MASTER OF SCIENCE PROGRAM
SELF-STUDY REPORT

2018

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

TABLE OF CONTENTS

List of Tables

List of Figures

PROGRAM OVERVIEW

The Department of Civil and Environmental Engineering (CEE) has offered master's degree programs since 1965 with the first degrees conferred in 1969. During the past 47 years, more than 350 Master's degrees have been awarded to students specializing in the sub-disciplines of Structural Mechanics, Environmental Engineering, Transportation Engineering, Construction Materials, and Structural Engineering. The degrees granted have included the Master of Science in Civil Engineering (MSCE), which began at the college level in 1965, the Master of Civil Engineering (MCE) and the Master of Engineering (ME). The ME programs were available to students from 1975 to 1985. The MSCE (MS for short hereafter) is the only degree currently available to students in the form of two options: "thesis" and "non-thesis." Those who select the "thesis" option take a minimum of 6 credit hours of research in addition to a minimum of 24 hours of graduate coursework, while those who select the "non-thesis" option take a minimum of 3 credit hours of project work in addition to a minimum of 31 hours of graduate coursework. The Department also has a Fast-track MS Program in Civil Engineering that provides the opportunity for CEE undergraduate students at Tennessee Tech University with an excellent academic record (qualifying requirements can be found at https://www.tntech.edu/graduatestudies/fast-track-to-a-masters-degree and selecting Civil and Environmental Engineering) to accelerate completion of the MS program. This is achieved by allowing a qualified senior undergraduate student to accumulate up to six credit hours of graduate coursework while still completing the undergraduate degree. These six credit hours of graduate coursework are used to satisfy both undergraduate and graduate degree requirements.

Consistent with the missions of Tennessee Tech University (can be found at Tennessee Tech University Mission) and the College of Engineering (can be found at College of Engineering Mission), the mission of the MS program in CEE is to provide students with the strong academic training required for making significant contributions to the civil engineering profession in the 21st century, for becoming well informed productive members of society, and/or for preparing them for advanced study at the doctoral level. The goals of the program include continued improvement of its research and scholarly profile, a coursework portfolio that is relevant to professional practice and research, and production of graduates that are professionally engaged. Consistent with these goals, specific objectives of the program include increasing the scholarly work done by CEE faculty and graduate students, increasing externally funded research led by CEE faculty and students, increasing enrollment of the graduate program by attracting more high quality students, continuing provision of high quality courses that keep graduate students abreast of developments in their CEE sub-disciplines and that equip them for undertaking high quality research, and increasing engagement in the profession by graduate students through professional service activities.

By virtue of the breadth of the CEE discipline, each MS student is required to select and build emphasis in one of the six sub-disciplines of the CEE MS program, namely Structural Engineering, Environmental Engineering, Transportation Engineering, Construction Materials, Geotechnical Engineering, and Structural Mechanics. The MS program had lacked the sub-discipline of geotechnical engineering for several years. To increase the breadth of the program and increase enrollment by being able to attract graduate students seeking expertise in geotechnical

engineering, CEE faculty set as an objective to recruit a faculty member with expertise in this sub-discipline. In 2015, Dr. Daniel VandenBerge was hired to fill the position. With his expertise, the Department has begun to recruit MS students to the geotechnical sub-discipline (two within the study period). Further, within some of the sub-disciplines, the CEE MS program provides for additional specialization, allowing a graduate student to build depth in a specific area. As examples, within the sub-discipline of structural engineering, graduate students specialize in either bridge design or building design. In the sub-discipline of transportation engineering, graduate students specialize either in traffic engineering or in transportation planning. In the sub-discipline of environmental engineering, graduate students specialize in either water resources engineering or environmental quality and wastewater treatment engineering.

The MS program has a coursework component, a thesis research/project component, and a professional development component. These components are discussed in turn. For the coursework component, nearly all the courses offered in the program are three-credit-hour courses. Each sub-discipline has required core courses and graduate elective courses from which students select. The courses are structured to ensure achievement of the MS program objectives and learning outcomes. Collectively, the courses emphasize critical thinking, reviews of the relevant literature in a sub-discipline, independent work, team work, and written and oral communication. The thesis research and project component emphasize independent work. In the case of thesis research, its conduct is expected to lead to significant technical contributions being made in a specific area of a CEE sub-discipline. In the case of project work, its conduct is expected to lead to contributions to the practice of the profession. The professional development component seeks to inculcate into students the importance of and how to keep abreast of developments in their sub-disciplines post-graduation, through participation in technical meetings, conferences, workshops, etc. The components of the program, in the final semester of the five-year review period, were delivered by 16 CEE faculty each of whom holds the terminal degree in their respective CEE sub-discipline.

Since the last program review period of 2008-2012, the total annual graduate enrollment has held steady in the range of about 25 to 30 students (of which PhD enrollment has ranged between 6 and 8 students). On average, there have been about 20 graduate students in the MS program at any given time. Over the 2012-2017 review period, the program received a total of 271 applications from domestic and international students. Ninety-three applicants (34.3%) were granted admission (including provisional standing), and 53 of them actually enrolled during this five-year review period. These data are a reflection of the consistent demand and success of the CEE MS program. A summary of the applicants and enrollees is presented in Table A-1 of Appendix A. Thirty (56.7%) of those who enrolled have successfully completed their MS degree. The other 43.3%, as at the time of documentation, were either continuing in the program (with some of them expected to complete it by December 2017) or had dropped out of the program due to low grades or other reasons.

A notable feature of the CEE MS program is that its 5-year running average graduation rate has never been below 5 students per year, which is the Tennessee Higher Education Commission (THEC) specified limit below which a graduate program is classified as "low-producing." In fact, since the last program review, the average number of students graduating has increased by over 25%. The most recent 5-year (2012-2017) annual average graduation rate is about 9.4 graduates (**see red line** in **Figure 1,** which shows the distribution of MS degrees

conferred each academic year since the program was initiated) as compared to 7.4 in the previous review cycle (2008-2012). The annual average graduation rate calculation considered students who enrolled and graduated during the 2012-2017 time period, as well as those who enrolled prior to 2012, but graduated during this time period.

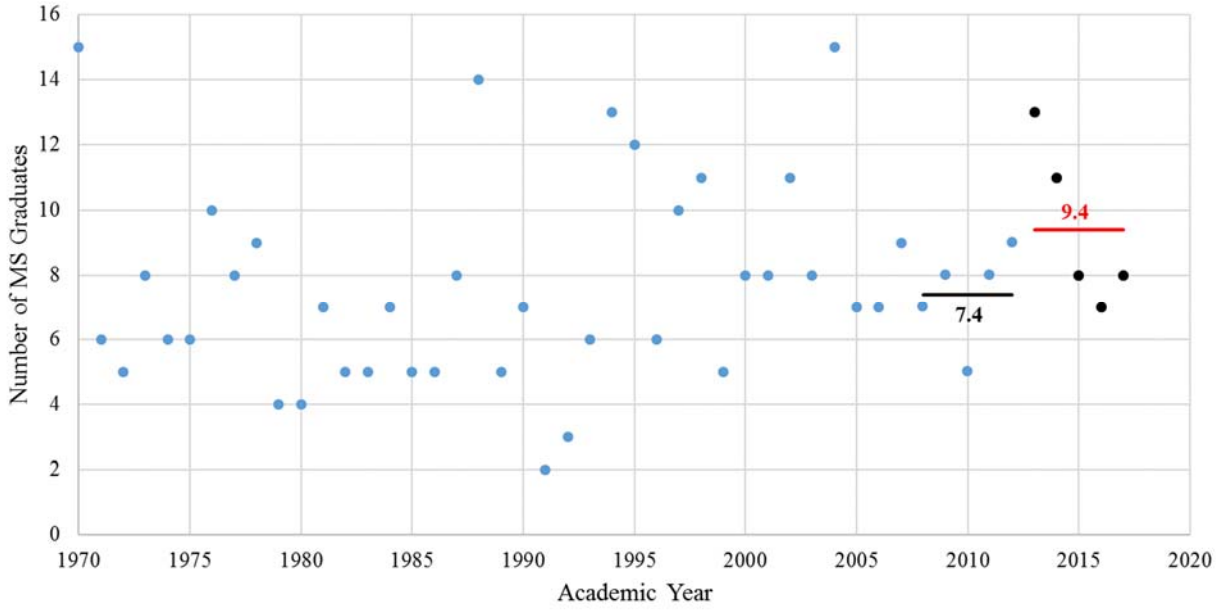

Figure 1. Distribution of MS degrees conferred each academic year since inception.

A summary of the demographic characteristics of applicants to the program and those that actually enrolled indicate that the graduate student body comprises both US citizens and international students respectively in good numbers. The diversity of both the applicant-pool and the eventual enrollees is testimony to the increasing visibility of the CEE graduate program and success of its outreach into the international arena. Demographic characteristics of applicants to the program, their GRE and TOEFL scores, as well as their undergraduate GPA are presented in Table A-1 of Appendix-A.

GRADUATE PROGRAM CONTENT AND DIRECTION

Admission Procedures

Admission decisions on applications into the MS program in Civil and Environmental Engineering at TTU are based on multiple criteria, which are listed in TTU's Graduate Catalog (http://catalog.tntech.edu/content.php?catoid=22&navoid=4188) and on the College of Engineering's website for graduate studies (http://www.tntech.edu/engineering/coe-graduate-programs). These criteria are as follows:

1. An undergraduate GPA of at least 3.00 on a 4.0 scale.
2. Graduate Record Exam (GRE) General Test scores with breakdown as follows: the Quantitative score should be greater than or equal to 50%; the Verbal score should be greater than or equal to 33%; and the Analytical Writing score should be greater than or equal to 33%. Students with BS degrees in related fields from TTU are not required to take the GRE.
3. Three (3) letters of recommendation from persons familiar with the applicant's academic abilities, which demonstrate strong evidence for success in the graduate program.
4. Availability of appropriate faculty to serve as research advisor(s).
5. Participation in undergraduate research.
6. Post-BS degree professional experience relevant to planned degree of study.
7. Publications in peer reviewed journals and/or award-winning presentations in technical conferences.
8. International students must score at least 550 (213 computer-based or 79 internet-based) on the Test of English as a Foreign Language (TOEFL) or a minimum base score of 6.0 on the International English Language Testing System (IELTS).

Completed electronic application forms submitted by applicants are received by TTU's College of Graduate Studies (CGS). Initial screening is done by CGS using base criteria specified by the CEE Department. Currently, the base criteria is for an application to have at least two of the three GRE General Test scores being no less than the minimum specified above. If for a particular application the base criteria are met, then the application is forwarded to the CEE Department for further evaluation and a recommendation to be made for its final disposition. If the base criteria are not met, the application is rejected.

Each received application in the CEE Department is evaluated based on the eight criteria by the chairperson and by CEE faculty in the applicant's planned area of specialization. After consultation amongst the evaluators, the CEE chairperson recommends a decision which could be to Deny Admission; Grant Admission with Full Standing; Grant Admission with Provisional Standing; or Grant Admission with Special Standing. Provisional or Special Standing status may be changed to Full Standing after the student satisfies the requirements specified by the CEE Department at the time of admission. It should be noted that even though an applicant may not meet a few of the eight criteria, admission to Full Standing may be granted based on the extent to

which the remaining criteria are satisfied (typically, if five of seven criteria, excluding letters of reference, are met, the applicant is admitted).

The CEE MS program is designed for graduates from approved undergraduate civil engineering programs. Thus, a baccalaureate degree in civil engineering is required for Full Standing admission to be granted. Applicants with an undergraduate degree in a closely related field are evaluated on a case-by-case basis and may be admitted to Full Standing after successful completion of the identified background courses. An applicant that is admitted with Provisional Standing due to a low TOEFL score is required to take one or more English as a Second Language course: ESL 1010 and/or ESL 1020 as remedial study.

Statement of Desired Outcomes

The learning outcomes of the CEE MS program, as described later in Section 1.1, are for students in the MS program in Civil Engineering to be able to:

1. Demonstrate clear understanding of the chosen sub-discipline of civil engineering covered in course material in the graduate program;
2. Apply advanced methods in the development of solutions in the chosen sub-discipline of civil engineering ; and
3. Give professional presentations or write scholarly manuscripts worthy of publication in peer reviewed journals.

In consonance with the above, specific desired outcomes of instruction for CEE MS students are for them to:

1. Have a mastery of the theoretical fundamentals in their area of specialization;
2. Have a thorough understanding of the advanced concepts in their area of specialization;
3. Be able to apply both the fundamental and the advanced concepts in their respective areas of specialization to the development of solutions pertinent to civil engineering problems;
4. Have, in their area of specialization, comprehension of relevant technical material found in journals and papers presented at technical conferences;
5. Be able to perform technical work in their area of specialization working independently;
6. Be able to perform technical work in their area of specialization working in teams;
7. Be able to author technical papers worthy of consideration for publication in journals, or for presentation at technical conferences, or as technical reports to civil engineering agencies or other clients;
8. Have the ability to deliver effective technical presentations orally; and
9. Recognize the importance of continuing education towards keeping abreast of technical developments in their fields of specialization.

Innovative, Unique, or Outstanding Features

Ways in which the CEE MS program is innovative, unique, and outstanding are described below.

1. The first feature of the program that is outstanding relates to its size. The program has a size that allows CEE faculty in each area of specialization to work more closely with their graduate students, provide more personal attention to each student's academic needs, and adopt teaching styles that better address the needs of their students and therefore enhance student learning.
2. A second feature of the program that is outstanding is its value of scholarship. One way in which this is demonstrated is through encouraging all graduate students that have made significant progress on their research to participate in Research Day, a research event organized by TTU's Office of Research and Economic Development, to showcase research being done on campus and reward the adjudged highest quality research performed in each discipline.

   Another way in which the MS program demonstrates its value of scholarship is through the financial support given by both the CEE Department and the College of Engineering to graduate students to enable them participate in regional and national conferences, particularly so when they are a coauthor of a technical paper(s) to be presented at these meetings.
3. A third feature of the program that is outstanding is the admissions process adopted by the CEE Department and the College of Engineering. It is a compensatory model that allows an applicant that does not necessarily meet all the admission's criteria to still be granted provisional admission, giving them an opportunity to demonstrate in their first semester the capability to successfully complete the program.
4. A fourth feature of the program that is both outstanding and unique is the regular graduate training provided on Plagiarism, Proposal/Thesis writing, communication skills, and development of a program of study. These are accomplished through the Graduate Seminar course.
5. A fifth outstanding feature of the program is the BS/MS fast-track master's degree option it offers which has been effective in attracting exceptional students in the CEE undergraduate program to pursue a graduate degree.
6. An innovative feature of the program relates to how funds are raised to support MS students. The Department raises funds from the traditional sources, typically from State and National research funding agencies. However, CEE faculty continually look for alternative ways to provide additional financial support to graduate students. One of the innovative ways the CEE Department is accomplishing this is through the establishment of a golf tournament in Cookeville, TN annually. This event is well patronized by both faculty and alumni, and the tournament proceeds are used to provide additional summer support for three meriting graduate students. As the event grows, the number of student beneficiaries will grow as well.

Breadth and Depth of the Program

As stated earlier, the CEE Department offers two options in the MS program: a thesis option and a non-thesis option (see CEE Graduate Handbook). Course work and/or research requirements for these options are described in turn below

1. The non-thesis option requires a student to take a minimum of 34 credit-hours of graduate courses, which are specified in the student's approved Program of Study, with a breakdown as follows: 30 credit-hours of graduate-level course work, one credit hour of CEE 6910 Graduate Seminar, and three credit-hours of CEE 6980 Special Topics (Project Work). The non-thesis MS student has to submit a project report on the Special Topics course, give an oral presentation of the project, and pass an oral comprehensive exam.
2. The thesis option requires a graduate student to complete a minimum of 31 graduate credit-hours with a breakdown as follows: 24 credit-hours of graduate courses, one credit-hour of CEE 6910 Graduate Seminar, and a minimum of six credit hours of CEE 6990 Thesis Research. Requirements for the thesis include development of a research problem statement relevant to the civil and environmental engineering profession, successful execution of the research, and documentation of the research findings and results to the satisfaction of the student's graduate advisory committee and to the College of Graduate Studies. Additionally, the thesis, which among others embodies a literature review, a methodology, results, and conclusions must be successfully defended by the graduate student to his/her graduate advisory committee.

For both MS options, at least 15 of the credit-hours for graduate courses in their Program of Study must be CEE courses. Occasionally, there may be special circumstances that merit a deviation from the above requirement. Where this is the case, approval has to be obtained from both the Chairperson of the CEE Department and the student's graduate advisory committee.

In both MS options, in some instances, an unlisted course may be included in a student's Program of Study. These are assigned the course number CEE 6900 (Special Problems) and have a specific title associated with each occurrence. Such special problem courses are initiated at the CEE sub-discipline level and must be approved by the CEE Research and Graduate Advisory Committee before they are offered. It is required that the proposal submitted to the committee for the offer of such courses include the list of topics to be covered in them. CEE 6900 courses serve at least two purposes. First, they serve as the "pilot test" for new graduate courses, allowing the instructor to refine course content and requirements before the course is eventually submitted for approval by the necessary committees and listed in the university graduate catalog. Second, CEE 6900 serves as a vehicle for CEE faculty to involve graduate students in research the faculty may be engaged in at a given time that has interesting intellectual and practical aspects, allowing the students to earn graduate course credit-hours while working on something relatively unique.

In both MS options, it is required that at least 15 of the credit-hours for graduate courses be at the 6000 level. The remainder of the courses in a student's Program of Study may be at the 5000 level. However, not more than 30 percent of the courses in a student's program of study may be in dually listed courses, that is, 4000- and 5000-level courses. Courses below the 5000 level are not counted towards a graduate degree. Although they may be listed in a student's Program of Study as background requirements, these courses are not considered in establishing completion of degree requirements.

It is apparent from the structure of the course requirements above that the CEE MS program strongly encourages its students to take relevant courses from non-CEE departments. This is deliberate and in recognition of the breadth of knowledge often required for the development of

context sensitive solutions to problems faced by civil and environmental engineers in today's world. Thus, several of the MS students are advised to take courses from other departments including Biology, Statistics, Mathematics, Chemistry, and Earth Sciences.

The CEE Department also offers a Fast-track MS Program in Civil Engineering. Its purpose is to provide an opportunity for promising CEE undergraduate students to accelerate the completion of the MS program. Students invited to this program have to complete and submit their application for approval by the end of the second semester of their junior year. The admission criteria for this program are: be enrolled as an undergraduate Civil Engineering student at TTU with at least junior standing; have an overall GPA of at least 3.25; have at least a 3.5 GPA based on performance on CEE courses only; and have a recommendation from a CEE faculty that will serve as the student's graduate advisor. Meeting these minimum requirements is not a guarantee of admission to the graduate program. In addition to the requirements for admission to the CEE Fast-track M.S. program, all requirements for admission to the CEE graduate program must also be met upon graduation.

Selection of a graduate student's committee, the nature of the comprehensive examination, and the culminating experience

The CEE chairperson does the initial advisement of all MS students. The chairperson meets with each of them to discuss among others the graduate program, the student's interests, potential funding sources if he/she is not already funded, and other needs such as office space, etc. They agree on the first semester's courses to be taken by the student. The chairperson then has the student meet individually with each faculty member in the chosen area of specialization to discuss courses for the program, research, and funding. The student is responsible for identifying, in consultation with the departmental chairperson, a faculty member who is willing to chair his/her committee. Then, in conjunction with the chairperson of the committee, the graduate student is responsible for identifying at least two other faculty members who are willing to serve on the committee. The advisory committee must consist of at least three members of the TTU graduate faculty and must be chaired by a member of the Department of Civil and Environmental Engineering.

The advisory committee is expected to be appointed during the student's first semester but not later than the semester in which the student is expected to complete 15 credit-hours of coursework. The mission of the committee is to guide, review the student's progress and assist the student as needed, and ensure that the students embark on a journey of self-inquiry that is relevant to the civil and environmental engineering profession.

Once the advisory committee is formed, the student's program of study or plan of study is developed and should be approved by all members of the advisory committee. In this plan of study, a student outlines a thoughtful plan of which courses to take, the order in which courses should be taken, and the amount of effort to be devoted to research/project each semester. This outline of courses should provide the required tools for the students' successful research completion. The student, along with the advisory committee chairperson, has to identify a research problem of interest, and then prepare a proposal and present it to the advisory committee. During this stage, a

student receives constructive input and recommendations from the advisory committee members on improving the plan to make a successful study more likely.

On completion of the thesis or project, the student's advisory committee members are required to review it prior to the comprehensive examination, and assist in the conduct of the examination. During the examination, the strength of the graduate student's knowledge of the technical subject matter embodied in their program of study is judged by the committee. In addition, the quality of his/her thesis/project is assessed by the advisory committee members to determine if he/she merits being awarded a Master of Science degree in Civil Engineering. Prior to and after the comprehensive examination, the thesis/project document goes through cycles of editing and revision in close consultation with the major advisor and the advisory committee until it is of acceptable quality and meets the College of Graduate Studies requirements.

Research in the Program

By design, the MS program (thesis or non-thesis option) requires, along with the coursework component of the program, a significant self-driven scientific investigation into an approved research topic, the process of which imbues graduate students with independent thinking and problem-solving skills. For the thesis option, this translates into the program requirement of a research thesis to which a minimum of 6 credit-hours is allocated, successfully defending it, and demonstrating the relevance of the work done through scholarly publications and presentations and advisory committee approval. For the non-thesis option, this is usually a 3-credit hour semester-long project report that tackles a more applied science problem not necessarily innovative in design but challenging enough to foster independent thinking by the students.

