al, " A Survey of Capstone Engineering Courses in North America," Journal of Engineering Education, April 1995.

9. Welch (2003) Welch, R. W.; Estes, A.C., "Client-Based Projects for Every Senior – A Mark of Excellence of Any Program," Proceedings of the 2003 American Society of Engineering Education Annual Conference, June 2003, Session 3515.

10. State House Network, "Engineering and Land Surveying Regulations," *2002 South Carolina Code of Regulations*, http://www.scstatehouse.net/coderegs/c049.htm.

11. State House Network, "Engineering and Land Surveying Code of Laws," *2002 South Carolina Code of Laws*, http://www.scstatehouse.net/code/t40c022.htm.

William Jeff Davis

Dr. Davis is an Associate Professor in the Department of Civil & Environmental Engineering at The Citadel in Charleston, South Carolina. He obtained a B.S. in Civil Engineering from the University of Alabama in 1981, M.S. from Auburn University in 1987 and earned a Ph.D. in Transportation Engineering from Georgia Institute of Technology in 1997. He is a registered Professional Engineer and has over 15 years of experience in highway design and traffic engineering projects. Dr. Davis is a member of ASEE, ASCE, Institute of Transportation Engineers and Transportation Research Board. He currently serves as Secretary of the Southeastern Section ASEE Research Unit, Executive Committee Secretary for the Urban Transportation Division of the American Society of Civil Engineers and is a member of the TRB Highway Capacity and Quality of Service Committee.

Timothy Wayne Mays

Dr. Mays is an Assistant Professor in the Department of Civil & Environmental Engineering at The Citadel in Charleston, SC. Prior to his arrival at The Citadel, he worked as an structural engineering intern in Charleston, SC while teaching at The Citadel as an adjunct professor. He received a Ph.D. in Civil Engineering from Virginia Polytechnic Institute and State University and specialized in structural/seismic engineering. During his time at Virginia Polytechnic Institute and State University, Dr. Mays received numerous regional and national awards such as a National Science Foundation Graduate Research Fellowship, the Earthquake Engineering Research Institute's most outstanding student paper award, and the University's most outstanding engineering research award.

James "Keith" Plemmons

Dr. Plemmons is an Assistant Professor in the Department of Civil & Environmental Engineering at The Citadel in Charleston, SC. He obtained a B.S. in Civil Engineering from the Citadel in 1980, M.S. from Clemson University in 1991, and earned his Ph.D. in Civil Engineering from Clemson University in 1995. During his time at Clemson, Keith received the Fluor Daniel Fellowship. He is a registered Professional Engineer with over 15 years of experience in the public and private sectors. His experience includes major design and construction projects in Japan and the United States. Dr. Plemmons is also a Project Management Professional as certified by the Project Management Institute.