Other than the advanced and inter-disciplinary coursework, the MS program also offers other resources and tools for honing the research and critical thinking skills of graduate students. For instance, the required one-hour graduate seminar course, offered every fall semester, brings speakers from industry and academia who are experts in their fields to give presentations on state-of-the-art topics that inspire graduate students intellectually. Students taking this course also give seminars on their research to their peers to gain experience in presenting research and project results to a technical audience and receive feedback on the quality of their work and communication skills. The University also organizes a Research and Creative Inquiry Day event annually with the primary goal of stimulating high quality student research and creative inquiry on campus and providing a venue for presenting that work. Students are required to first submit an Abstract, which has to conform to guidelines and requirements set by the Office of Research and Economic Development, and then, second, to create a poster of their research, which again must meet specified guidelines. The posters are judged and awards given to the winners. Abstracts and posters, with the consent of the primary author, are published in an online journal titled Proceedings of Student Research and Creative Inquiry Day. Student Research Day often acts a catalyst for students to compete and strive for intellectual excellence while they are beginning to perform scientific inquiry in a field they have not completely explored.

Fundamental to the scientific research process is the conduct of a comprehensive and critical review of the relevant literature on a topic of interest. Hence, as part of the process of inculcating into students the scientific process of inquiry, critical review papers are required in

some of the graduate courses. Writing these papers helps to nurture independent thinking and identification of possible pathways to advancing the state-of-the-art, which could possibly serve as the starting point of a student's MS research.

Nearly all students enrolled in the MS program in CEE receive some sort of financial assistance in the form of graduate assistantships (GAs). These assistantships are further designated as either a teaching assistantship (TA), or a research assistantship (RA), depending on the nature of the required job duties associated with the assistantship. Funding of these assistantships comes from a variety of sources, including the CEE Department, external grants secured by CEE faculty, and internal research grants from the Office of Research and Economic Development and/or Centers of Excellence. Currently there are twelve students holding graduate assistantships.

MS students, in general, are provided with office space and a personal computer. In addition, there are a number of state-of-the art networked computers available in the CEE student computer laboratory in Prescott Hall, which houses the CEE Department. This laboratory is open 24 hours a day to provide easy access to MS students who might find need of it during their research and coursework.

Public Service

Public service and outreach is integral to the civil engineering profession. Therefore, faculty members make efforts to integrate it with graduate-level coursework and scholarly and extra-curricular activities whenever possible.

As examples of public service through coursework, during offerings of CEE 6900 Special Topics: Stormwater Design and Applications, Dr. Kalyanapu and Dr. Datta mentor students to develop stormwater management plans for Tennessee Tech University and other communities within the City of Cookeville. Students work with the city's Public Works department to host educational events that inform local citizens on issues relating to stormwater pollution and water quality. Dr. Kalyanapu's CEE 6520 Open Channel Hydraulics class has developed models for flood management in Dry Valley, Tennessee, which is a small community that experiences frequent floods and property damage. Through these student-driven projects, the community is able to plan for or avoid flood emergency situations. These are but some of the examples of public service.

Outreach events are often organized through CEE student chapters, such as the ASCE, Engineers Without Borders and the Water Professionals chapter mentioned earlier. In addition, Dr. Datta, Dr. Kalyanapu and the Environmental and Water Resources research group participate in several outreach events such as the "Water for Life" event organized by the Kentucky/Tennessee chapter of the Water Environment Federation, watershed education and awareness events, state park clean-ups and voluntary data collection to assist state parks, surrounding natural area and the City of Cookeville.

Teaching

Graduate students, in the last two weeks of each semester, are given the opportunity to evaluate all graduate level courses offered by the program, as well as faculty effectiveness in teaching the courses through the Individual Development and Educational Assessments (IDEA) tool. This tool allows students to rate courses based on learning objectives and outcomes. It also allows students to rate the teaching methods and styles adopted by the faculty, which includes categories such as their ability to stimulate student interest in the course, foster student collaboration, establish a healthy rapport with them, and relate course material to real life situations. The IDEA survey results are evaluated annually by the CEE Department chair, and the college dean. For additional details on the latter see section 4.6. Alumni through the surveys are able to assess the quality and content of instruction and courses offered in the program (see Table D-4).

Assessment Methods

Assessment methods employed by the program are:

- IDEA evaluation of courses,
- grades on core courses,
- thesis proposal and MS oral defense and thesis assessment form,
- alumni surveys,
- employer surveys,
- student publications and awards,
- conference presentations, and
- MS thesis documents.

THEC PROGRAM REVIEW RUBRIC

1. Learning Outcomes

1.1. Program and student learning outcomes are clearly identified and measurable.

The CEE MS program objectives and student learning outcomes are posted at https://www.tntech.edu/files/cee/pdfs/Program_Objectives_and_Graduate_Student_Plan.pdf. The program objectives are:

3. MS graduates will have the technical competence to be successful in the chosen sub-discipline of civil engineering professional practice or research.
4. MS graduates will have the skills to undertake technically sound analysis independently and present their work at professional meetings or publish their work in scholarly journals.
5. MS graduates will have the technical competence to successfully undertake further advanced study at the doctoral level in civil engineering or a related area, and pursue lifelong learning through professional education.

The learning outcomes used to assess the effectiveness of the MS program are:

1. MS graduates will demonstrate clear understanding of the chosen sub-discipline of civil engineering covered in course material in the graduate program.
2. MS graduates will apply advanced methods in the development of solutions in the chosen sub-discipline of civil engineering.
3. MS graduates will give professional presentations or write scholarly manuscripts worthy of publication in peer reviewed journals.

Each sub-discipline within the CEE program also has individual student learning outcomes, which are summarized in Table 1.

The program objectives and learning outcomes are measurable and evidence of this is provided in Section 1.2.

Table 1. **Specific Student Learning Outcomes for CEE Sub-Disciplines**

CEE Sub-Discipline	**Specialized Student Learning Outcomes**
Environmental Engineering	Students will have advanced level knowledge of environmental chemistry, transport and quantitative methods.
Transportation Engineering	Students will have advanced level knowledge of traffic control and transportation demand analysis.

CEE Sub-Discipline	Specialized Student Learning Outcomes
Construction Materials	Students will have advanced level knowledge of cement-based materials
Structural Engineering	Students will have advanced level knowledge of structural analysis, behavior of structures, and design of structures with concrete, steel or masonry.
Structural Mechanics	Students will have advanced level knowledge of theoretical and computational mechanics, statics and dynamics behavior of continuum media.
Geotechnical Engineering (added in 2017)	Students will have advanced level knowledge of soil mechanics, shear strength, consolidation, slope stability, and water seepage through soil.

1.2. The program uses appropriate evidence to evaluate achievement of program objectives and student learning outcomes.

Program Objective #1 focuses on technical competence of the MS graduates. This objective is evaluated through the accomplishment and performance of students in their MS coursework. The required sub-discipline courses and electives provide both an in-depth and broad understanding of civil engineering to students. Technical competence is also encouraged using the CEE 6910 Graduate Seminar course. Competence in the research area of an MS student is evaluated by the individual's graduate advisory committee during proposal presentation and oral defense of the MS thesis. A formal evaluation of students' communication (written and oral) skills during thesis presentations was instituted in 2015 to track their ability to deliver technical content effectively, as well as assess their technical competence. Finally, occasional surveys of MS alumni and their employers are used to assess adequacy of technical content of the MS program.

Program Objective #2 emphasizes the analysis and presentation of technical and/or scientific data. MS students obtain the skills to analyze civil engineering data via the MS core course requirements (see Table 2) and via MS thesis or project work. Non-civil-engineering courses, such as statistics, hydrogeology, or applied environmental chemistry provide a complementary knowledge base that also helps students to critically analyze data and interpret results with an interdisciplinary perspective. Achievement in these areas is tracked through course grades. The communication skills of MS students are demonstrated to their graduate advisory committees and public at the proposal presentation and oral defense of the MS thesis or project. These skills are evaluated by CEE faculty and graduate students present at the defense using a rating form developed by the Department. The forms are collected by the CEE department after each presentation and feedback on improvements is provided to students by their graduate advisors. The program also encourages MS students to present their research or project work at professional conferences and publish in peer-reviewed journals.

Program Objective #3 highlights competence for further advanced study and lifelong learning. For MS students taking the thesis option, each student's MS thesis-research provides evidence of the achievement of this objective. Advisors and graduate committees provide guidance and training to students in research methods. Successful completion of the thesis requirement provides evidence of the ability for further study. Additional research skills are obtained through the CEE Graduate Seminar course. Finally, acceptance of MS graduates to doctoral programs at Tennessee Tech or peer institutions provides evidence of this competence.MS students who take the non-thesis option are required to complete a project that is applied in nature and to document their findings in a technical report. Undertaking the project work and authoring the document provides non-thesis MS students with important training in independent study, literature search, and the evaluation of previous studies, all of which are desirable qualities for further advanced study and lifelong learning. The non-thesis MS students also have a graduate advisory committee that provides them with technical guidance. In addition, they too are required to take the CEE Graduate Seminar course, which provides them with some research skills. The passing of the comprehensive exam and the successful completion of the project requirement provide evidence of the student's ability for further study.

Learning Outcome #1 requires a clear understanding of the course material within the chosen sub-discipline in civil engineering of each student, in particular the specific outcomes for each specialization that are summarized in Table 1. Evidence of this outcome is provided primarily through course grades. Graduates gain additional understanding and an opportunity to apply course materials through the in-depth research performed as part of their thesis or project work.

Learning Outcome #2 involves the application of advanced methods to develop solutions in the graduate's chosen sub-discipline in civil engineering. The evidence for this outcome is primarily obtained through specific research design or analyses performed by students for projects and theses. The graduate committee of individual students evaluates the methodology adopted and the results and interpretation of these analyses by the students. Successful completion of the MS thesis or project indicates that advanced analytical or quantitative methods have been employed. Most graduate courses also require the application of advanced analytical methods. Therefore, course grades also provide evidence that graduates have effectively implemented them.

Learning Outcome #3 requires graduates to give professional presentations and write scholarly manuscripts worthy of publication in peer reviewed journals. All MS students are required to give oral presentations of their proposed research or project, and of their completed research or project at the time of defense. Evaluation feedback for these oral presentations is provided to the students, which helps them to improve their technical communication skills. Many of the core courses also require oral presentations that are evaluated as part of the course grades. Evidence of achievement in technical writing is provided through the accomplishment of a written thesis or project report that is reviewed and approved by the student's graduate committee. Additional evidence of achievement comes from scholarly manuscripts that were submitted and accepted, and presentations given at regional and national meetings.

1.3. The program makes use of information from its evaluation of program and student learning outcomes and uses the results for continuous improvement.

The CEE Department has in place a framework/process for the continual improvement of the MS program to ensure its learning outcomes are met and that the outcomes are themselves updated as necessary to reflect any changes that may occur in vision, mission as well as the needs of the profession and research community. Information that is "continuously" collected for evaluation of program objectives and learning outcomes include (1) student performance on graduate courses as reflected in grades earned; (2) number of journal and conference papers authored or co-authored by MS students; (3) performance of students in the defense of their thesis research; (4) IDEA course evaluations done by students at the end of each semester; and (5) CEE sub-discipline faculty discussion of course offerings in the sub-discipline to judge adequacy of breadth of course-offerings, and adequacy of content-depth to which each course is covered. Information for evaluation of program and student learning outcomes that have been collected according to the five-year review cycle include (1) employer surveys; and (2) MS graduate surveys. Other sources of information for program and learning outcomes evaluation are slated to commence in fall 2018. One of these will be Exit Interviews of MS students.

Examples of how some of the information collected has been used for improvement are as follows. (1) Two of the program and student learning outcomes address technical competence in a CEE sub-discipline and the communication of research through the writing of journal/conference papers. A student's ability to understand and communicate in English is central to comprehension of what is taught in class and presented in course texts, the ability to undertake good reviews of relevant literature in a CEE sub-discipline, and the ability to effectively communicate the results of research orally and in writing. In short, English comprehension is critical to a student's success in the program. Based on student performance on written and oral presentation elements of graduate courses and proposals several years ago, an action by the CEE Graduate Affairs committee was prompted. The committee recommended to the CEE Department that evaluation of communication skills of each student also be undertaken at the time of proposal presentation and, where necessary, have a student take a course in communication to strengthen their skills. The CEE Department approved that action. It has been in effect since fall 2015. Based on the evaluations done so far, the quality of writing and oral communication skills of MS students has been good. It did not end here – steps were taken to pay greater attention to the strength of the communication skills of those being admitted. Scores on the verbal and analytical writing components of the Graduate Record Exam as well as the quality of the written application submitted by an applicant are looked at more closely to give more insight into an applicant's communication skills. Finally, where necessary, CEE faculty have had phone conversations with applicants to better assess their communication skills before admission is granted. (2) The second student learning outcome calls for an ability to apply advanced methods in the development of solutions in a chosen CEE sub-discipline. CEE faculty in the different sub-disciplines have over the years, in response to the periodic advances made in the sub-discipline, developed Special Problems (CEE 6900) courses or updated the topics covered in existing courses such that MS students are introduced to these advances (see Table A-2 for a list of these courses). A specific example is in the sub-discipline of transportation engineering in which the activity-based approach for modeling travel demand has gained traction in the research and professional community. As a

result Activity Based Forecasting of Travel was introduced as a major topic in the Transportation Demand Analysis (CEE6470) course.

1.4. The program directly aligns with the institution's mission.

The key component of Tennessee Tech's mission that applies to the CEE department's MS program is to "provide leadership and outstanding programs in engineering, the sciences, and related areas that benefit the people of Tennessee and the nation."[1] The CEE program produces technically competent graduates in an engineering discipline, most of whom are employed either directly or indirectly in the public service sector. Program objectives 1 and 3 align with this aspect of Tennessee Tech's mission along with Learning Outcome 1. In addition, Tennessee Tech seeks the "life-long success" of its graduates at all educational levels. CEE Program Objective 3 aligns with this aspect of the institution's mission. Tennessee Tech also desires engagement in "scholarly activities, especially basic and applied research, creative endeavors, and public service, with special emphasis on community and economic development." Program Objective 2 and Learning Outcomes 2 and 3 align with this aspect of the mission. Finally, it is the institution's policy to support "all eligible persons without regard to age, gender, ethnicity, race, religion, national origin, disability, or sexual orientation," and the CEE Department fully supports this mission of diversity and non-discrimination.

Table 2. Alignment of Program with Institutional Mission

Aspect of Tennessee Tech's Mission	**CEE Program Objectives / Learning Outcomes:** **MS graduates will...**
"provide leadership and outstanding programs in engineering, the sciences, and related areas that benefit the people of Tennessee and the nation."	"have the technical competence to be successful in the chosen sub-discipline of civil engineering professional practice or research." (Program Objective 1) "have the technical competence to successfully undertake further advanced study at the doctoral level in civil engineering or a related area, and pursue lifelong learning through professional education." (Program Objective 3) "demonstrate clear understanding of the chosen sub-discipline of civil engineering covered in course material in the graduate program." (Learning Outcome 1)
"life-long success" of its graduates	"have the technical competence to successfully undertake further advanced study at the doctoral level in civil engineering or a related area, and pursue lifelong learning through

[1] Tennessee Tech (2017). "Our Mission and Vision," https://www.tntech.edu/about/mission, (Accessed 9/23/17).

Aspect of Tennessee Tech's Mission	CEE Program Objectives / Learning Outcomes: MS graduates will...
	professional education." (Program Objective 3)
"scholarly activities, especially basic and applied research, creative endeavors, and public service, with special emphasis on community and economic development."	"have the skills to undertake technically sound analysis independently and present their work at professional meetings or publish their work in scholarly journals." (Program Objective 2) "apply advanced methods in the development of solutions in the chosen sub-discipline of civil engineering." (Learning Outcome 2) "give professional presentations or write scholarly manuscripts worthy of publication in peer reviewed journals." (Learning Outcome 3)

2. Curriculum

2.1. The curriculum content and organization is reviewed regularly and the results are used for curricular improvement.

The curriculum improvement process used by the CEE MS program is presented in Figure 2. Within the Department, the CEE Research and Graduate Advisory Committee oversees the process for making curriculum changes and improvements to the program. Proposals for change usually originate from CEE faculty in the different sub-disciplines within the Department or from the Research and Graduate Advisory Committee as a result of feedback received from periodic program assessments.

The proposals originating from CEE faculty are formalized after an initial evaluation and discussion by faculty in a sub-discipline to judge the impact of a planned change(s) on the sub-discipline and/or on the MS program. Thereafter, the resource needs for successful and sustained implementation of the planned change are determined. Finally, in the case of planned new courses, CEE faculty in the sub-discipline ensure that overlaps in content with existing courses are minimal. Such discussions about the curriculum by CEE faculty in the different sub-disciplines typically take place ahead of the Department's annual retreat at the beginning of the academic year or earlier if warranted.

Similarly, proposals originating from the Research and Graduate Advisory Committee are carefully reviewed to determine among others what effects they will have on the MS program objectives and student learning outcomes, what contribution(s) they will make to the program curriculum, and what resources would be required for their successful implementation. As an example, one of the program weaknesses identified by the Research and Graduate Advisory

Committee was the oral communications skills of graduate students. Therefore, to improve upon communication skills, CEE faculty, at the Department's annual retreat in 2015, adopted a proposal by the Committee to have the style, content and effectiveness of graduate student communication evaluated at the time of the proposal defense and subsequently, at the MS thesis defense. An evaluation form was developed for this purpose. After the proposal defense, the evaluations of faculty and student-peers are summarized and feedback provided to the student. Where weaknesses are identified, a student works on addressing them with the help of his/her advisor and thesis advisory committee. In this regard, the College of Engineering has begun offering a three-credit-hour course with title Technical Communication for Engineers (ENGR 5250) whose primary objective is to strengthen the communication skills of graduate students in engineering. At the thesis defense of a student, a second oral evaluation is performed. The thesis advisory committee is able to judge from the two sets of evaluations the effectiveness of any intervening measures taken. Since implementation of the evaluation of the oral and written communication of students at the time of proposal defense and, where necessary, the actions taken by a students' graduate advisor/committee to strengthen the student's communication skills, the quality of oral presentations and written thesis documents at the final defense have been good. Completed evaluations of MS students' presentation skills and quality of thesis at the final defense by their respective thesis advisory committee members are available in CEE's administrative office located in Prescott Hall Room 216.

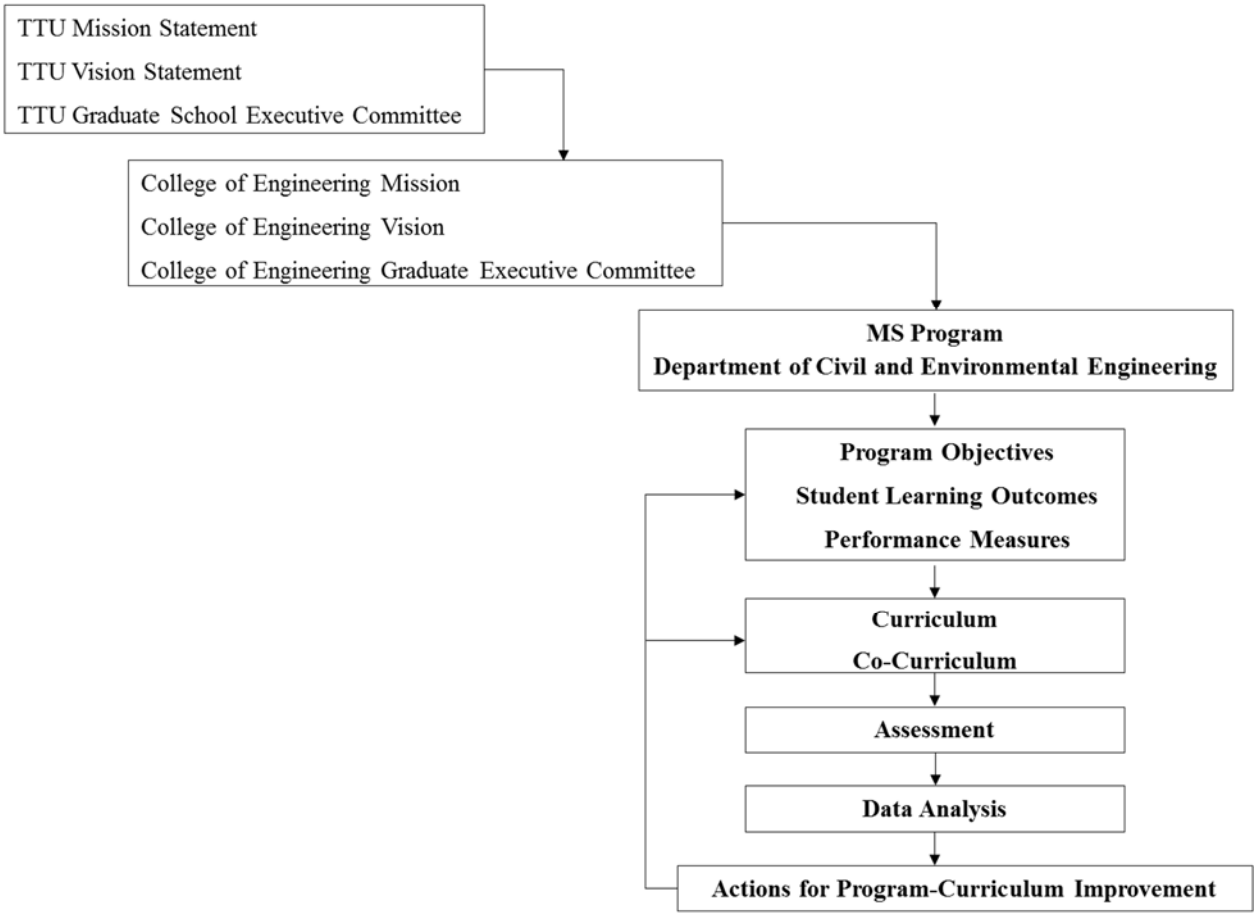

Figure 2. Improvement Process for the MS CEE Program Curriculum

2.2. The program has developed a process to ensure courses are offered regularly and that students can make timely progress towards their degree.

In the CEE MS program, each sub-discipline has a set of core courses that graduate students in the sub-discipline are required to take (see Table 3 below) and several elective courses from which they can select based on their interest as well as their MS research topic. Given the importance of core courses, the CEE faculty in each sub-discipline ensure that they are offered at least once a year knowing well that first, it allows students to progress through the courses in their respective programs of study in a timely fashion, and second, that it allows students to develop the foundational technical competence in a CEE sub-discipline necessary for undertaking their MS research early in the program. This can be ascertained from Table A-2 in Appendix A, which lists all the graduate courses and the semesters they have been offered in the last five academic years (detailed syllabi for all the graduate courses can be found at the website Graduate-Course-Syllabi). In this Table, core courses are shown in bold and have an asterisk by the course number. CEE 7610 Finite Element Analysis I, is the only core course in the table that is shown not to have been offered each year since fall 2015, and this is because its number and title were changed to CEE 6350 Finite Element Analysis. CEE 6350, as shown in Table A-2, was subsequently offered in both spring 2016 and spring 2017 semesters.

An important required course, which amongst others provides an introduction to the conduct of research, is CEE 6910 Graduate Seminar. It is offered at a minimum every fall semester.

Most graduate elective courses are also offered at least once every one- to one-and-a-half years giving students the opportunity to take them during the typical two-year period it takes to complete the MS program. It should be noted that the absence of a check mark for a graduate elective course in a given academic year does not necessarily mean it was not offered in any of the semesters of that year. Rather, in some of the instances, this was due to no student registering to take the course, hence its deletion from the university schedule, which served as the information source for construction of Table A-2. Occasionally also, changes to the CEE faculty body resulted in a course not being offered in some semesters. Given the described frequency at which courses in the program are offered, evidence of students being able to complete the program requirements in a timely fashion is reflected in the time students take to complete the MS program. Data on this is reported in the "Duration" field of Table A-3 (column 2) in Appendix A. The average number of months taken to complete the MS program by MS students that graduated was 21 months, which is less than the typical 24 months duration associated with masters programs in engineering. A chart of the time taken to complete the program is presented in Figure 3. It shows that 85 percent of those that graduated in the 2012 to 2017 review period completed it in 24 months or less. Twenty-three percent of them (nine students) were fast-track MS students who completed it in 12 months. These metrics indicate that MS students do indeed have the opportunity to make timely progress towards completion of the degree.

Table 3. List of Core Courses by Civil Engineering Sub-Discipline

CEE Sub-Discipline	Course Number	Course Title
Water Resources and Environmental Engineering	CEE 6610	Applied Environmental Chemistry
	CEE 6520	Open Channel Hydraulics
	Statistics Course	Graduate level statistics course selected in consultation with advisor
Structural Engineering	CEE 6930	Theory of Elasticity
	CEE 7610	Finite Element Analysis I
Transportation Engineering	CEE 6410	Traffic Control Systems
	CEE 6470	Transportation Demand Analysis
	Statistics Course	CEE 6200 – Statistical Inference for Engineers OR MATH 6170 – Experimental Design I OR other graduate level Statistics course selected in consultation with advisor
Construction Materials	CEE 6300	Multi-Scale Analysis of Concrete
	CEE 5190	Advanced Mechanics of Materials
	Statistics Course	CEE 6200 – Statistical Inference for Engineers OR MATH 6170 – Experimental Design I OR other graduate level Statistics course selected in consultation with advisor
Structural Mechanics	CEE 6930	Theory of Elasticity
	CEE 7610	Finite Element Analysis I
	MATH 5510	Advanced Math for Engineers
Geotechnical Engineering	CEE 6800	Advanced Soil Mechanics (application for Graduate Catalog in progress)
	CEE 6810	Seepage and Slope Stability (application for Graduate Catalog in progress)
	Mechanics or Hydraulics Course	CEE 6350 – Finite Element Analysis – geo/structural students **OR** CEE 6520 – Open Channel Hydraulics – geo/environmental students

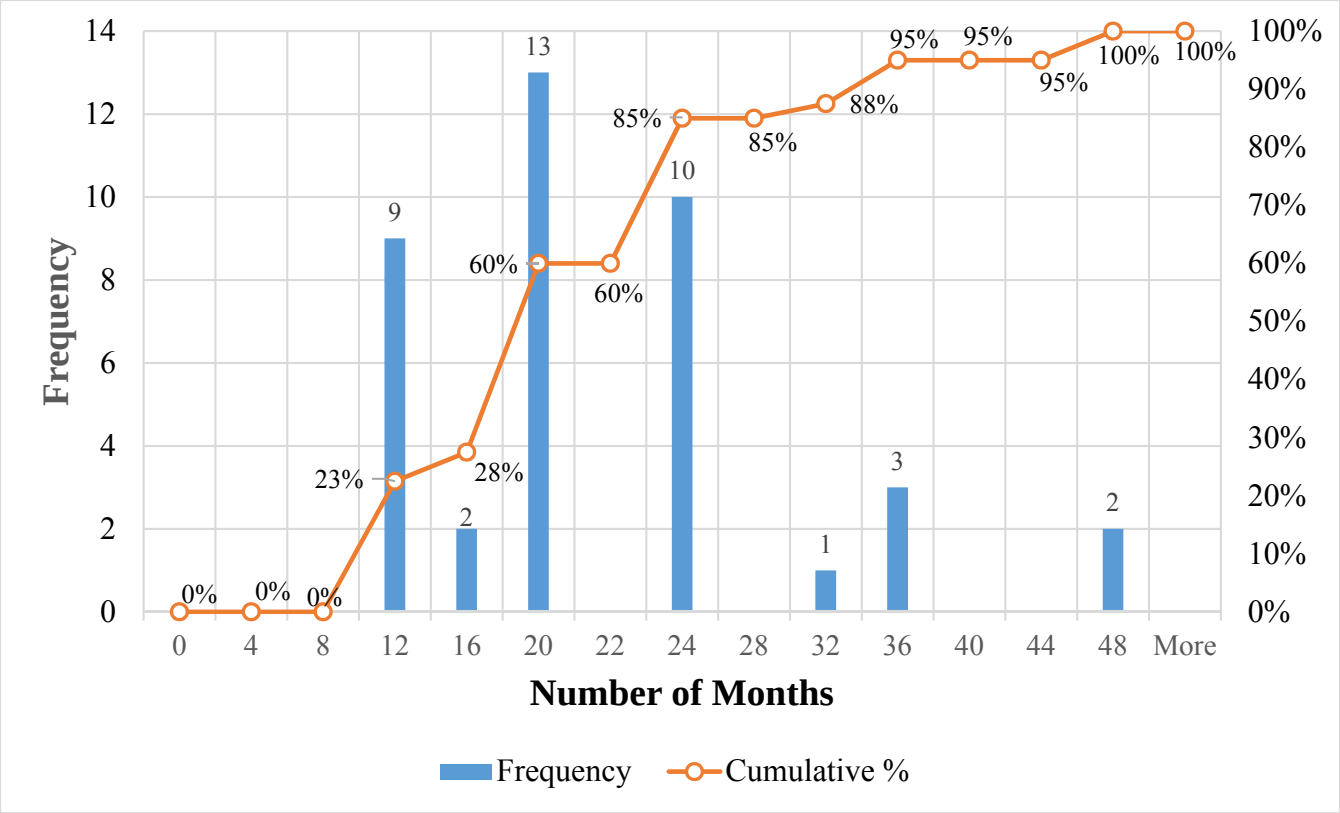

Figure 3. **Number of Months Taken to Complete CEE MS Program (2012 – 2017)**

2.3. The program reflects progressively more advanced in academic content than its related undergraduate programs.

Graduate courses in the program are required to place greater emphasis on theoretical development, critical reviews of relevant literature, advanced applications, and independent work undertaken by graduate students. Thus the CEE Department's Research and Graduate Advisory Committee approves courses for offering at the graduate level only if their content shows significant advancement beyond those offered in the undergraduate program. To illustrate this, the additional requirements for graduate students taking ten split-level elective courses (that is, courses offered to both senior students in the undergraduate program and students in the graduate program) are provided in Table 4 below. The course outlines (includes the syllabi) for these split level courses are provided in Appendix B. A review of the additional requirements shows that more challenging work is required of graduate students and, in many instances, they are required to undertake these tasks independently. The additional activities include writing term papers, giving oral presentations to the class on reviews of selected topics, writing computer programs to perform analysis, and solving additional problems on homework problem-sets and tests, respectively.

Table 4. Selected Split-Level Courses Showing Additional Work to be done by Students Taking the Graduate Level Version

Course Number	Course Title	Additional Work Done by Students Taking the Graduate Version of Split Level Course
CEE 4130 (5130)	Matrix and Finite Element Methods	Students registered in 5000 level will have additional computer programming tasks such as writing subroutines to include different types of member loads in the structural systems and run their programs to analyze different structural systems exploiting the symmetry of the structural system.
CEE 4190 (5190)	Advanced Mechanics of Materials	Additional course project will be assigned to the graduate students registered in CEE/ME5190. The topic for the project should be in the general area of the course. The results of the project will be presented in the form of an oral presentation or a poster.
CEE 4610 (5610)	Pavement Design	Additional work in the form of a term paper, presentation, computer modeling exercise or laboratory project on a subject chosen in consultation with the instructor will be required for graduate credit.
CEE 4380 (5380)	Bridge Design	5000 level students are required to perform additional tasks during the final project of the course.
CEE 4420 (5420)	Engineering Hydrology	Independent research into hydrologic characterization and modeling of a medium-sized river basin.
CEE 4430 (5430)	Water and Wastewater Treatment Design	Graduate students are required to select a course-related topic in consultation with the instructor, conduct a thorough research on the selected topic and present it to the class. This is typically an 80 minutes lecture-based presentation.
CEE 4440 (5440)	Water Resources Engineering	Group presentation by all graduate students of at least 45 minutes on a water resources related topic.
CEE 4630 (5630)	Traffic Engineering	Graduate students are required to complete a series of special assignments intended to provide them with greater theoretical background and to require them to work more complex problems. They are also required to complete additional test questions.
CEE 4640 (5640)	Highway Engineering	Graduate students are required to complete all design projects individually instead of in teams, to

Course Number	Course Title	Additional Work Done by Students Taking the Graduate Version of Split Level Course
		prepare and give a course lecture as a team, and to complete additional test questions.
CEE 4660 (5660)	Transportation Planning	For those enrolled in CEE 5660, additional problems are assigned in homework; a term paper on a transportation topic is required together with an oral presentation (using PowerPoint) to the class.
CEE 4700 (5700)	Masonry Design	Graduate students in masonry are required to pursue the above topics in more depth, often automating the design process using programs like MathCad, Excel, Visual BASIC, etc.

Additionally, example syllabi/course outlines (see Appendix B) from three junior and/or senior elective courses from the undergraduate program (3000 and/or 4000-level courses) and the graduate courses (6000-level courses) they serve as prerequisites to are presented. This is to illustrate the differences in course content and/or student-requirements for the undergraduate and graduate courses respectively to demonstrate that graduate courses are indeed more advanced in academic content compared to their related undergraduate courses.

- The first pair of courses whose syllabi are compared are CEE 4660 Transportation Planning and CEE 6470 Transportation Demand Analysis. CEE 4660 is a prerequisite course to CEE 6470. In the transportation planning course (CEE 4660), about 38 percent of course lecture-hours are devoted to the application of methods for forecasting traffic volumes on isolated routes and links of regional road networks. In the transportation demand analysis course (CEE 6470), 100 percent of the course lecture-hours are devoted to the development of methods for forecasting traffic volumes. The objective of the transportation demand module in CEE 4660 is simply to apply travel demand models to predict travel. On the other hand, the primary objective of CEE 6470 is on both the theoretical development of travel demand models from consumer theory in microeconomics and statistics, and their estimation and application to forecast traffic volumes under alternative urban and transportation conditions. Course requirements for the transportation demand module in CEE 4660 are (i) homework problem sets on the application of travel demand models, and (ii) a term project which is a traffic impact study of a proposed mixed-use development in a suburban area. On the other hand, course requirements for CEE 6470 are (i) critical review papers on topics in travel demand modeling, (ii) estimation of travel demand models using data collected in a household travel behavior survey, and (iii) homework problem sets that emphasize both theory and application.
- The second pair of courses whose syllabi are compared are CEE 4130 Matrix and Finite Element Methods and CEE 6350 Finite Element Analysis. CEE 4130 is a prerequisite to CEE 6350. In CEE 4130 about ten percent of the course lecture hours are devoted to the finite element method. However, in the graduate level course (CEE 6350), 100 percent of the course lecture hours are devoted to finite element analysis to allow a far more in-depth coverage of the method. The primary objective for CEE 4130 is to increase understanding

of structural systems, the application of structural analysis methods to solve basic problems, and the application of computer programs in structural analysis. On the other hand, the primary objectives for CEE 6350 are on the theoretical underpinnings to the finite element method and the development of computer programs to solve pertinent problems relating to structural systems.

- The third and last pair of courses whose syllabi are compared are CEE 3420 Hydraulics and CEE 6520 Open Channel Hydraulics. There are differences in course objectives. The primary objective of CEE 3420 is to provide students with the capability to apply concepts and principles related to hydraulics to solve relatively straightforward problems in that technical sub-discipline of civil engineering. On the other hand, the primary objective of CEE 6520 is to equip students with the more advanced theoretical principles to open channel flow and the tools necessary for the accurate analysis and design of open channels. There are some differences in course requirements. The main course requirements for CEE 3420 are (i) homework problem sets; (ii) a mid-term exam; and (iii) a final exam. On the other hand, the main course requirements for CEE 6520 are (i) homework problem sets; (ii) a mid-term exam; (iii) a comprehensive final exam that tests a student's mastery of the theory to open channel hydraulics; and (iv) a team project that encompasses a significant design or analysis element directly related to open channel flow and which requires the preparation of a comprehensive engineering report as the final output. Relative to CEE 3420, CEE 6520 clearly requires the following of students: critical thinking, learning how to review the relevant literature, development of written communication skills in the reporting of engineering analysis and design, and, very importantly, development of a thorough understanding of the theoretical underpinnings to hydraulics.

These are but only three example comparisons of what is typical of all the graduate courses offered in the MS program relative to their prerequisite undergraduate courses.

2.4. The curriculum is aligned with and contributes to mastery of program and student learning outcomes identified in 1.1.

2.4.1. How curriculum is aligned to provide technical competence in chosen civil engineering area of specialization:

A critical requirement of courses offered in the CEE MS program is demonstrated comprehension of theory and the application of the theory to the solution of problems. As such, graduate courses in the CEE MS program have formal class meetings for three contact hours each week in which the course instructor covers topics relating to the theoretical underpinnings of a subject and its applications. To foster development of their technical competence, students enrolled in a graduate course are required to provide solutions to homework problem sets, take tests, and possibly take a final exam to demonstrate their comprehension of the theory in a course. Wholly laboratory courses or courses with a laboratory component are also offered to provide graduate students with the technical competence and skill necessary for obtaining valid data through the conduct of experiments. Graduate courses also require students to undertake critical reviews of the relevant literature on selected course topics with importance assigned to their personal evaluation of the state of the art in the area of the topic and how they, as students, might remedy some of the shortcomings they identify in the literature. Some courses require graduate students to apply the theoretical and foundational knowledge to solve real-world problems either through hands-on or

modeling-based projects. For example, through the CEE 6720 Environmental Engineering Unit Operations – Wastewater Treatment course, graduate students have conducted design and economic feasibility studies to implement grey water reuse and rainwater harvesting systems on Tennessee Tech University's campus. This was done in collaboration with the university's Facilities Department to evaluate campus sustainability alternatives.

Finally, graduate students also take a comprehensive exam of which their MS thesis or MS project defense is a part to ensure that they maintain comprehension of theory covered in the courses listed in their program of study and that they know how to apply them to develop solutions to civil engineering problems.

2.4.2. How curriculum is aligned to contribute to independent and scholarly work:

CEE MS students are required to undertake thesis research or a project independently under the direction of a CEE faculty advisor and the student's graduate advisory committee. Students through this experience learn to manage a significant research or project effort, acquire the technical knowledge and skills required for its successful completion, learn to pose the appropriate questions whose answers lead to the advancement of their research or project, and also learn to have meaningful periodic interaction with their advisory committee. To provide students with some experience in undertaking work independently ahead of their MS research or project, several of the graduate courses require students to write papers and give oral presentations on course topics of interest.

Communication skills are critical to achieving scholarly accomplishments; that is, they are critical to proper technical paper writing and its presentation at conferences, or publication in peer reviewed journals. Hence, at the onset of his/her research or project, a graduate student has to present a proposal on his/her proposed research or project to his/her graduate advisory committee for approval. In addition to judging the intellectual merit of the proposal, the advisory committee also evaluates the oral communication skills of the student and provides feedback to the student soon thereafter through a standardized form adopted by the CEE Department. At the completion of a graduate student's research or project, a technical paper is written for submission to a journal, practice periodical, or a technical conference. Additionally, several of the graduate courses require students to give oral presentations on critical reviews of relevant literature and term projects they undertake and to submit written technical reports. Graduate students are also required to take the graduate seminar course (CEE 6910) whose topics include (i) avoiding plagiarism; (ii) research ethics; and (iii) learning to write good research proposals and communication skills.

2.4.3. How curriculum is aligned to prepare MS students for advanced study at the doctoral level in civil engineering or a related area, and pursue lifelong learning through professional education:

As stated earlier in this sub-section, MS students, in the graduate courses they take, are required to undertake critical reviews of the relevant literature on selected course topics with importance assigned to their personal evaluation of the state of the art in the area of the topic and how they, as students, might remedy some of the shortcomings they identify in the literature. This activity generates interest in students for advanced study in which they can address some of the gaps they identify in the state of the art in an area of interest.

MS students in the "thesis" option are also required to write and present/defend their proposal to their graduate advisory committee. This requires them to among others, review the literature in the proposed area of research, identify gaps/weaknesses in the area, develop a hypothesis, clearly define research objectives, outline the significance of the proposed research, where applicable develop a data collection plan that meets statistical requirements, and determine what analysis methods might be required to process the data to address the research hypothesis or objectives. Going through the above provides comprehension of and interest in the research process, which is equally applicable at the doctoral level.

The CEE MS program also offers breadth in terms of courses. Graduate students are required to take a minimum of 15 credit hours of CEE courses. The remaining nine credit hours of coursework can be taken from other departments. Typically, students take courses in mathematics/statistics, biology, chemistry and earth sciences. The inclusion of science and mathematics courses in the program provides students with a sound grounding in the fundamentals of their CEE sub-discipline, which serves as an excellent platform on which to build in the doctoral program.

It is evident from the foregoing that MS students' satisfactory performance in graduate coursework, and in the conduct of their research or project results in mastery of a CEE sub-discipline consistent with what is specified in the program and student learning outcomes.

2.5. The curriculum is structured to include knowledge of the literature of the discipline.

With recognition of the importance of knowledge and understanding of the existing literature in a discipline as being one of the fundamental prerequisites to accomplishing research that contributes to the advancement of the field, the CEE graduate program curriculum requires graduate students to engage in a number of course activities that expand their knowledge of the relevant literature in a field.

Coursework-wise, some of the courses require students to write critical review papers on topics of interest that require them to delve extensively into the literature. Some courses require a term project, which also has students undertaking a review of the relevant literature.

Research-wise, the MS program requires each student to present a proposal of his/her planned research or project. Central to this proposal is a thorough review of the relevant literature to demonstrate the anticipated contribution of the planned research to a field. Finally, the thesis or project document written by each MS student devotes a chapter to an up-to-date literature review related to the research topic.

2.6. The curriculum strives to offer ongoing student engagement in research and/or appropriate professional practice and training experiences.

The CEE MS program has two options – the "thesis (research)" option and the "non-thesis (project)" option. Since the overwhelming majority of MS students select the "thesis (research)" option, nearly all of them engage in research as part of the program requirements and for a period of time typically no less than eight months. MS students that select the "non-thesis (project)" option typically work on a topic that has relevance to professional practice.

Some of the research projects undertaken by CEE faculty are applied and directly relevant to professional practice. As an example of this, in the area of structural engineering, Dr. Henderson is undertaking research relating to masonry grout, the results of which will be incorporated into the masonry code. The graduate students working on this project with him are gaining experience in the development of aspects of a code vital to professional practice. Further, CEE faculty from time to time package aspects of some of the professional practice/small research problems they have to address as Special Problems courses (some of these are listed as CEE 6900 Special Problems in Table 2.1) to give graduate students important experiences in these areas.

Graduate students are also strongly encouraged to attend the proposal and final thesis defense of their peers. To this effect, a message announcing the final thesis defense of a graduate student is sent to all CEE faculty and students a week before it takes place. Further, flyers with details of a thesis defense are posted on the CEE Department's board.

Outside the curriculum, that is, in terms of co-curricular activity, CEE faculty have also had some of their graduate students go through specific training that in some cases has culminated in students obtaining appropriate industry certification. An example of this is in the area of civil engineering materials in which Dr. Crouch has periodically had his graduate students go through training to obtain certification as ACI Concrete Field Testing Technician Grade.

CEE faculty also have students participate in professional technical workshops in their area of specialization. An example of this is in the area of transportation, where as part of a long term project funded by Tennessee Department of Transportation (TDOT) to upgrade the technical capabilities of travel demand modelers in Tennessee, a workshop on the use of TransCAD, a travel demand modeling software, is held on TTU's campus every two to three years. Graduate students enrolled in transportation participate in the four-day workshop to give them experience with this software which TDOT requires be used for all long range transportation planning analysis done for the State by consultants, and by state and local government modeling staff.

2.7. Programs offered entirely through distance education technologies are evaluated regularly to assure achievement of program outcomes at least equivalent to on-campus programs.

The CEE MS Program at Tennessee Tech University is a completely onsite program. Hence, the above rubric survey statement is not applicable.

2.8. The program incorporates appropriate pedagogical and/or technological innovations that advance student learning into the curriculum.

Active learning, as a process for teaching students, has been demonstrated to be superior in its effectiveness compared to teaching by the standard mode of instruction in which a teacher does most of the talking in the delivery of content while students play a passive role in the process. CEE faculty employ active learning strategies to engage students in the learning process. Adopted strategies include:

i. Team projects in which a challenging project is assigned to a small number of graduate students (two or three). Students, in undertaking the projects, learn to define what the critical questions are to address the project objectives, learn to

search for relevant information from technical sources, learn to work with each other and to bounce ideas off each other and learn from the ensuing discussions;

ii. In-class critical thinking problems that are addressed by students working in small groups, usually pairs. Students through this activity learn to engage each other in the development of solutions to civil and environmental engineering problems;

iii. Field trips that provide physical linkages to some of the concepts covered in lecture sessions;

iv. Use of technology to record lectures given by a CEE faculty member, which allows graduate students to access them after class meetings, on as many occasions as needed, to understand what was taught;

v. Case-study reviews and presentations by students working in small teams; and

vi. Experiments undertaken in the laboratory to reinforce comprehension of theoretical concepts covered in lecture sessions.

3. Student Experience

The Department strives to enhance the graduate student experience by providing students with opportunities to participate in enrichment programs both within and outside of the normal academic and research routine.

3.1. The program ensures a critical mass of students to ensure an appropriate group of peers.

During the 2012-2017 review period, the CEE MS program had an average enrollment in excess of 20 students each year. This allowed students to be immersed within a group of peers and enrich their graduate experience both on an individual and collective level. For example, collective participation in student orientation and graduate seminars has become a regular event since 2005 and has been mandatory for all graduate students since 2010. This is a key forum where students regularly exercise their curiosity to understand and learn more about emerging issues in CEE that are otherwise not easily apparent from coursework or traditional research. Graduate students also receive a 3-week training on conducting research, plagiarism detection and thesis writing while attending seminars on diverse CEE topics during the semester. Moreover, graduate students are encouraged to form peer groups within their CEE sub-discipline. To facilitate this, the Department has created workspaces to house students per CEE sub-discipline, which allows them to collaborate and interact both academically and socially.

3.2. The program provides students with the opportunities to regularly evaluate the curriculum and faculty relative to the quality of their teaching effectiveness.

Each semester, students are able to evaluate all graduate level courses in the program they take, as well as evaluate the teaching effectiveness of the course instructor through the Individual Development and Educational Assessments (IDEA) tool. This tool allows students to rate courses based on learning objectives and outcomes. It also allows students to rate the teaching methods and styles adopted by CEE faculty, which includes categories such as their ability to stimulate student interest in the course, foster student collaboration, establish a healthy rapport with them, and relate course material to real life situations. In addition to the above, the IDEA survey

instrument makes provision for students to provide comments on each course. Some students use this as a vehicle to provide feedback on course topics and course requirements. The average IDEA ratings on Progress on Relevant Course Learning Objectives, Teaching Effectiveness, and Usefulness of the Course since the 2012-2013 academic year are presented in Figure 4, Figure 5, and Figure 6, respectively. On average, all ratings fell within the "similar" comparison category, demonstrating the CEE graduate curriculum success.

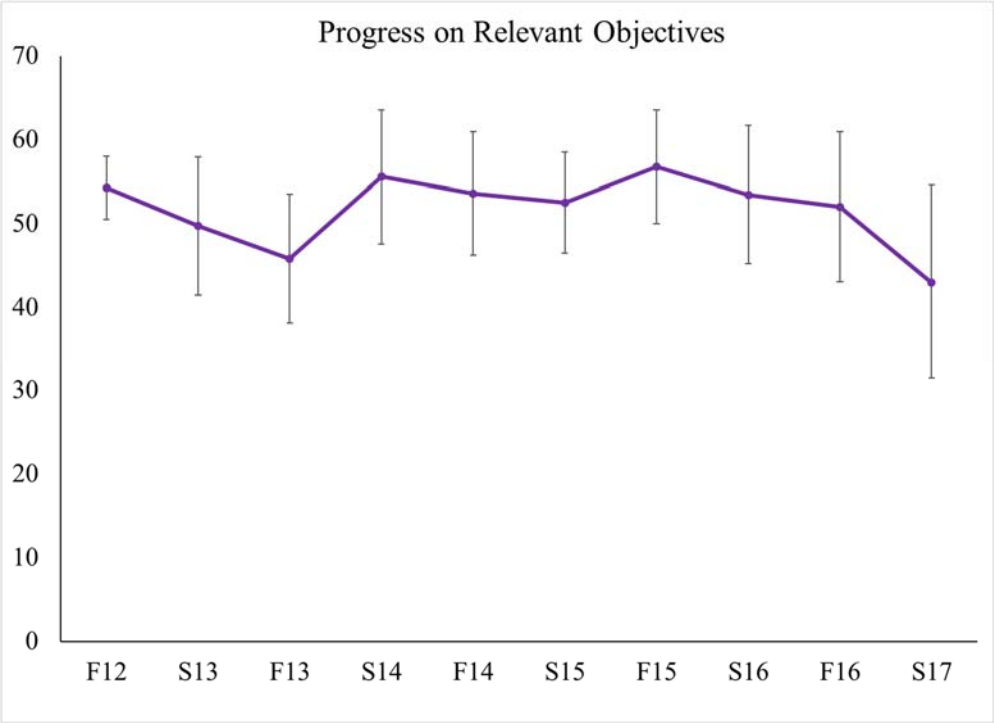

Figure 4. Converted Average of Ratings for Progress on Relevant Objectives when Compared to all Classes in the IDEA Database

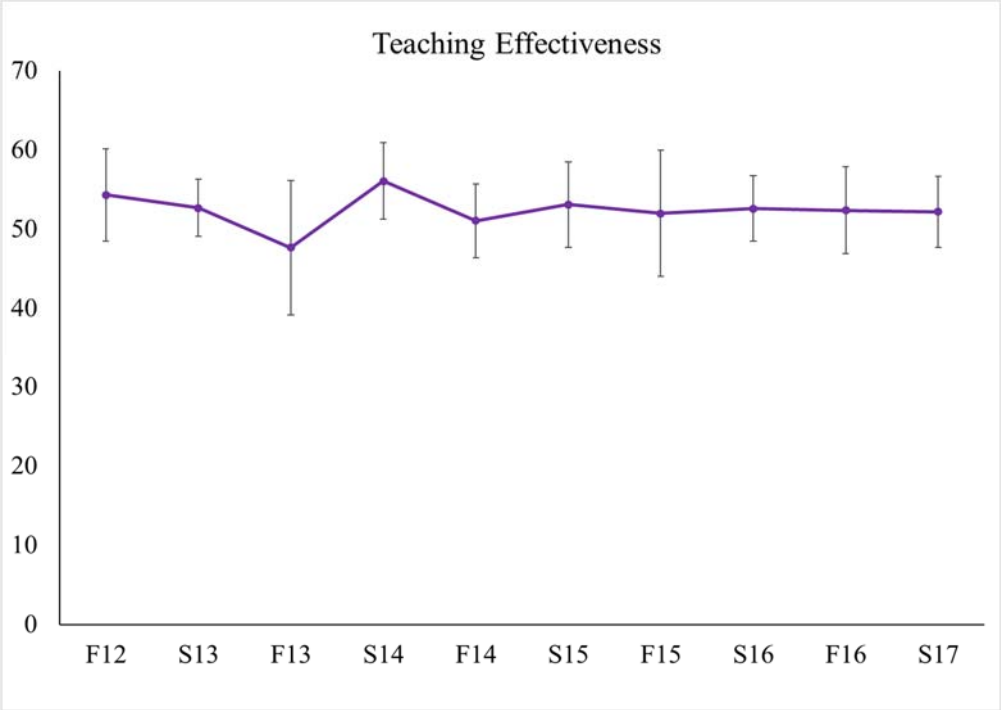

Figure 5. Converted Average of Ratings for Teaching Effectiveness when Compared to all Classes in the IDEA Database

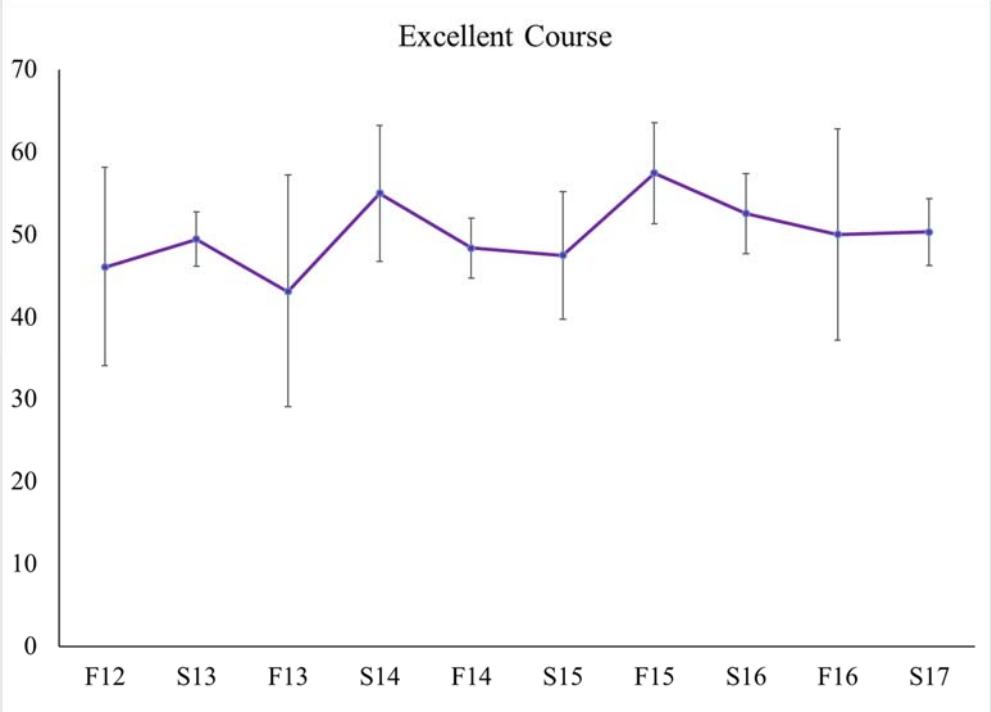

Figure 6. Converted Average of Ratings for Excellent Course when Compared to all Classes in the IDEA Database

3.3. The program provides adequate professional development opportunities, such as encouraging membership in professional associations, participation in conferences and workshops, and opportunities for publication.

Professional development of graduate students is inherent to the program's learning outcomes and success. Within the CEE Department there are several student chapters of professional organizations such as the American Society of Civil Engineers (ASCE), Water Professionals (a combined chapter of the Water Environment Federation, American Water Resources Association, and American Water Works Association) and Engineers Without Borders that enable and encourage students to pursue professional membership, attend seminars and conferences and present their scholarly work. These groups collectively host seminars and other professional development activities at a frequency of about two per month. Through the ASCE chapter, students are invited to the Nashville Section meetings on a monthly schedule, where seminars are presented on all aspects of civil engineering. Once a year, the ASCE student chapter at Tennessee Tech hosts the Nashville Section and a formal technical presentation is coordinated. Students are also provided with travel scholarships to attend and present at the Kentucky/Tennessee Water Professionals Conference and the Tennessee Water Resources Symposium every year, where they can participate in poster competitions, oral presentations, professional networking and outreach events. Most students are also members of their respective scientific/professional bodies, such as American Society of Civil Engineers, Association of State Dam Safety Officials (ASDSO), Institute of Transportation Engineers, American Concrete Institute, Water Environment Federation and American Water Works Association, to name a few. In transportation, graduate students participate in some of the quarterly meetings of the Tennessee Travel Demand Model Users Group. Transportation graduate students also participate in a biennial workshop on the use of TransCAD, a travel demand modeling software used in transportation planning, that is held on TTU's campus. In geotechnical engineering, graduate students are encouraged to participate in national student competitions held by ASCE's Geo-Institute and ASDSO.

Within the University, a Student Research and Creative Inquiry Day (https://www.tntech.edu/research/research-day/) is organized each year in April by the University's Office of Research. CEE students are regular participants of the event, showcasing their scholarly work. Several CEE students have won the best poster/paper award at this event.

Graduate students also regularly attend regional and national conferences where they present their research. Data from the past 5 academic years show that MS student have made 36 conference presentations, out of which 10 were published as conference proceedings. Moreover, MS students are regularly encouraged and sometimes required to publish their scholarly work in peer-reviewed journals. Thirty-six publications were either authored or co-authored by MS students in the past 5 years. Details of these accomplishments are presented in Table 11.

3.4. The program provides adequate enrichment opportunities, such as lecture series, to promote a scholarly environment.

Students utilize a wide range of enrichment opportunities to ensure a healthy scholarly environment. The graduate seminar series and the earlier described seminars organized by the various student chapters of professional organizations within the CEE Department are among the

most notable examples of enrichment activities that are sustained by student participation and presentations. The Stonecipher Symposium and the Prescott-Brown Lecture Series are also among high profile lecture events organized each year by Tennessee Tech University in which a nationally recognized authority in a discipline of interest is hosted for a seminar on a timely topic. Information on these events can be found at https://www.tntech.edu/cas/annual-events/stonecipher-lecture-series and https://www.tntech.edu/engineering/news-events/prescott-brown-legacy-endowment/the-lecture-series, respectively.

The University's Centers of Excellence, including the Center for Energy Systems Research, the Center for Manufacturing Research, and the Center for the Management, Utilization and Protection of Water Resources (also known as the Water Center), occasionally host seminars open to all CEE graduate students. These seminars are widely advertised and known to the students. While only some of the seminars hosted by the Energy and Manufacturing Centers are applicable to civil and environmental engineering, the seminars sponsored by the Water Center are always pertinent. Recent seminars hosted by the Water Center have featured nationally renowned lectures such as the 2016 AEESP Distinguished lecture with Dr. Menachem Elimelech, and the Kappe Lecture with Dr. Danny Reible. The Kappe Lecture was co-hosted by University of Tennessee at Knoxville, Vanderbilt University and Tennessee Tech's Water Center.

3.5. The program seeks to include diverse perspectives and experiences through curricular and extracurricular activities.

Graduate students are encouraged to take courses outside of the Department, and sometimes outside of the College of Engineering to broaden their interdisciplinary knowledge base and to diversify their perspectives. The enrichment and professional development opportunities presented above also enable inclusion of diverse curricular activities. Occasional study-abroad opportunities, such as the Spring Break Holland and Belgium trips, organized by Dr. Lenly Weathers, and international outreach to Southern Belize, organized by Dr. Tania Datta, are offered by CEE Department faculty, and they are open to graduate student participation.

3.6. Students have access to appropriate academic support services.

Each enrolled MS student is assigned a graduate advisor. This is perhaps the most critical academic support provided to CEE MS students, as it is the advisor's responsibility to guide and mentor the student throughout his/her stay in the program. Through regular one-on-one interactions, the advisor and student plan a program of study, agree on a research topic, and plan academic funding, professional development activities and other aspects of the program that lead to the eventual success of the student. Additionally, the College of Engineering provides some academic support services. These include the occasional availability of graduate student assistantships, conference travel funds, and conflict resolution with academic advisors.

Other academic support includes access to sufficient learning resources, workspaces and research infrastructure. A description of these services is provided in Section 5.

4. Faculty

4.1. All faculty, full time and part-time, meet the high standards set by the program and expected SACSCOC guidelines for credentials.

In spring 2017, which is the final semester of the five-year review period, there were 16 full-time graduate faculty in the CEE Department with responsibility for delivering the MS program. Their names and sub-discipline expertise are presented in Table 5, along with the names of other faculty who retired or left during the review period. Their expertise covers the breadth, depth and the level of sophistication required for today's highly interdisciplinary civil engineering profession. All of the graduate faculty hold a terminal degree (PhD) in a major sub-discipline of civil engineering, which complies with SACSCOC (Commission on Colleges of the Southern Association of Colleges and Schools, which is the recognized regional accrediting body in the eleven U.S. Southern states for institutions of higher education that award associate, baccalaureate, master's or doctoral degrees) guidelines. Tennessee Tech University relatively recently went through a SACSCOC review and in December 2016 received "reaffirmation of accreditation by SACSCOC". Reaffirmation does confirm that CEE faculty credentials do comply fully with SACSCOC requirements.

Very importantly, Tennessee Tech University, to ensure compliance with accreditation standards for all faculty, has a process that must be followed and requirements that must be met during the hiring of any new full-time tenure-track and one-year faculty, as well as new adjunct instructors, and any current TTU administrative/professional employees assigned to teach a TTU course. One of the important forms that must be completed and verified in this regard is the Faculty Qualifications Certification Form for New Faculty Appointments Guidelines and Procedures (https://www.tntech.edu/files/provost/Faculty_Information/FQC_Form_Procedures_February_2014_New.pdf). Thus, through the university's hiring policy and procedures, the qualifications of graduate faculty that deliver the CEE MS program meeting high standards is assured.

Detailed qualifications of each faculty are provided in the abbreviated version of their curriculum vitae presented in Appendix C.

Table 5. Summary of Faculty Expertise in the CEE Department

Name	PhD degree	CEE Sub-Discipline					
		Geotechnical	Civil Eng. Materials	Transportation	Structural Mechanics	Structural Engineering	Water/ Environ.
Daniel Badoe	Univ. of Toronto			✓			
Steven Click	NC State Univ.			✓			
L. K. Crouch	Univ. of Missouri	✓	✓				
Tania Datta	Univ. of Utah						✓
Dennis George[1]	Clemson Univ.						✓
Craig Henderson	Univ. of Tenn.				✓	✓	
David Huddleston	Univ. of Tenn.				✓		✓
Faisal Hossain[2]	Univ. of Conn.						✓
Sharon Huo[3]	Univ. of Nebraska					✓	
Alfred Kalyanapu	Univ. of Utah						✓
Jane Liu	Univ. of Hawaii				✓	✓	
Ben Mohr	GA Tech	✓	✓				
Guillermo Ramirez	Colorado State Univ.				✓	✓	
Ed Ryan[1]	U. New Mexico	✓				✓	
Daniel VandenBerge	Virginia Tech Univ.	✓					
Lenly Weathers	Univ. of Iowa						✓
Matthew Yarnold[2]	Drexel Univ.					✓	
Jessica Oswalt[3]	GA Tech						
Jim Smith[1]	Virginia Tech Univ.						

Notes:

[1] **Retired during the review period**

[2] **Took appointment at other university**

[3] **Did not teach graduate courses due to administrative responsibilities**

4.2. The faculty teaching loads are aligned with the highly individualized nature of graduate instruction, especially the direction of theses or dissertations.

CEE faculty, in addition to teaching graduate courses, are also expected to have successful research programs, which can be integrated into the curriculum. In addition, CEE faculty are required to serve effectively as mentors of graduate students. In recognition of these responsibilities, teaching loads are as much as possible made compatible with the needs of the graduate program. For newly recruited faculty in particular, the CEE Department assigns a lower than typical teaching load during their first few years when they work at establishing their research programs. The lower teaching load allows them to take on multiple MS students, who are typically funded through start-up packages.

In the past five academic years, the average taught-course-load per graduate faculty per semester was 2.42, while the average thesis credit-hours per faculty per semester was 5. The average graduate student to CEE faculty ratio was 1.33. As a result of the reasonable teaching loads, CEE faculty have been able to devote adequate time to one-on-one meetings with their MS students to monitor their progress in coursework and provide guidance in their thesis research, both of which are critical to the successful completion of the MS program by graduate students.

4.3. The faculty strives to cultivate diversity with respect to gender, ethnicity, and academic background, as appropriate to the demographics of the discipline.

It is the University's policy not to discriminate on the basis of race, color, religion, ethnic or national origin, sex, disability, age (40 and over), status as a protected veteran, genetic information or any other category protected by federal or state law. The process for hiring new faculty has checks instituted to ensure compliance with this non-discriminatory policy. The Department itself values diversity. This is reflected in its gender composition with four of the total 19 faculty members who were in the department during the review period being female, and in its ethnic composition with about 35% of CEE faculty originating from non-US countries namely Bangladesh, China, Colombia, Ghana and India, thus bringing a global perspective to the program.

Given the breadth of civil engineering and the technical background required to contribute to the advancement of the state-of-the-art in each sub-discipline, the CEE faculty body is diverse in academic background (see Table 5). As examples, in the Water Resources and Environmental Engineering area, Dr. Datta has an undergraduate degree in chemical engineering, and dual graduate training in environmental engineering and applied microbiology, a scientific background necessary to keep abreast of and contribute to the advancement of environmental engineering. Dr. Crouch has undergraduate degrees in geology and geological engineering and graduate degrees in geological engineering and civil engineering. This background is invaluable to his research on aggregates used in paving mixtures and portland cement concrete. Two of the faculty, Drs. Oswalt and Smith have degrees in industrial and systems engineering and have expertise in statistics and engineering economics, which allows them to provide important technical support to research in some of the CEE sub-disciplines.

4.4. The faculty engages in regular professional development that enhances their teaching, scholarship and practice.

In order to enhance faculty teaching, scholarship, and practice and to enrich the overall graduate and research experience of MS students, CEE faculty actively engage in professional, academic and scholarly development by publishing journal papers, attending and presenting at scholarly conferences, attending proposal-writing workshops, and working on externally sponsored research. During 2012-2017, CEE faculty remained active not only in terms of productivity of scholarly work, but also in providing leadership to their professional societies, such as the American Society of Civil Engineers (ASCE), Transportation Research Board (TRB), American Concrete Institute (ACI), American Geophysical Union (AGU), American Water Resources Association (AWRA), Water Environment Federation (WEF), International Water Association (IWA), etc. More than 60 journal papers and 60 conference proceedings were published by the CEE graduate faculty during 2012-2017, translating into an average number of scholarly articles published in journals by the collective CEE faculty of approximately 12 journal papers per year. Several of the published papers were lead-authored or co-authored by MS students.

Two CEE faculty members hold editorial positions in scholarly journals of the CEE profession. Dr. Daniel Badoe serves as an associate editor for the ASCE Journal of Urban Planning and Development and Dr. Steven Click serves on the Traffic Signals Committee of the Transportation Research Board.

CEE faculty, also through grantsmanship, brought in externals funds from agencies such as the National Science Foundation and Tennessee Department of Transportation to the tune of $2,405,589 from 2012 to 2017 distributed as follows: $717,878 (2012-2013), $521,323 (2013-2014), $253,980 (2014-2015), $519,405 (2015-2016), and $393,003 (2016-2017). Sponsored projects facilitate research and scholarship, which consequently help build intellectual capital for the MS program through student-involved research activity and the possible creation of knowledge in the process.

The CEE faculty vitas provided in Appendix C include professional development, publications, and scholarly activities of faculty over the five-year review period.

4.5. The faculty is actively engaged in planning, evaluation and improvement processes that measure and advance student success.

Given the criticality of student success to the program, the CEE Department has a committee, the Research and Graduate Advisory Committee that is dedicated to the continual planning, evaluation, and identification of improvement-measures to advance student success. As presented in Figure 2 in Section 2.1, the Department has a continuous improvement process for its graduate program that is used by the committee and the Department. The committee, in this process, leads efforts to refine or redefine goals, objectives, and performance measures if necessary. The committee is also responsible for assessments, which include surveys of MS graduates, employers, and advisors of MS graduates that are pursuing a doctoral degree, and the generation of summaries of the university conducted IDEA student evaluations to provide the necessary information for making data-driven decisions regarding the future of the graduate

program. Approved proposals by the committee are submitted to the full CEE faculty body for their discussion as well and eventual approval or disapproval by a vote. Meetings of the full faculty to address proposals/issues occurs at least once a year, just before the beginning of each academic year, when the CEE Department has its annual retreat, and as necessary during the course of the academic year. Thus, from the foregoing, it is apparent that all CEE faculty are engaged in the program enhancement process to advance student success.

4.6. The program uses an appropriate process to incorporate the faculty evaluation system to improve teaching, scholarly and creative activities, and service.

CEE faculty members, both tenured and non-tenured, are evaluated annually by the Department's chairperson and the college dean. These annual faculty evaluations include a performance assessment in the areas of instruction, advising, research, and service both at the undergraduate and graduate levels. As part of this evaluation, each faculty member is required to prepare and submit a Faculty Annual Report documenting activities and effort with respect to his/her current Agreement of Responsibilities Form that is completed at the beginning of each academic year. Evaluation of graduate instruction includes teaching evaluations by students using the IDEA instrument. Evaluation of research is based on, but not limited to, number of publications in journals and/or conferences, sponsored research projects and number of graduate students. Evaluation of advising and service includes the number of undergraduate advisees (for both academics and research) and number of graduate advisees of whom the faculty member is either the committee chair or committee member, number of department, college and university committees the faculty member serves on, and other external professional and scholarly services. As a result of this evaluation, each faculty member receives feedback from both the Department chairperson and the dean of the college with regards to his/her performance. Where performance problems are detected, they can normally be addressed at the Department level. In rare instances, however, when the performance of a tenured faculty member is significantly below an acceptable level for an extended period of time, and attempts at the Department and college level have been unsuccessful at resolving the problem, the faculty member may be asked to participate in a formal development program designed to improve the faculty member's performance.

5. Learning Resources

5.1. The program regularly evaluates its equipment and facilities, encouraging necessary improvements within the context of overall institutional resources.

The CEE Department has a standing Facilities Committee that regularly evaluates the condition of classrooms, laboratories, and equipment. The Facilities Committee comprises faculty members from across the sub-disciplines in the Department to ensure a breadth of input and perspectives on facilities and equipment.

As budget allows, the department updates classrooms and laboratories, and purchases new equipment. Faculty are asked to maintain lists of desired renovations for the facilities that they use for research and/or teaching. They are also asked for lists of equipment that would benefit the classroom or research experiences of students, including those in the MS program. The proposed renovations and purchases are decided by the CEE Department chair and faculty with recommendations from the CEE Facilities committee.

5.2. The program has access to learning and information resources that are appropriate to support teaching and learning.

Most graduate students in the program have computers provided by the CEE Department in their respective workspaces. The computers are equipped with Microsoft Office as well as technical design software necessary for coursework and research.

The Civil Engineering Computer lab in Prescott Hall, Room 341 is also available to graduate students. Seventeen desktop computers are available for student use. Software packages installed on each computer include: Absoft ProFortran, Adobe products, Arc Hydro Tools, ArcGIS, AutoCAD, AutoDesk, Bentley software, HEC-RAX, HEC-HMS, LEAP Bridge, Maple, MathCAD, Matlab, Microsoft Office and Project, Microstation, Minitab, PipeLink for STAAD, Rocscience suite, STAAD Suite, Synchro Studio, TecPlot, and TSIS.

Students can also access computing resources in the College of Engineering computer laboratories: Learning Resource Center (Bartoo 204), MoLE-SI Lab (Brown Hall 207), Engineering Workstation Lab (Clement 405), and Basic Engineering Labs (Clement Hall 406 & 409). Other campus-wide computer labs are available at the University PC Lab (Clement Hall 313A & B) and Learning Commons (Volpe Library). The software available in these labs includes up-to-date versions of: Abaqus, Absoft, Adobe, Alice, ANSYS, ArcGIS, AutoCAD, AutoDesk, COMSOL, Fluent, Gambit, Hyperchem, ImageJ, IrfanView, JabRef, LT Spice, LabVIEW, LibreOffice, Logger Pro, Maple, MathCAD, Matlab, Microsim pSpice, MS Office, MS Project, MS Silverlight, MS Visio, Minitab, Nasgro, Perl, ProEngineer, PuTTY, Python, Ruby, SAS, SPSS, SumatraPDF, TeX Live, TortoiseSVN, and West Point Bridge Designer.

The Angelo and Jeanette Volpe Library has a number of services to support research and graduate programs. EagleSearch is the Library's one-stop search service for resources. Available from the Library homepage, it searches most of the Library databases for journal articles, books, and conference proceedings. Every TTU student has an account that allows searches and results to be saved, and the search capability is integrated with interlibrary loan, Get It Now, and RefWorks. Interlibrary loan is a free service for the TTU community to find and access full-text resources. Resources requested average one day for arrival to the requestor's account and provide PDF file access. Get It Now allows patron-driven access of materials from the Copyright Clearance Center. This service is available at no cost for graduate students and faculty to obtain full text items outside of Library database subscriptions. RefWorks is an online citation management software system provided to TTU students and faculty. Like most university libraries, the Volpe Library has transitioned from a focus on providing on-site resources to an approach of enabling access to online resources. Numerous online databases, along with e-journals, and government publications, are available from the Library website (See https://www.tntech.edu/library/research/). A list of the available online databases can be found at https://erdb.tntech.edu/databases.php), and some of the most relevant for engineering include the following:

- Applied Science and Technology Full-Text (EBSCO)
- ASCE Library (American Society of Civil Engineers)
- ASTM Compass (American Society for Testing and Materials)
- Emerald Insight 120
- Knovel

- Safari Tech Books Online
- Science (Proquest)
- Scitation
- SciTech Connect (U.S.D.O.E.)
- Web of Science Citation Online

In addition, one library faculty member, David Hajdik, is assigned as the engineering subject librarian for the College of Engineering and is available for class instruction and consultations. He is available by appointment as well as on-demand for walk-up assistance. The program provides adequate materials and support staff to encourage research and publication.

5.3. The program provides adequate materials and support staff to encourage research and publication.

The tools essential for graduate students to be successful in referring to scientific and engineering literature, and in establishing research or testing methodologies, are supported by the Volpe Library (described in Section 5.2). This support includes electronic access to the ASCE Library and ASTM Compass services. These research tools can be accessed directly on-campus and by proxy log-in from off-campus.

Additionally, the CEE Department has 19 physical laboratories that provide space for its surveying, environmental/water resources, structural, construction materials, geotechnical, mechanics of materials, transportation and computing facilities. Each area of concentration has specific rooms or floor space designated for research and development. The rooms are properly equipped with supplies and equipment for research and are often modified to accommodate special research needs. A listing of these rooms and laboratories follows in Table 6.

Table 6. CEE Department Physical Laboratories

Building and Room Number	Purpose of Laboratory	Condition of Laboratory	Adequacy for Instruction	Area (sq. ft.)
PRSC 127	Surveying Equipment Storage	Fair to Good	Primarily for Equipment	628
PRSC 127C	Transportation Laboratory	Good	Adequate	200
PRSC 131	Construction Materials	Very Good	Adequate	1000
PRSC 132	Construction Materials	Very Good	Adequate	992
PRSC 134	Construction Materials	Very Good	Adequate	874
PRSC 310 / 345	Geotechnical Instruction	Good	Adequate	1296
PRSC 315	Cement-based Materials Laboratory	Very Good	Adequate	360
PRSC 317	CLSM Research Laboratory	Very Good	Adequate	360
PRSC 326	Environmental Research and Instruction	Good	Adequate	1700
PRSC 328	Environmental Preparation and Instruction	Good	Adequate	264
PRSC 329	Environmental Research and Instruction	Very Good	Adequate	900

Building and Room Number	Purpose of Laboratory	Condition of Laboratory	Adequacy for Instruction	Area (sq. ft.)
PRSC 335	Environmental Preparation Lab	Good	Adequate	172
PRSC 336	Environmental Preparation and Research	Very Good	Adequate	172
PRSC 338	Environmental Instruction	Very Good	Adequate	740
PRSC 341	Computing Laboratory	Very Good	Adequate	740
Stadium ESTA 122	CEE Shop – Support Services	Good	Adequate	1035
Stadium ESTA 121	Structures Lab, Shop – Support	Fair	Adequate	2988
CLEM 104	Mechanics Instruction	Excellent	Adequate	1640
CLEM 122D	Cement and Concrete Composites Laboratory	Good	Adequate	900
			Total Square Footage:	17,301

The CEE physical laboratories and research equipment are regularly updated. Major equipment (> $1,000) acquired in the last five years include:

- Two Rickly Hydrological USGS Pygmy current meters (Water Resources)
- Four Global Water Instrumentation water level loggers (Water Resources)
- Two computer-controlled, 2-kip GeoJac load frames for unconfined compression, triaxial compression, and one-dimensional consolidation testing (Geotechnical)
- One computer-controlled, 5-kip GeoJac load frame with flow pump pressure control for automated triaxial testing as well as one-dimensional incremental and constant rate of strain consolidation testing (Geotechnical)
- One concrete freeze-thaw chamber (ASTM C 666) (Materials)
- Alkali silica reaction mortar bar water baths (ASTM C 1260) (Materials)
- Half-cell potentiometer for corrosion measurements (ASTM C 876) (Materials)
- Automatic Vicat for cement setting time (ASTM C 191) (Materials)
- Environmental cabinet with constant RH/T controls (Materials)
- Vic-3D System for full-field displacement and strain data (Structural Mechanics)

Tennessee Tech University's College of Engineering and CEE Department operate a well-equipped machine shop with the capability of producing some of the equipment faculty need for their research. CEE employs a full-time technician, Mark Davis, who provides support to research activities.

It should also be noted that the Departmental research and laboratory facilities are supplemented by the facilities and infrastructure available through the three state-funded Centers of Excellence for research - Center for Energy Systems Research, Center for Manufacturing Research, and Center for the Management, Utilization and Protection of Water Resources (also

known as the Water Center). The Centers provide financial support to CEE graduate students in the form of research assistantship from research projects directed by CEE faculty. Students are provided access to the laboratories of the Centers for conducting research. The chemistry analytical laboratory and the Geographic Information Systems (GIS) laboratory of the Water Center have been regularly accessed by CEE students to perform graduate level research in the field of water resources and environmental engineering. The College of Engineering's Computer Aided Engineering Laboratory has been frequently used by CEE graduate students engaged in high performance computational research in the engineering mechanics and water resources area.

6. Support

6.1. The program's operating budget is consistent with the needs of the program.

The budget for the University is composed primarily of three components:

- A state funding-formula allocation from the Tennessee Higher Education Commission (THEC) via Tennessee Tech University Board of Trustees to the University;
- Revenues obtained from student tuition and University and Engineering fees, including Technology Access Fees, Student Course Fees, and Laboratory Fees; and
- External funding sources, including donations.

Revenues from the above funding sources are received centrally by the University and then allocated to the colleges and administrative units on campus. In the past, this distribution has been primarily based on each unit's previous year's budget allocation, with some modification for unit growth or other special needs. However, with the inception of a new THEC funding formula as a result of the Complete College Act-TN, budget division among the colleges and administrative units has been modified to include performance factors directly related to the new funding formula (degrees produced, retention, etc.). The monies received by the College of Engineering are then further distributed to each department in the College.

Student course fees (SCF) are fees paid by students for each credit hour enrolled in engineering and most other courses. Currently, the fee is $65/credit hour for engineering courses, which is an increase over the $30/credit hour charged in academic year 2012-13. The college takes a portion of the total revenue from SCF generated by undergraduate and graduate students in each department to fund programs, such as the Student Success Center. With University budget cuts beginning in academic year 2016-17, the College of Engineering has had to increasingly rely on SCF in order to fund instructors and other instructional needs. As such, the CEE Department has actually seen a reduction in SCF allocations beginning this current fiscal year. At the same time, the purpose of SCF per THEC is for "the enhancement of undergraduate education" so the use of these funds must be tied to undergraduate students.

Concurrent with the aforementioned University budget cuts, all departmental graduate assistantships funds were withdrawn in Fall 2016. Currently, departmentally funded graduate students are paid via SCF as teaching assistants. In other words, the department cannot fund graduate students as research assistants from SCF, but graduate students do benefit from SCF through SCF support of graduate teaching assistantships.

Although not optimal, the sources of recurring funds and non-recurring funds described in the previous sections do currently provide the minimum support and continuity of funding to meet the needs of the department. The current fiscal year (FY18) funding is at the lowest level since the last program review. In the long term, the use of SCF to fund graduate students is not sustainable for the department as a whole, considering that these funds must also be used for a variety of other needs, including undergraduate student support, equipment/computer purchases and maintenance, and laboratory and classroom upgrades.

Permanent (recurring) sources of support for the CEE Department and the amounts allocated through these sources are shown in Table 7.

Table 7. Recurring Budget Items

Source of Funds	**Allocated Budget ($)**					
	2012-13	**2013-14**	**2014-15**	**2015-16**	**2016-17**	**2017-18 (to date)**
State Allocation, Tuition, General Fees	18,550	18,550	18,550	18,550	18,550	18,550
Student Course Fees	100,924	105,864	166,173	178,784	184,812	147,174
Graduate Tuition/Fees and Stipend	59,910	59,910	59,910	59,910	0	0
Lab Fees	4,000	4,000	4,000	4,000	4,000	4,000
Indirect Cost Return on Research Projects	14,470	15,200	17,230	12,310	17,658	11,160
TOTAL	**197,854**	**203,524**	**265,863**	**273,554**	**225,020**	**180,884**

Non-recurring sources of support include:

- Donations/gifts
- Scholarships
- Industrial sponsorship of senior design or other student projects
- Faculty release-time funds from research or service projects or Center matches

No fixed allocations are provided to the department for the acquisition, maintenance, and upgrade of infrastructure, facilities, or equipment. Instead, support is obtained from a variety of recurring and non-recurring sources including:

- Student course fees and lab fees (equipment)
- Technology access fee (TAF) grants (facilities)
- Endowment earnings (equipment)

- Faculty release time funds and indirect cost returns from research projects (equipment, facilities, infrastructure)
- Tennessee State Board of Architectural and Engineering Examiners (equipment) – College level, but portion available to departments
- Grants from companies/foundations (equipment, facilities, infrastructure)
- Equipment grant and donation programs (equipment)
- Direct donations from individuals/corporations (equipment, facilities, infrastructure)
- Matching support from the Centers of Excellence (equipment)
- Matching support from the College of Engineering for new faculty (equipment)
- Matching support from the Office of Research for new faculty (equipment)

Although not optimal, the sources of recurring funds and non-recurring funds described in the previous sections do currently provide sufficient support and continuity of funding to meet the needs of the Department. However, the use of SCF to fund graduate students is not sustainable for the Department as a whole in the long term, considering that these funds must also be used for a variety of other needs, including equipment purchase and maintenance, and laboratory and classroom upgrades.

6.2. The program has a history of enrollment and/or graduation rates sufficient to sustain high quality and cost-effectiveness.

Figure 1 shows the distribution of MS degrees over the last 40 years. The five-year average of the annual number of degrees conferred has grown, with an increase of over 25% from the last review cycle conducted in 2012. On average, there have been about 20 graduate students in the MS program at any given time. Over the 2012-2017 period, 271 complete student applications to the CEE MS program were received (plus an additional 63 incomplete applications). Ninety-two applications (34%) were granted admission (including provisional standing). A total of 54 applicants actually enrolled during this time. Thirty (56%) of those enrolled have successfully completed their MS degree. Approximately 20% (at the time of documentation) were either continuing in the program or were expected to complete it in a timely manner. These data are a reflection of the high standards related to retention and quality control of MS graduates that is implicit in the CEE MS program.

6.3. The program is responsive to local, state, regional, and national needs.

The CEE program works toward a consistent and proactive approach to meeting industry needs. This is accomplished by cultivating communication between Departmental faculty and industry leaders primarily through the CEE Advisory Board (AB). The AB comprises TTU alumni who are engineers from each of the respective CEE sub-disciplines. The Board members or employees of their agencies/firms are licensed in virtually every US state and are involved in the planning, design, construction, and management of major civil engineering infrastructure in the country.

The board meets semi-annually for at least one full day to evaluate current Departmental approaches in light of changing industry objectives. Some recent AB discussions have included:

- The appropriate approach and timing of CAD training for CEE students;
- Student use of Building Information Modeling (BIM);
- Evaluation of computer programming as an appropriate CEE course, given limited curricular hours and industry needs;
- The introduction and proper scope of construction management courses within CEE; and
- The need for the MS degree in Structural Engineering

The advisory board, is uniquely qualified to provide an accurate assessment of local, state, regional and national needs. Thus, the CEE Department relies heavily on the Board's input and prioritizes regular and consistent meetings to discuss these needs and formulate changes as necessary.

6.4. The program regularly and systematically collects data on graduating students and evaluates placement of graduates.

CEE staff maintain a spreadsheet that has as its fields, name of graduate student, year of graduation, CEE sub-discipline, title of MS thesis, and name of student's thesis advisor (see Table A-5 in Appendix A). CEE faculty that serve as thesis advisor maintain lists of employers of the graduate students they advise, and this information is relayed to CEE staff for compilation each semester. Tennessee Tech University's Alumni Association also keeps track of all university graduates and through one of its webpages https://alumni.tntech.edu/update-my-information receives periodic updates on amongst others changes that occur in employment of graduates. The CEE Department staff put in periodic requests to Alumni Association for updates on CEE graduates for which the Department lacks current information.

Graduates of the MS program in the five-year review period either took up civil engineering positions in the public or private sector or pursued an advanced degree. Those that went into the profession secured employment either before graduation or shortly thereafter, and no issues were ever noted. A few of the employers of recent graduates of the MS program include US Army Corps of Engineers, Tennessee Department of Transportation, Ross-Bryan Associates Inc, and Carpenter-Wright Engineering. Additional information on employers and placement of MS graduates is presented in Table A-4 in Appendix A.

In addition to the above, the CEE Department, because of the importance it attaches to the continued success of CEE graduate students, collected and evaluated placement data from CEE MS graduates from this review cycle and their respective employers. Faculty worked collectively to draft commonly agreed upon questionnaires for graduates and employers (a more thorough description is available under the "Indicators of Program Quality" section below). Unlike an exit interview of graduating students, MS alumni have no vested interest in promoting or championing the MS program, particularly if their expectations had not been fulfilled in becoming a useful member of the profession. Thus, such surveys were deemed by CEE faculty as a more honest reflection of 'overall performance' and a good starting point to initiate dialogue. More than 60 alumni and employers were surveyed on their overall perception of the quality of the MS program.

Among the many aspects surveyed, alumni were asked if they would recommend the MS program to anyone else while employers were asked if they would again hire a Civil Engineering MS graduate from TTU. 100% percent of alumni and 100% percent of employers responded in the affirmative to their respective questions. Complete results from the survey of alumni and employers are in Appendix D.

6.5. The program's procedures are regularly reviewed to ensure alignment to institutional policies and mission.

The interaction of the departmental policies and strategies with those of the university and college is important to the CEE faculty. Each new academic year begins with a one-day "faculty retreat" where the goals (graduate and undergraduate) for the year are discussed. The CEE faculty and staff then meet periodically throughout the semester to monitor progress in terms of graduate and undergraduate objectives. In addition to these broader meetings, the CEE Research and Graduate Affairs Committee is responsible for implementing continuous improvement measures at the graduate level by:

- Conducting annual assessments;
- Discussing lab and research space allocation, improvement and renovation;
- Coordinating CEE participation in TTU Annual Research Day; and
- Representing the CEE Department at the College of Engineering and Tennessee Tech University's Graduate Executive Committees.

INDICATORS OF PROGRAM QUALITY

Evidence of Student Demand

One indicator of program quality is the number of students that apply for admission into the program from the CEE undergraduate program at Tennessee Tech and other universities. The CEE MS program continues to have consistent demand in terms of student applications and enrollment as summarized in Table 8. Between academic years 2012-13 and 2016-17, 271 students applied to the program from seven states and over 20 countries (see Table A-1 for a full list of applicants). Of these applicants, 49 were granted admission with full standing while 44 were granted admission with provisional standing. This translates to a 34.3% acceptance rate. Table 8 also shows that between 2014-15 and 2016-17, more students were admitted with full standing than with provisional standing. A number of factors contributed to this. First, there was an increase in the number of students admitted into the Fast-track MS Program. As described earlier, the Fast-track MS Program provides the opportunity for CEE undergraduate students at Tennessee Tech University with an excellent academic record to accelerate completion of the MS degree. Thus, by virtue of their strong academic record, which is a prerequisite to admission into the Fast-track Program, fast-track students were and are admitted with full standing. Second, the quality of the applicant pool improved with the increase in applications allowing more admissions to be made with full standing. Third, the university put in place a policy to the effect that provisionally admitted students cannot receive assistantships. Finally, the College of Engineering in 2014 put in place a new MS admission policy which takes into consideration multiple criteria, which allows for admission justification beyond just GPA and GRE scores.

Table 8. Applications and Admissions to the CEE Graduate Program from 2012 to 2017

Academic Year	Complete Applications Received	Admitted students	
		Provisional Standing	Full Standing
2012-13	34	19	5
2013-14	21	12	4
2014-15	71	8	15
2015-16	80	3	12
2016-17	65	2	13

Evidence of Effectiveness of the Curriculum

Effectiveness of the program is considered in relation to the Program Objectives and Student Learning Outcomes (see Section 1 under the THEC Program Review Rubric). Much of the procedure adopted to assess program effectiveness is discussed in the "THEC Program Review Rubric" section, and a summary of the evidence is presented below.

In order to obtain external evidence of the effectiveness of the curriculum, an electronic survey of alumni of the TTU Civil and Environmental Engineering MS Program was undertaken during the fall of 2017. A link to the survey was sent to 53 alumni of the program, and 35 of them responded. The results are summarized in detail in Appendix D. Figure 7 provides a summary of the responses to the questions directly related to the program objectives and learning outcomes.

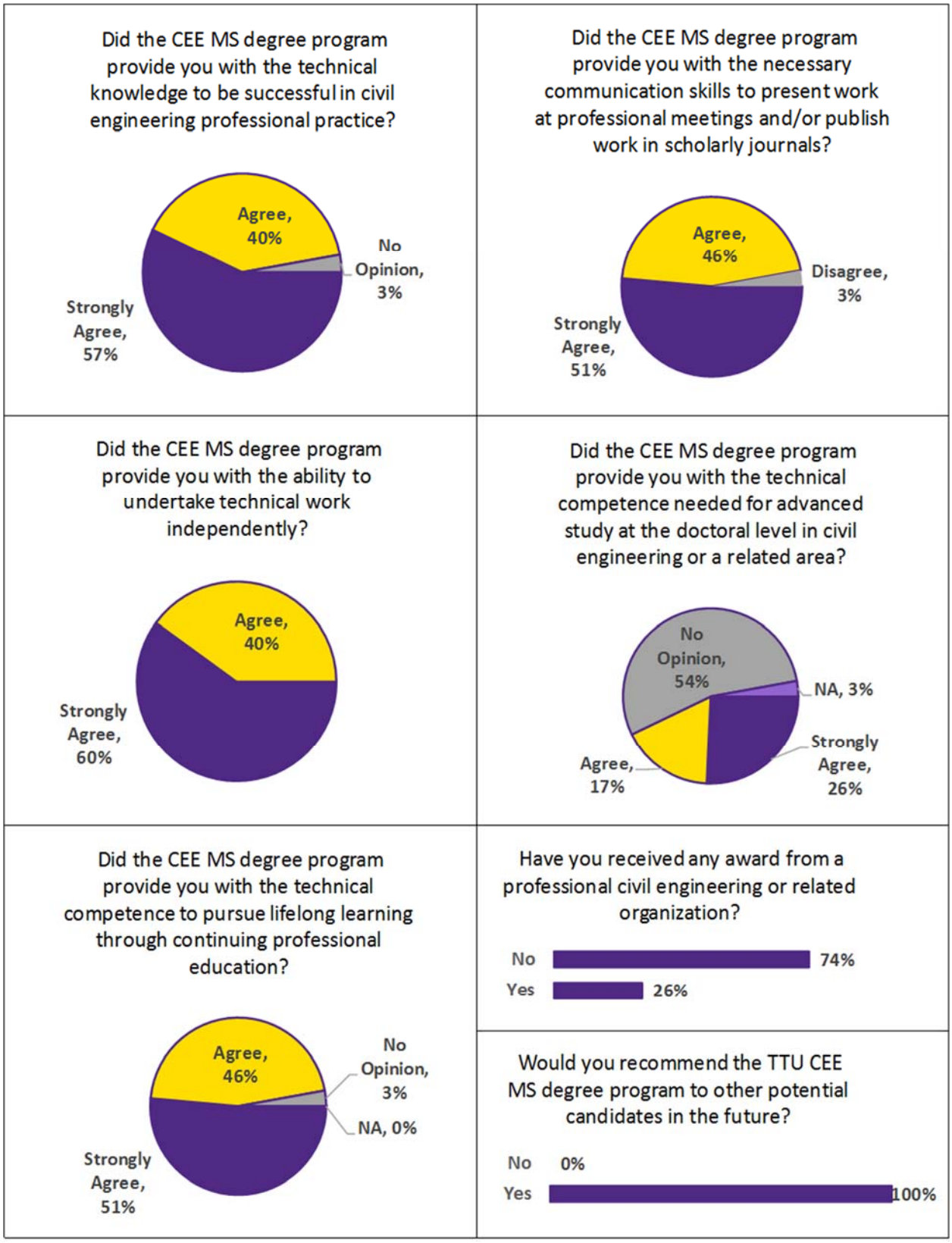

Figure 7. MS Program Alumni Survey Results – (35 Respondents)

Accomplishment of Program Objectives

Program Objective #1 (technical competence) is evaluated through course grades in core courses, the number of degrees completed, and alumni survey results. The grades for core courses are summarized in Table 9. As stated previously, since the 2012-2013 academic year, 63% of students enrolled between Fall 2012 and Spring 2016 have successfully completed the MS program, indicating that they have passed the core courses and their elective programs of study.

Table 9. Summary of Grades and Five-Year Average of Course Enrollment in Core MS CEE Courses

Course	Average Grades (by academic year)					Average number of students
	2012-13	2013-14	2014-15	2015-16	2016-17	
CEE 6200 – Statistical Inference for Engineers	4.00	3.36	3.47	3.60	---	15.75
CEE 6300 – Multiscale Analysis of Concrete	---	3.60	4.00	3.88	3.75	6.20
CEE 6410 – Traffic Control Systems	---	4.00	4.00	4.00	3.50	2.75
CEE 6470 – Transportation Demand Analysis	---	2.00	3.00	3.50	3.50	1.83
CEE 6520 – Open-Channel Hydraulics	3.80	4.00	3.75	3.33	3.40	4.60
CEE 6610 – Applied Environmental Chemistry	3.86	3.20	3.67	4.00	3.89	6.00
CEE 6930 – Theory of Elasticity	3.20	3.00	3.75	3.50	3.25	4.80
CEE 7610 / 6350 – Finite Element Analysis	3.17	3.50	3.60	3.43	3.33	5.80

The MS alumni survey responses indicate that 97% of graduates felt the M.S. program provided them with the technical knowledge required to be successful in their field. All of the respondents indicated that the program gave them the ability to undertake technical work independently. The surveys indicated that 97% of the respondents felt technically competent to pursue life-long learning as a result of the M.S. program.

Program Objective #2 (analysis and presentation or communication skills) is assessed through core course grades and oral presentation evaluation forms (a copy of the evaluation form can be found in Appendix E). Course grades are summarized in Table 9. Oral presentation assessments during MS students' proposal and theses defense conducted since 2015 are summarized in Table 10 and Table 11. The assessments indicate that the MS students met or exceeded expectations in their oral communication skills. Additionally, the survey results indicate that 97% of MS graduates agree or strongly agree that the program provided them with good communication skills for professional or scholarly purposes.

Table 10. Assessments of MS Proposal Presentations

Assessed by	Academic Year	Number of Evaluations	Average Score[1]				
			Content	Visual Aids	Presenter Preparation	Presentation Mechanics	Response to Questions and Comments
Committee Members	2015-2016	5	4.000	3.665	4.000	4.000	3.665
	2016-2017	3	4.000	3.665	4.000	3.660	3.330
	2017-2018	6	3.250	3.660	3.250	3.500	3.250
Other Faculty	2015-2016	NA	NA	NA	NA	NA	NA
	2016-2017	NA	NA	NA	NA	NA	NA
	2017-2018	1	4.000	4.000	4.000	4.000	4.000
Students	2015-2016	NA	NA	NA	NA	NA	NA
	2016-2017	2	4.000	4.000	4.000	4.000	4.000
	2017-2018	12	3.833	4.000	3.833	3.577	3.855

[1] Assessment scale: 1 = Not Acceptable, 2 = Below Expectations, 3 = Meets Expectations, 4 = Above Expectations

Table 11. Assessments of MS Thesis Defense Presentations

Assessed by	Academic Year	Number of Evaluations	Average Score[1]				
			Content	Visual Aids	Presenter Preparation	Presentation Mechanics	Response to Questions and Comments
Committee Members	2015-2016	17	3.818	3.622	3.623	3.581	3.595
	2016-2017	10	3.832	3.915	3.915	3.750	3.665
	2017-2018	2	3.500	3.500	3.500	3.500	3.500
Other Faculty	2015-2016						
	2016-2017	1	4.000	4.000	4.000	4.000	3.000
	2017-2018	1	4.000	4.000	4.000	4.000	4.000
Students	2015-2016	5	3.750	3.580	4.000	3.750	4.000
	2016-2017						
	2017-2018	11	3.900	3.900	3.818	3.900	3.818

[1] Assessment scale: 1 = Not Acceptable, 2 = Below Expectations, 3 = Meets Expectations, 4 = Above Expectations

Program Objective #3 (technical competence and preparation for future study/lifelong learning) can be evaluated by the percentage of students completing their thesis and the number of students pursuing doctoral work at peer institutions. A list of MS theses is provided in Table A-5 of Appendix A. Eight of the students that responded to the survey have entered doctoral programs in institutions, such as McGill University, Purdue University, University of Central Florida, University of Southampton, and University of Texas at Austin, after earning an MS from Tennessee Tech's CEE program. These students indicated agreement that the MS program provided them with the technical competence required to pursue doctoral studies.

Accomplishment of Student Learning Outcomes

Student Learning Outcomes #1 (demonstration of a clear understanding of the chosen CEE sub-discipline) and #2 (application of advanced methods in the development of solutions) is evaluated using core course grades as indicated in Table 8 and the successful completion of the thesis or project work requirement. Student Learning Outcome #3 (professional presentations and manuscripts) is assessed through the number of thesis and other peer-reviewed manuscripts published, and the number of external conference presentations given. These data are summarized in Table 122.

Table 12. Student Publications, Presentations, and Awards/Accolades

Academic Year	Student-Authored Publications			Oral Presentations		Regional / National Awards
	Journals	Conference Proceedings	Thesis Documents	MS Defense	Conference	
2012-13	6	2	12	12	12	
2013-14	3	2	9	9	8	1
2014-15	2	2	5	5	6	
2015-16	4	2	7	7	6	1
2016-17	11	2	7	7	5	1

Evidence of Student Achievement

Evidence of MS student achievement is captured by their performance on graduate courses, in the oral defense of their MS thesis research, in the strength of the analytical work reported in their written thesis document, and in conference presentations and journal publications resulting from their research. Performance metrics on core courses and scholarly work based on their research are presented in Table 8 and Table 11 above. All MS students that successfully progressed to their comprehensive examination were successful in the exam and went on to graduate. The responses provided by the MS-survey respondents (with about a 66 percent response rate) showed the majority of them to be employed in civil and environmental engineering or undertaking advanced study at the doctoral level (see Table A-4 in Appendix A). They all indicated being successful in their careers and pleased with the graduate level education they received (see Figure 6, and Appendix D). Further, the employer survey results, which were discussed in more detail earlier, were also indicative of employers that felt graduates of the CEE MS program were well prepared for professional work. Finally, three MS graduates during the five-year program review period were recipients of regional or national awards. In sum, all the above performance measures point to very good achievement of the desired outcomes of the program.

Evidence of Program Quality

One way of evaluating the effectiveness of the graduate program is to track the performance of MS graduates either in their places of employment or doctoral programs in which they are enrolled. Results of such surveys help identify any weaknesses in the program for appropriate remedial measures to be crafted and implemented. They also help determine the strengths of the program that is, what it does well at and therefore should strive to maintain. Historically, qualitative reports in terms of awards, placement, attendance of seminars, workshops and industry feedback have been collected. These usually indicate that graduate students are well prepared by the MS program for a professional career in civil engineering.

As part of the CEE quality assurance process, formalized surveys of recent MS graduates as well as their employers were conducted. Faculty worked collectively to draft questionnaires for graduates and employers respectively. The questionnaires were aligned closely to the program objectives and learning outcomes, and the survey was conducted online. Fifty-three MS graduates were invited to complete the online survey, and 35 of them responded. Their responses are provided in Appendix D while a summary of the responses was provided in Figure 6 (see page 47) followed by a discussion. As stated in the discussion, the overwhelming majority of the graduate respondents felt they received high quality education from the MS program. Twelve employers of CEE graduate students were invited to complete the online survey and 6 of them responded. Though this number of employer-respondents is small, the general tenor of opinion from them is that Tennessee Tech University offers a solid graduate program that meets employer needs. The eight key questions posed to employers and the corresponding results are provided in detail in Appendix D.

CLOSING STATEMENT

Summary of the CEE MS Program over the Five-Year Review Period

The indicators of program health show the CEE MS program over the five-year review period to have remained healthy and to have advanced itself modestly notwithstanding significant reductions in non-recurring budgetary allocations that occurred over the last two years of the review period. Census of the MS program showed it consistently had more than 20 students each academic year. The graduation rate went up by 25 percent, rising from 7.4 MS graduates per year in the previous review period to 9.4 MS graduates per year in the current review period. The BS/MS fast-track program continued to enable the Department attract exceptional students from the CEE undergraduate program at TTU into the MS program. The quality of graduate applications received by the program also improved, contributing in part to the increased number of applicants that were admitted with full standing.

In terms of the program curriculum, Geotechnical Engineering was added as a new CEE sub-discipline, adding to the course offerings at the graduate level, creating more research opportunities for the Department, and providing prospective MS students with an additional sub-discipline in which to specialize. CEE faculty worked at keeping the curriculum abreast of significant developments in their respective fields as well as to address the changing needs of the profession. In line with this, new courses were developed over the five-year period as well as incremental updates made to the content of existing courses.

Graduates of the MS Program whose desire was to enter into professional practice secured employment with major public or private sector agencies either before graduation or shortly thereafter. Several of these agencies are repeat employers of the MS programs' graduates, which serves as evidence of their pleasure with the program's products. Graduates of the MS program that continued on to pursue a doctoral degree have done so at reputable universities that include the University of Texas, Austin, Texas A & M University, College Station, Texas, and Southampton University, UK.

CEE faculty continue to be productive in research and scholarly work. Additionally, their MS students have been co-authors of several of the papers either published in journals or presented at conferences. Several of these papers have been based on the thesis research undertaken by these MS students. CEE faculty continue to have MS students participate in conferences, workshops, and other professional development activities.

Vision

With a long term goal of becoming a nationally recognized university and having a regionally competitive CEE graduate program that is able to attract well qualified applicants, provide funding support to admitted students, and provide a high quality graduate school experience, the program cannot rest on its current achievements. Thus, going forward, the CEE Research and Graduate Affairs Committee and the CEE Department, with inputs from the program's constituencies, will continue to use its improvement process to enhance the quality of

the graduate experience offered at TTU. Specific short and long term goals to be pursued by the Department include:

- Recruitment of faculty with research expertise in niche areas to be identified by the CEE Department as targets for attaining regional recognition;
- Recruitment of faculty that are both excellent teachers as well as researchers to strengthen products of the program academically, prepare them well for advanced study, and prepare them well for professional practice;
- Have a graduate course offering in civil and environmental engineering that is complemented by non-civil engineering courses that keep our students at the cutting edge of research and professional practice;
- Increase the number of proposals authored by CEE faculty to funding agencies such as Department of Transportation, National Science Foundation, and Federal Highway Administration with the goal of increasing the dollar amount of funded research done by the Department; and finally,
- Develop a set of actions for the progressive increase in graduate program student enrollment.

APPENDIX A

Supplemental Data

Appendix A

Table A- 1. Summary of Applicant Data since 2012

Entry Term	GRE Score Q	V	AWA	TOEFL	Undergrad GPA	Admission Decision	Nationality
201250	Q-162	V-156	AW-4.5		3.51	Full	US-TN
201280	Q-145	V-134		IE-5.0		Denied	S. Arabia
201280	Q-650	V-330		IE-6.0	1.38	Denied	S. Arabia
201280					1.951	Denied	S. Arabia
201280	Q-145;Q-149	V-133; V-139	AW-2.0	IE-5.5		Provisional	S. Arabia
201280						Incomplete	S. Arabia
201280	Q-163	V-141	AW-3.0	590	3.04	Denied	India
201280	Q-158	V-155	AW-3.5		3.48	Full	US-TN
201280	Q-151	V-135		IE-5.0		Denied	S. Arabia
201280	Q-163	V-146	AW-3.0	590	3.45	Denied	Bangladesh
201280	Q-640	V-500	AW-4.0		3.1	Full	US-TN
201280	Q-156	V-146	AW-3.0		3	Provisional	US-TN
201280	Q-158	V-158	AW-4.5		3.33	Incomplete	US-TN
201280	Q-750	V-440	AW-3.5		3.42	Provisional	Ghana
201280	Q-161	V-154	AW-4.0		3.98	Full	US-TN
201280					3.06	Incomplete	US-TN
201280	Q-151	V-139	AW-2.5		2.639	Denied	Cameroon
201280	Q-154;Q-149	V-154;V-145	AW-3.0;AW-3.5	603	3.4	Provisional	India
201280	Q-159	V-152	AW-3.5		2.82	Provisional	US-TN
201280					3.39	Incomplete	US-AR
201280	Q-151	V-150	AW-2.5		2.47	Provisional	US-TN
201280	Q-157	V-149	AW-45		3.67	Provisional	US-TN
201280						Incomplete	Iraq
201280	Q-156	V-144	AW-1.5	IE-6.0	2.83	Provisional	Bangladesh
201280	Q-150	V-149	AW-4.0		3.13	Provisional	US-TN
201280	Q-730	V-300	AW-3.5	610	4	Provisional	Ukraine
201280	Q-162	V-145	AW-3.5	567	3.072	Provisional	Bangladesh

Appendix A

Entry Term	GRE Score Q	V	AWA	TOEFL	Undergrad GPA	Admission Decision	Nationality
201280	Q-153	V-152	AW-3.5		2.9	Provisional	US-TN
201280	Q-151	V-147	AW-3.5		2.72	Provisional	US-TN
201280	Q-157	V-161	AW-5.0		3.84	Full	US-ID
201310						Incomplete	Kuwait
201310					2.361	Incomplete	S. Arabia
201310						Incomplete	S. Arabia
201310						Incomplete	Iran
201310	Q-148	V-141	AW-3.0	563	2.64	Denied	Ghana
201310	Q-154	V-145	AW-3.5		3.44	Provisional	US-TN
201310	Q-152	V-151	AW-4.0		3.17	Provisional	US-TN
201310	Q-143	V-140	AW-3.0	IE-7.0		Incomplete	Iraq
201310	Q-151	V-146	AW-3.0	553		Denied	India
201310	Q-750	V-470	AW-3.0	IE-6.5	3.738	Provisional	Nepal
201310	Q-154;Q-153	V-140;V-132	AW-2.0;AW-2.5	490, 533	2.782	Provisional	Iran
201310	Q-145	V-143	AW-3.0		2.75	Provisional	US-TN
201310	Q-152	V-139	AW-3.5	IE-6.5	2.832	Provisional	Iran
201350						Incomplete	Tanzania
201350	Q-164	V-157	AW-4.0		3.94	Full	US-TN
201380	Q-730	V-560	AW-4.0		3.55	Full	US-TN
201380				IE-5.0		Incomplete	S. Arabia
201380	Q-144;Q-740	V-144; V-310	AW-2.5	567	2.936	Provisional	US-TN
201380					3.01	Incomplete	US-TN
201380	Q-140	V-139	AW-2.0			Incomplete	US-TN
201380	Q-140	V-139	AW-2.0			Denied	S. Arabia
201380	Q-153	V-143	AW-3.0		3.943	Denied	India
201380	Q-159	V-152	AW-4.0		3.55	Provisional	US-TN
201380						Incomplete	Pakistan
201380					3.79	Incomplete	US-TN

Appendix A

Entry Term	GRE Score Q	V	AWA	TOEFL	Undergrad GPA	Admission Decision	Nationality
201380						Incomplete	US-TN
201380	Q-158;Q-151	V-142;V-147	AW-4.0;A2-3.5		3.72	Provisional	Ghana
201380	Q-152	V-144	AW-3.0	IE-6.5	3.18	Full	Bangladesh
201380	Q-155	V-152	AW-3.0		3.58	Incomplete	US-TN
201380	Q-143;Q-150	V-145;V-141	AW-3.5;AW-2.5	563	3.053	Provisional	US-TN
201380	Q-153	V-137	AW-2.5			Incomplete	Bangladesh
201380	Q-158	V-146	AW-3.0	577		Provisional	India
201380	Q-152	V-144	AW-3.5	560	3.4	Provisional	Pakistan
201380				553		Denied	India
201380						Incomplete	US-MD
201380	Q-160	V-155	AW-3.5		3.41	Full	US-TN
201380						Incomplete	Turkey
201410	Q-155	V-147	AW-4.0	627	3.21	Provisional	Ghana
201410					3.429	Incomplete	S. Arabia
201410	Q-162	V-143	AW-3.0	IE-7.0	3.838	Provisional	India
201410					2.57	Incomplete	US-TN
201410	Q-154	V-152	AW-3.0		3.36	Provisional	US-FL
201410	Q-147	V-140	AW-3.0	587		Incomplete	Nigeria
201410	Q-610	V-510	AW-3.0		2.63	Provisional	US-TN
201410	Q-160	V-140	AW-3.0	IE-6.5	3.883	Provisional	India
201410						Incomplete	India
201410	Q-156;Q-159	V-138;V-143	AW-2.5;AW-2.0		2.85	Provisional	Iran
201410	Q-151	V-141	AW-1.5	IE-6.0	3.552	Denied	India
201410	Q-144	V-137	AW-2.0	IE-6.0	2.66	Denied	India
201410						Incomplete	Ethiopia
201450						Incomplete	Syria
201450					3.72	Full	US-TN
201450					3.81	Full	US-TN

Appendix A

Entry Term	GRE Score Q	V	AWA	TOEFL	Undergrad GPA	Admission Decision	Nationality
201450						Incomplete	Egypt
201450					3.16	Full	US-TN
201480						Incomplete	India
201480	Q-142;Q-132;Q-137	V-140;V-140;V-137			3.06	Provisional	S. Arabia
201480	Q-136	V-135	AW-1.5	IE-5.0		Denied	S. Arabia
201480					3.01	Full	US-TN
201480	Q-145	V-131	AW-3.0	IE-6.0;IE-6.5		Denied	India
201480	Q-145	V-136	AW-2.0	IE-5.5	3.514	Denied	India
201480	Q-141	V-142	AW-2.5	553	3.757	Denied	India
201480	Q-154;Q-154	V-145;V-141	AW-3.0;AW-3.0	570		Provisional	China
201480		V-130	A-154;AW-2.0	IE-6.0		Denied	India
201480					3.73	Full	US-TN
201480	Q-154;1-148;Q-153;Q-147	V-140;V-133;V-130;V-132;AW-3.0-AW-3.0-AW-3.0-AW-2.5		IE-5.5	3.44	Denied	Iran
201480				477	3.98	Incomplete	Iraq
201480					3.25	Full	US-TN
201480	Q-158	V-137	AW-2.0	IE-5.5	3.752	Denied	India
201480	Q-146;Q-147	V-139;V-132	AW-2.5;AW-2.5	IE-6.0		Denied	India
201480	Q-160	V-142	AW-3.5	603	3.132	Full	Nepal
201480	Q-137	V-135	AW-2.0	IE-6.0		Denied	India
201480	Q-144;Q-137	V-134;V-134;V-135;Q-136	AW-2.0;AW-1.5;AW-1.5	IE-6.0	3.1	Denied	India
201480	Q-155	V-142	AW-2.5	IE-7.0		Denied	India
201480	Q-158	V-146	AW-2.5	IE-6.0	2.73	Provisional	Bangladesh
201480	Q-161	V-150	AW-3.5	613		Full	India
201480	Q-139;Q-134	V-141;V-133	AW-1.5;AW-1.0	IE-5.5	3.667	Denied	India
201480	Q-161	V-140	AW-3.0	560		Denied	India
201480				IE-5.5		Incomplete	India
201480					3.59	Full	US-TN

Appendix A

Entry Term	GRE Score Q	V	AWA	TOEFL	Undergrad GPA	Admission Decision	Nationality
201480	Q-148	V-140	AW-2.5	IE-6.0	3.619	Denied	India
201480	Q-155	V-130	AW-2.0	IE-6.0		Denied	India
201480	Q-730	V-550	AW-3.0	593	2.88	Provisional	India
201480	Q-162	V-152	AW-3.5	IE-7.0	4	Full	Nepal
201480	Q-158	V-136	AW-3.0	IE-6.0	2.914	Denied	India
201480	Q-147	V-133	AW-2.5	IE-6.0;IE-6.5	3.574	Denied	India
201480	Q-170	V-154	AW-4.0	627	3.4	Provisional	Nepal
201480						Incomplete	Nepal
201480	Q-148	V-150	AW-2.5	580	3.548	Denied	India
201480	Q-146	V-136	AW-1.5	IE-5.5	3.886	Denied	India
201480	Q-156	V-138	AW-3.0	560	3.881	Provisional	India
201480	Q-149	V-139	AW-2.0	IE-6.0	3.933	Provisional	India
201480	Q-153	V-141	AW-2.0	IE-6.0	3.795	Denied	India
201480	Q-150;Q-138	V-137;V-130	AW-2.0;AW-1.5	IE-6.0	2.706	Denied	India
201480	Q-155	V-134	AW-2.5			Incomplete	Turkey
201510	Q-160	V-145	AW-2.5	593		Denied	India
201510	Q-138	V-137	AW-1.5	IE-5.0		Incomplete	India
201510	Q-142	V-142	AW-1.5	IE-6.0		Incomplete	India
201510	Q-133	V-136	AW-1.5			Incomplete	S. Arabia
201510	Q-149	V-145	AW-3.0	IE-6.5	3.657	Denied	India
201510					3.88	Full	US-TN
201510	Q-152	V-136	AW-3.9	PTEA-52		Incomplete	India
201510	Q-145	V-142	AW-3.0	IE-5.5	3.193	Denied	India
201510	Q-147	V-135	AW-2.0	IE-5.5	3.074	Denied	India
201510	Q-156	V-143	AW-2.5	IE-6.5	3.16	Denied	Turkey
201510	Q-145;Q-144	V-139;V-134	AW-2.0;AW-2.0	IE-5.5	3.56	Denied	India
201510	Q-147	V-144	AW-2.0	IE-6.0	3.731	Denied	India
201510	Q-152	V-139	AW-3.5	IE-6.5	3.655	Denied	India

Appendix A

Entry Term	GRE Score Q	V	AWA	TOEFL	Undergrad GPA	Admission Decision	Nationality
201510	Q-150	V-139	AW-3.0	IE-6.0	3.574	Denied	India
201510	Q-152;Q-147	V-132;V-136	AW-2.0;AW-2.0	IE-6.0	3.738	Denied	India
201510	Q-150	V-140	AW-2.0	IE-6.0	3.826	Denied	India
201510					3.48	Full	US-TN
201510	Q-141	V-134	AW-2.0	IE-6.0	3.605	Denied	India
201510	Q-149	V-140	AW-3.0	IE-6.5	3.255	Denied	India
201510	Q-159	V-144	AW-3.0	IE-6.0	2.608	Denied	India
201510	Q-146;Q-141	V-140;V-133	AW-2.0;AW-2.9	IE-6.0	3.13	Denied	India
201510	Q-146	V-137	AW-2.9	IE-6.0		Denied	India
201510	Q-149	V-135	AW-2.0	IE-6.0	3.648	Provisional	India
201510	Q-139	V-137	AW-2.0		2.83	Denied	India
201510	Q-145	V-136	AW-3.0	IE-6.0	3.576	Denied	India
201510	Q-150;Q-149	V-135;V-130	AW-2.5;AW-2.5	IE-5.5	3.75	Denied	India
201510	Q-136	V-152	AW-4.5		3.354	Denied	Nigeria
201510	Q-158	V-150	AW-3.5	IE-8.0	3.912	Denied	India
201510				490		Incomplete	Iraq
201510	Q-166	V-139	AW-2.5	553		Incomplete	Turkey
201510	Q-143	V-136	AW-1.0	IE-5.5	2.18	Denied	Turkey
201510	Q-150	V-141	AW-2.5	553	2.844	Denied	India
201510	Q-156	V-141	AW-1.5		3.778	Incomplete	India
201510	Q-161	V-140	AW-2.5	577	3.7	Denied	India
201510	Q-143	V-136	AW-2.0	IE-5.5		Incomplete	India
201510					3.53	Full	US-TN
201510	Q-159;Q-151	V-141;V-137	AW-2.5;AW-2.0	PTEA-55	3.683	Denied	India
201510					3.02	Full	US-TN
201510	Q-157	V-139	AW-2.5	IE-6.0		Incomplete	India
201510	Q-154	V-140	AW-2.5	IE-7.0	3.97	Denied	India
201510					3.19	Full	US-TN

Appendix A

Entry Term	GRE Score Q	V	AWA	TOEFL	Undergrad GPA	Admission Decision	Nationality
201510	Q-139	V-135	AW-2.0			Incomplete	India
201510	Q-146;Q-144	V-139;V-135	AW-3.0;AW-2.5	IE-6.0	3.212	Denied	India
201550	Q-149	V-130	AW-2.0	543	2.925	Denied	Iraq
201550					3.01	Full	US-TN
201550					3.65	Full	US-TN
201550	Q-148	V-140	AW-3.5	553	2.775	Denied	India
201550	Q-144	V-141	AW-1.5	IE-6.0	3.626	Denied	India
201580						Incomplete	S. Arabia
201580	Q-157	V-140	AW-2.5	IE-6.5		Denied	India
201580	Q-142	V-139	AW-2.5			Denied	India
201580					3.54	Full	US-TN
201580						Denied	India
201580	Q-149	V-138	AW-3.0	550	3.867	Denied	India
201580	Q-145	V-138	AW-2.5			Denied	India
201580	Q-148;Q-137	V-132;V-134	AW-1.0;AW-1.5	PTEA-49		Denied	India
201580	Q-159	V-166	AW-3.5		3.18	Full	US-TN
201580	Q-780	V-490	AW-3.0	587	2.97	Provisional	Eritrea
201580	Q-143	V-133	AW-1.5	ELS-112		Denied	Libya
201580	Q-154	V-134	AW-2.0	IE-6.0		Denied	India
201580	Q-152	V-131	AW-2.0			Denied	India
201580	Q-153	V-142	AW-3.0	IE-6.5		Denied	India
201580	Q-143;Q-146	V-143;V-139	AW-2.5;AW-2.5	570	3.562	Denied	India
201580				IE-5.5		Denied	India
201580	Q-157	V-148	AW-4.0		3.3	Full	US-TN
201580						Denied	Nepal
201580	Q-144; Q-146	V-148;V-142	AW-3.0;AW-3.0	563	3.633	Denied	India
201580	Q-163	V-138	AW-2.5	593	3.171	Denied	Iran
201580	Q-156	V-136	AW-2.5	IE-6.0	4	Denied	India

Appendix A

Entry Term	GRE Score Q	V	AWA	TOEFL	Undergrad GPA	Admission Decision	Nationality
201580	Q-163	V-139	AW-3.0	613		Denied	India
201580	Q-154	V-152	AW-4.0		3.43	Incomplete	US-TN
201580	Q-148;Q-147	V-132;V-147	AW-2.0;AW-2.5			Denied	India
201580	Q-144;Q-147	V-139;V-140	AW-2.5;AW-3.0	IE-6.0	3.507	Denied	India
201580	Q-147	V-136	AW-2.5	IE-5.5		Denied	India
201580	Q-157	V-141	AW-3.0			Denied	India
201580	Q-161	V-142	AW-2.0	IE-6.0		Denied	India
201580				IE-5.5		Incomplete	US-TN
201580	Q-148	V-139	AW-2.5	547		Denied	India
201580	Q-149	V-136	AW-1.5			Denied	India
201580	Q-142	V-130	AW-2.0			Denied	India
201580	Q-140	V-140	AW-2.0	IE-5.5		Denied	India
201580	Q-152	V-159	AW-4.0		2.69	Full	US-TN
201580	Q-142	V-130	AW-2.0	IE-6.0		Denied	India
201580	Q-155;Q-149	V-139;V-140	AW-2.0;AW-2.5	IE-6.0		Denied	India
201580	Q-156	V-140	AW-3.5	IE-6.0	3.7	Denied	Nepal
201580						Denied	US-CA
201580	Q-153	V-148	AW-3.0			Incomplete	US-KY
201580	Q-158	V-149	AW-3.0	573	2.55	Provisional	Poland
201580	Q-1454	V-144	AW-2.5	IE-6.5	3.721	Denied	India
201580	Q-136	V-136	AW-1.5	IE-5.5		Denied	India
201580						Incomplete	Iran
201580	Q-151;Q-145	V-150;V-147	AW-3.5;AW-3.5	583	3.123	Denied	Nigeria
201580	Q-690	V-350	AW-3.0		3.54	Full	US-TN
201580	Q-163	V-157	AW-3.0	613		Full	India
201580	Q-139;Q-130	V-144;V-138	AW-1.5;AW-2.0	IE-5.5		Denied	India
201580	Q-160	V-145	AW-3.0	563		Denied	India
201580	Q-154	V-146	AW-2.0	543	2.995	Denied	India

Appendix A

Entry Term	GRE Score Q	V	AWA	TOEFL	Undergrad GPA	Admission Decision	Nationality
201580	Q-145	V-137	AW-3.0	550		Denied	India
201580	Q-156	V-143	AW-3.0	573;553	3.826	Denied	Iraq
201580	Q-154	V-140	AW-2.5	587		Denied	India
201580	Q-149	V-141	AW-3.0	553		Denied	India
201580	Q-151	V-141	AW-3.0	IE-6.5		Denied	India
201580	Q-154	V-138	AW-2.5	IE-6.0		Denied	India
201580	Q-156	V-136	AW-2.0	PTEA-62		Denied	India
201610					3.08	Incomplete	S. Arabia
201610	Q-155	V-141	AW-2.5	543		Denied	India
201610	Q-145	V-141	AW-2.5	IE-6.0	3.778	Denied	India
201610	Q-143;Q-138	V-138;V-140	AW-6.0;AW-5.5	IE-5.5	3.524	Denied	India
201610					4	Full	US-TN
201610					3.19	Full	US-TN
201610	Q-156;Q-150	V-134;V-136	AW-2.0;AW-2.0	IE-6.5	2.62	Denied	India
201610					3.53	Full	US-TN
201610	Q-143;Q-141	V-134;V-134	AW-2.0;AW-1.5	IE-6.0	3.569	Denied	India
201610						Incomplete	India
201610				IE-5.5; IE-7.5		Incomplete	India
201610	Q-148;Q-146	V-139;V-133	AW-2.0;AW-2.5			Denied	India
201610	Q-146	V-140	AW-2.5		2.98	Denied	India
201610	Q-153	V-156	AW-3.0		3.74	Full	US-TN
201610	Q-139	V-139	AW-2.0	IE-5.5	2.84	Denied	India
201610	Q-147;Q-147	V-142;V-143	AW-3.0;AW-3.5	580		Denied	India
201610	Q-149	V-147	AW-3.0	IE-6.0		Denied	India
201610	Q-161	V-133	AW-2.5	IE-5.5	2.615	Denied	India
201610	Q-154	V-130	AW-2.0		3.033	Denied	India
201610	Q-155	V-138	AW-2.0		3.029	Denied	India
201610	Q-149;Q-154	V-136;V-130	AW-2.0;AW-2.0	503		Denied	India

Appendix A

Entry Term	GRE Score Q	V	AWA	TOEFL	Undergrad GPA	Admission Decision	Nationality
201610	Q-139	V-136	AW-2.0	IE-5.5	3.686	Denied	India
201610	Q-147	V-139	AW-3.0	IE-6.0	2.889	Denied	India
201610					2.7	Provisional	US-TN
201610						Incomplete	China
201610	Q-144	V-130	AW-2.0		3.795	Denied	India
201610	Q-156	V-141	AW-2.0	IE-6.5	3.507	Denied	India
201650					3.94	Full	US-TN
201650					3.15	Full	US-TN
201650	Q-155;Q-146	V-143;V-140	AW-3.0;AW-2.5		3.082	Denied	US-TN
201650					3.56	Full	US-TN
201680	Q-156	V-138	AW-3.0	IE-6.5	3.384	Denied	Sudan
201680	Q-142	V-140	AW-1.5	IE-6.0	2.925	Denied	S. Arabia
201680	Q-139	V-135	AW-2.0	IE-5.5		Denied	S. Arabia
201680	Q-147	V-142	AW-3.0		3.215	Denied	India
201680	Q-154	V-151	AW-3.0	620	3.514	Incomplete	Ghana
201680	Q-137;Q-137	V-142;V-134	AW-2.5;AW-2.0	IE-5.5	2.87	Denied	India
201680	Q-143;Q-145	V-142;V-134	AW-2.0;AW-2.0	IE-6.0	3.23	Denied	India
201680	Q-150	V-146	AW-2.5	IE-6.5	3.49	Denied	India
201680					3.55	Full	US-TN
201680	Q-151	V-149	AW-3.5	IE-7.0	3.06	Provisional	Bangladesh
201680	Q-154	V-144	AW-2.5	IE-6.5	3.57	Denied	Bangladesh
201680	Q-146;Q-148	V-145-V-140	AW-2.5;AW-2.5	553	3.69	Denied	India
201680	Q-150	V-135	AW-2.5	IE-6.0	2.503	Denied	Iran
201680	Q-160	V-139	AW-2.5	567	2.906	Denied	India
201680					3.68	Full	US-TN
201680	Q-161	V-162	AW-3.5		3	Incomplete	US-TN
201680	Q-160;Q-149	V-136;V-137	AW-3.0;AW-2.5	550	3.335	Denied	India
201680	Q-153	V-143	AW-1.5	IE-6.0		Denied	India

Appendix A

Entry Term	GRE Score Q	V	AWA	TOEFL	Undergrad GPA	Admission Decision	Nationality
201680	Q-147;Q-154	V-136;V-133	AW-2.5;AW-2.0	533		Denied	India
201680	Q-153	V-143	AW-3.0	553		Denied	India
201680	Q-148	V-143	AW-1.5	IE-6.0	3.686	Denied	India
201680	Q-160	V-142	AW-3.0	550		Denied	India
201680	Q-155	V-144	AW-3.0	IE-6.5	3.385	Denied	India
201680	Q-158	V-142	AW-3.0	567	3.77	Denied	Bangladesh
201680	Q-162	V-148	AW-3.5	593	3.643	Denied	Ghana
201680	Q-158	V-143	AW-3.0	587		Denied	India
201680	Q-150	V-151	AW-3.5	603	3.549	Full	Ghana
201680	Q-151;Q-147	V-141;V-137	AW-3.0;AW-3.0	IE-6.5	3.33	Denied	India
201680	Q-156;Q-152	V-152;V-148	AW-3.0;AW-3.5	583	3.01	Denied	Nigeria
201680	Q-151	V-139	AW-2.0	IE-6.0		Denied	India
201680	Q-139	V-137	AW-2.0	IE-6.0		Denied	India
201680	Q-148	V-144	AW-2.5	563		Denied	India
201680					3.74	Full	US-TN
201680					3.67	Full	US-TN
201680	Q-165	V-160	AW-3.5		4	Full	Nepal
201680	Q-154	V-144	AW-3.0	IE-6.0	3.44	Denied	Bangladesh
201680	Q-140	V-134	AW-2.0	IE-5.5	3.881	Denied	India
201680	Q-150;Q-145	V-142;V-140	AW-2.5;AW-2.5	IE-6.5		Denied	India
201680	Q-147	V-136	AW-2.0			Denied	India
201680	Q-149	V-140	AW-3.0	537	3.45	Denied	India
201680				IE-6.5		Incomplete	India
201680	Q-159;Q-157	V-149;V-147	AW-3.0;AW-2.5	577		Incomplete	Bangladesh
201680	Q-154	V-136	AW-2.0	IE-5.5		Denied	India
201680	Q-154	V-141	AW-2.5	560	2.49	Denied	India
201680	Q-150	V-146	AW-3.5		3.19	Full	US-TN
201680	Q-157	V-136	AW-2.5	IE-6.0		Denied	India

Appendix A

Entry Term	GRE Score Q	V	AWA	TOEFL	Undergrad GPA	Admission Decision	Nationality
201710	Q-170	V-157	AW-4.0	610	3.782	Denied	Nigeria
201710	Q-138	V-134				Denied	S. Arabia
201710	Q-138;Q-138	V-134;V-130	AW-2.5	530	3.108	Denied	S. Arabia
201710	Q-148;Q-139;Q-140	V-156;V-142;V-140	AW-3.0;AW-2.0;AW-2.0	570;IE-6.5	2.793	Denied	S. Arabia
201710						Incomplete	Libya
201710	Q-155	V-140	AW-2.0	IE-6.0	2.915	Denied	India
201710				530		Incomplete	Mauritania
201710						Incomplete	US-TN
201710	Q-159	V-149	AW-3.5	607	3.534	Denied	Nepal
201710	Q-160	V-148	AW-3.5	610	3	Full	Bangladesh
201710						Incomplete	Pakistan
201710	Q-152;Q-140	V-137;V-138	AW-2.5;AW-2.0	IE-6.0		Denied	India
201710					3.45	Full	US-TN
201710	Q-154	V-147	AW-2.5		3.159	Denied	Nigeria
201710	Q-161	V-143	AW-3.0	IE-6.0		Denied	India
201710	Q-145	V-132	AW-1.5	IE-5.5	2.86	Denied	India
201710	Q-164	V-136	AW-3.0	IE-6.0	3.156	Denied	India
201710					3.72	Full	US-TN
201710	Q-165;Q-156	V-135;V-130	AW-2.0;AW-2.0	IE-6.0		Denied	India
201710	Q-151	V-143	AW-2.0	IE-6.0;IE-6.5	4	Denied	India
201710	Q-148	V-146	AW-3.0	IE-6.0	2.492	Denied	India
201710					2.95	Provisional	Japan
201710	Q-151	V-143	AW-3.0	IE-6.5	3.51	Denied	India
201710						Incomplete	Pakistan

Appendix A

Table A- 2. Graduate courses and the semesters they have been offered between Fall 2012 and Spring 2017

Course Number	Course Title	Semester									
		F12	S13	F13	S14	F14	S15	F15	S16	F16	S17
CEE 5130	Matrix and Finite Element Methods	✓		✓	✓		✓		✓		✓
CEE 5190	Advanced Mechanics of Materials	✓		✓		✓		✓		✓	✓
CEE 5350	Advanced Structural Design	✓							✓		✓
CEE 5360	Advanced Topics in Structural Concrete Design		✓		✓		✓				
CEE 5380	Bridge Design			✓		✓		✓			
CEE 5410	Solid and Hazardous Waste Management	✓		✓				✓		✓	
CEE 5420	Engineering Hydrology	✓		✓		✓		✓		✓	
CEE 5430	Water and Wastewater Engineering		✓		✓		✓		✓	✓	
CEE 5440	Water Resources Engineering		✓		✓		✓		✓		✓
CEE 5500	Engineering Construction Management		✓		✓		✓				
CEE 5600	Civil Engineering Materials II										
CEE 5610	Pavement Design			✓		✓		✓		✓	✓
CEE 5630	Traffic Engineering	✓		✓		✓		✓		✓	
CEE 5640	Highway Engineering		✓		✓		✓		✓		✓
CEE 5660	Transportation Planning	✓		✓		✓		✓		✓	
CEE 5700	Masonry Design		✓		✓		✓		✓		✓
CEE 5850	Forensic Engineering								✓		✓
CEE 5930	Noise Control		✓							✓	
CEE 5990	Special Problems: Engineering Management		✓		✓	✓					
CEE 5990	Special Problems: Forensic Engineering					✓					
CEE 5990	Special Problems: Computational Hydraulics						✓		✓		
CEE 5990	Special Problems: GIS Applications in CEE									✓	
CEE 6040	Intermediate Fluid Mechanics									✓	
CEE 6200	Statistical Inference for Engineers	✓			✓		✓		✓		
CEE 6300*	**Multiscale Analysis of Concrete**	✓		✓		✓		✓		✓	
CEE 6350*	**Finite Element Analysis**								✓		✓
CEE 6360	Introduction to Continuum Mechanics				✓		✓		✓		✓
CEE 6370	Vibrations of Continuous Media										
CEE 6410*	**Traffic Control Systems**		✓		✓		✓		✓		✓
CEE 6430	Probabilistic Methods in Hydroscience							✓			
CEE 6440	Hydrometeorology			✓							

* = core course in a CEE area of specialization

Appendix A

Course Number	Course Title	Semester									
		F12	S13	F13	S14	F14	S15	F15	S16	F16	S17
CEE 6470*	**Transportation Demand Analysis**	✓		✓	✓	✓	✓	✓	✓		✓
CEE 6520*	**Open-Channel Hydraulics**	✓		✓		✓		✓		✓	
CEE 6610	**Applied Environmental Chemistry**	✓		✓		✓			✓		✓
CEE 6710	Environmental Engineering Unit Operations and Processes – Water Treatment Design	✓						✓			
CEE 6720	Environmental Engineering Unit Operations and Processes – Wastewater Treatment Design		✓		✓		✓			✓	
CEE 6770	Environmental Engineering Laboratory: Water Treatment	✓		✓							
CEE 6780	Environmental Engineering Laboratory: Wastewater Treatment		✓		✓		✓				
CEE 6900	Special Problems: Introduction to Finite Element Analysis			✓		✓					
CEE 6900	Special Problems: LGS			✓							
CEE 6900	Special Problems: Mechanics of Composite Materials				✓						
CEE 6900	Special Problems: Water Quality Modeling using HSPF				✓						
CEE 6900	Special Problems: Study of Constructed Wetland as LID System of Nitrogen Removal				✓						
CEE 6900	Special Problems: Structural Identification of Constructed Systems					✓					
CEE 6900	Special Problems: Concrete Mix Design						✓				
CEE 6900	Special Problems: Traffic Flow at Secondary Schools						✓				
CEE 6900	Special Problems: Numerical Methods for PDEs								✓		
CEE 6900	Special Problems: Stormwater Management – Design and Applications								✓		
CEE 6900	Special Problems: Earthquake Engineering Principles								✓		
CEE 6900	Special Problems: Advanced Steel Design								✓		
CEE 6900	Special Problems: Advanced Remote Sensing Applications in Hydrology	✓							✓		
CEE 6900	Special Problems: hBN Cementitious Composites								✓		
CEE 6900	Special Problems: Simulation									✓	
CEE 6900	Special Problems: Advanced Soil Mechanics									✓	
CEE 6900	Special Problems: Advanced Engineering Mechanics									✓	
CEE 6900	Special Problems: Foundation Engineering										✓
CEE 6910	Graduate Seminar	✓		✓		✓		✓		✓	✓

Appendix A

Course Number	Course Title	Semester									
CEE 6930*	**Theory of Elasticity**	✓		✓		✓		✓		✓	
CEE 6980	Directed Study: Urban Hydrology Model Development	✓									
CEE 6980	Directed Study: Rural Regional Water Authority			✓							
CEE 6980	Directed Study: Culvert Design and Rating			✓							
CEE 6980	Directed Study: Statistics for Hydrology			✓							
CEE 6980	Directed Study: Water Quality Modeling using HSPF				✓						
CEE 6980	Directed Study: Microscopic & Genomic Analysis of Environmental Samples									✓	
CEE 7420	Public Transportation		✓								✓
CEE 7450	Advanced Topics/Concrete Durability		✓		✓		✓		✓		✓
CEE 7510	Theory of Plates and Shells	✓			✓				✓		
CEE 7610*	**Finite Element Analysis I**		✓	✓	✓		✓				
CEE 7620	Finite Element Analysis II	✓								✓	
CEE 7640	Theory of Inelastic Material Behavior								✓		
CEE 7710	Fracture Mechanics		✓				✓				
CEE 7720	Fiber-Reinforced Composite Materials		✓				✓				✓
CEE 7810	Structural Dynamics	✓	✓					✓			
CEE 7970	Selected Topics: advanced Modeling and Simulation for Flood Risk Management		✓				✓				
CEE 7970	Selected Topics: Deconstruction Monitoring									✓	
CEE 7980	Roller-Compacted Pervious Concrete	✓									
CEE 7980	Directed Study: Concrete Surface Resistivity					✓					
CEE 7980	Directed Study: Building Design					✓					

Table A- 3. Academic Data and Overall Performance of MS Graduates during 2012- 2017

Student Name (Initials)	Duration (months)	Total Credit Hours			GPA
		Thesis/Research or Project	Curriculum (CEE Courses)	Co-Curriculum (non-CEE course)	
JRA	24	7	25	0	4.00
BCD	14	14	22	3	4.00
MLE	17	9	25	0	4.00
EPH	12	6	25	0	3.84
BM	33	0	31	0	4.00
YS	36	10	25	0	3.14
WPS	32	8	25	0	3.28
LAA	24	6	22	3	3.88
DB	20	13	25	0	4.00
TKC	24	6	28	3	3.88
EDJ	24	6	25	0	4.00
WCS	24	17	34	0	3.79
CLS	17	6	25	0	4.00
JCT	24	6	25	0	4.00
BKE	15	7	25	0	3.84
SCL	NA	0	27	9	3.92
JL	12	6	31	0	4.00
NA	12	6	16	9	3.64
BB	NA	9	25	0	3.88
JF-M	12	6	25	0	3.76
TH	48	8	24	9	3.78
HK	NA	6	25	0	4.00
PVK	NA	16	28	0	3.21
JL	18	0	34	0	3.47
JMP	18	6	25	9	3.46
CLR	24	6	25	6	3.16
MAS	24	3	28	6	3.51
RLC	12	10	14	6	3.85
DJG	12	7	19	0	4.00
CEJ	24	6	22	3	3.76
KMK	12	6	24	6	3.88
TBK	24	6	22	3	3.84
AMS	12	6	19	9	3.28
MSS	12	6	22	9	NA
CNW	36	6	34	0	4.00
SAS	18	6	25	0	3.67
MB	18	9	31	0	NA
AAB	18	9	25	6	3.12
AMC	18	6	25	0	NA

Student Name (Initials)	Duration (months)	Total Credit Hours			GPA
		Thesis/Research or Project	Curriculum (CEE Courses)	Co-Curriculum (non-CEE course)	
BDF	18	6	22	3	NA
DGK	12	6	18	6	NA
ABM	18	6	25	0	NA
ALP	48	6	30	0	3.88
FWP	17	0	28	3	3.89

Table A- 4. Summary of Student Placement after Graduation

Academic Year	Number of Graduates	Continued to PhD Program (location)	Job Placement	
			Total Number	Sample Companies & Institutions Hiring TTU MS Graduates
2012-13	13	0	9+	Carpenter Wright Engineers, KCI Technologies, Structural Design Group, Strand Associates, TDOT, Tennessee Valley Authority, VDOT
2013-14	11	2 (Purdue, McGill)	4+	James C. Hailey Company, Schaefer, TDOT
2014-15	8	3 (TTU, Univ. Texas Austin, Univ. of Central Florida, Univ. of Southampton	1+	J. R. Wauford & Company, Consulting Engineers, Inc.
2015-16	7	1 (TTU)	5+	Structural Design Group, TDOT, USACE
2016-17	8	1 (Texas A&M)	7+	Barge Waggoner Sumner & Cannon, Barnhart Crane & Rigging, Cooper Steel, Ross Bryan

Note: Job placement information is not available for all students. Number of job placements corresponds to the known values.

Appendix A

Table A- 5. MS Thesis Titles

Last name of M.S. graduate	Year	CEE Sub-Discipline	Thesis Title	Advisor
Anderson	2012	Structural Mechanics	Analysis of Functionally Graded Piezoelectric Hollow Spheres	Dr. Guillermo Ramirez
Bednarcyk	2012	Structural Engineering	A Comparison of Load Factors Rating (LFR) and Load and Resistance Factor Rating (LRFR) in Reinforced Concrete Boxes and Slap Culverts	Dr. Sharon Huo
Biney	2012	Transportation / Materials	Impact of Travel Survey Advance Letter on Trip Underreporting and Number of Calls Required for Survey Completion	Dr. Daniel Badoe
Crowley	2012	Transportation / Materials	High Volume Fly Ash in Portland Cement Concrete for Bridge Decks	Dr. L. K. Crouch
Dillon	2012	Transportation / Materials	Utilizing A Substandard Fly Ash for A TDOT Aggregate-Lime-Fly Ash Stabilized Base Course	Dr. L. K. Crouch
Fennell	2012	Water Resources / Environmental	Water Reuse and Conservation Considerations In Drought Planning Using Oasis Modeling	Dr. Dennis George
Keaton	2012	Transportation / Materials	Nano-Scale Pore Analysis of Cementitious Mortars Undergoing Delayed Ettringite Formation	Dr. Ben Mohr
McDaniel	2012	Structural Mechanics	An Expansion To Frictionless Contact Problems on Magneto-Electro-Elastic Composite Half-Planes	Dr. Guillermo Ramirez
Pelham	2012	Water Resources / Environmental	Powdered Activated Carbon Feed Study on a 1.5 MGD Conventional Surface Water Treatment Plant for Big Creek Utility District	Dr. Lenly Weathers
Pittman Jeffries	2012	Transportation / Materials	Higher Volume Fly Ash PCC for Sustainability and Performance with F Ash	Dr. L. K. Crouch
Zhang	2012	Structural Engineering	Simplified Live Load Distribution Factor Equations for Tennessee Highway Bridge Design	Dr. Sharon Huo
Clark	2013	Water Resources / Environmental	Optimization Model to Determine Cost-Effective, Low-Impact Development Strategies To Achieve Designated Stormwater Flows	Dr. Dennis George
Gaw	2013	Structural Mechanics	Geometrically Nonlinear Analysis of Isotropic and Laminated Composite Plates Subjected to Thermal Loading Using Groebner Bases	Dr. Jane Liu
Jones	2013	Structural Engineering	Developing Rating Aids for the Evaluation of Concrete Culverts in Tennessee	Dr. Sharon Huo
Kelly	2013	Transportation / Materials	Trip Generation, Telecommuting and Their Interrelationship	Dr. Daniel Badoe
Kerley	2013	Structural Engineering	Finite Element Analysis of Reinforced Concrete Pile Caps to Cast-in-Shell Steel Piles	Dr. Craig Henderson
Kidwell	2013	Structural Engineering	Finite Element Analysis of Prestressed, Precast Concrete Piles Embedded in Cast-in-Place Concrete Caps Subjected to Lateral Loading	Dr. Craig Henderson
Paulson	2013	Structural Mechanics	A Parametric Study of Linear and Nonlinear Models For Moisture Diffusion In Composite Sandwich Structures	Dr. Jane Liu
Siddique E Akbor	2013	Water Resources / Environmental	Hydrologic Modeling as a Decision Making Tool for Water Resources Management in Ganges, Brahmaputra and Meghna Basin	Dr. Faisal Hossain
Sikder	2013	Water Resources / Environmental	Understanding Geophysical Sources of Uncertainty of Satellite Interferometric Discharge Estimation Using Manning's Approach: A Case Study of Gbm Delta	Dr. Faisal Hossain
Almdari	2014	Water Resources / Environmental	Development of Weighted Curve Number Approach and Watershed Quality Index Tool Using AnnAGNPS: An Obed River Watershed Case Study	Dr. Alfred Kalyanapu
Bartrom	2014	Structural Engineering	Impact of Shear Rating Factors for Reinforced Concrete Culverts and Enhancement of TDOT Culvert Rating Aids	Dr. Sharon Huo
Bhuyian	2014	Water Resources / Environmental	A GIS-based Approach for Digital Elevation Models (DEM) Correction to Derive Bathymetric Data with Improved Conveyance	Dr. Alfred Kalyanapu
France-Mensah	2014	Transportation / Materials	Development of Leachate Test for Delayed Ettringite Formation Potential in Cementitious Materials	Dr. Benjamin Mohr

Appendix A

Last name of M.S. graduate	Year	CEE Sub-Discipline	Thesis Title	Advisor
Harrell	2014	Structural Mechanics	Application of Groebner Bases to Geometrically Nonlinear Analysis of Axisymmetric Circular Isotropic Plates	Dr. Jane Liu
Kaufman	2014	Structural Engineering	Analysis and Rating of Reinforced Concrete Box Culverts Under Various Loading and Modeling Methods	Dr. Sharon Huo
Rogers	2014	Transportation / Materials	Expanding The Information Catalog of TDOT D-LP (Lower Permeability) Concrete Mixture	Dr. L. K. Crouch
Stratz	2014	Water Resources / Environmental	Propagation of Anthropogenic Variations in Hydroclimate Statistics for Dynamic Modeling of Probable Maximum Precipitation	Dr. Faisal Hossain
Kolosoz	2014	Water Resources / Environmental	Chemistry of Phosphorus Removal by Polonite Media	Dr. Dennis George
Eagan	2015	Transportation / Materials	The Effect of Supplementary Cementitious Materials on the Surface Resistivity of Concrete	Dr. L. K. Crouch
Locum	2015	Transportation / Materials	Investigation of Tennessee Bridge Deck PCC Surface Resistivity	Dr. L. K. Crouch
Rabbani Esfahani	2015	Water Resources / Environmental	Experimental Investigation of Nitrate Removal Using Zero Valent Aluminum Particles	Dr. Tania Datta
Woldemichael	2015	Water Resources / Environmental	Understanding The Modification of Regional Hydroclimatology In Impounded River Basins	Hossain / Huddleston
Bane	2016	Structural Engineering	Material and Structural Properties of Lightweight Masonry Grout	Dr. Craig Henderson
Cooper	2016	Transportation / Materials	Design of a Field Test to Evaluate a Video Based Vehicle Counting Device at an Intersection	Dr. Steven Click
James	2016	Structural Engineering	Development of a Rapid Field Evaluation Method for Steel Girder Bridges	Dr. Matthew Yarnold
Salaman	2016	Structural Engineering	Identification of the Force Distribution for Steel Truss Bridges	Dr. Matthew Yarnold
Smith	2016	Transportation / Materials	A Comparison of TDOT Class D Concrete Mixtures	Dr. L. K. Crouch
Thompson	2016	Transportation / Materials	Use of Superabsorbent Polymers as Physical Air Entrainer with the Use of Marginal Fly Ash	Dr. Ben Mohr
Thornton III	2016	Water Resources / Environmental	2D HEC-RAS Model Development in Data Poor Areas of India Case Study: Central Krishna River Basin	Dr. Alfred Kalyanapu
Alexander	2017	Structural Engineering	Structural Health Monitoring of the Hernando Desoto Bridge	Dr. Matthew Yarnold
Drane	2017	Structural Mechanics	Hyperelastic Modeling of Rohacell Foams by Employing the Planar Tension Test	Dr. Jane Liu
Edwards	2017	Transportation / Materials	An Investigation of the Impact of Count Duration, Cycle, and Seasonal Factor Development on Accuracy of Annual Average Daily Traffic Estimates from Short Period Traffic Counts	Dr. Daniel Badoe
Humphreys	2017	Transportation / Materials	Evaluating Triggers for Retiming Traffic Signals	Dr. Steven Click

APPENDIX B

Syllabi of Selected Graduate Courses and their Prerequisite Undergraduate Courses

Appendix B

Tennessee Technological University

Department of Civil and Environmental Engineering

CEE 4660 Transportation Planning

Section: 001 **Meeting Days**: Mondays, Wednesdays, and Fridays **Time**: 9:05a.m. – 10:00a.m.
Room: PRSC 325 **Semester:** Fall 2017
Instructor: Dr. Daniel Badoe **Room**: PRSC 434 **Phone**: 372-3490 **Email**: dbadoe@tntech.edu
Office Hours: 10:10a.m. – 12:10p.m. on Monday, Wednesday, and Friday
Prerequisite: CEE 3610-Transportation Engineering
Course Text: Transportation Engineering and Planning, 3rd edition by Papacostas, C. S. and P.D. Prevedouros, 2001

Recommended Reading: Urban Transportation Planning 2nd ed. by Meyer M.D. and Miller E.J., 2001
Course Description: System planning and evaluation. Characteristics, impacts, and costs. User patterns. Alternative analysis.

Course Objectives

- Understand the factors and issues that have shaped and continue to shape the evolution of urban transportation planning in the US
- Know the key elements of the regulations that govern the conduct of urban transportation planning in the US
- Develop the analytical capability for designing and executing an urban transportation planning study

Student Learning Outcomes:

1. Know the historical development of urban transportation planning in the USA, and legislation that currently guides the transportation planning process.
2. Know the entity required to conduct transportation planning at the metropolitan level, and what planning-products this entity is required to produce by US Federal law
3. Know how to design and conduct Origin-Destination surveys and Household Travel Behavior Surveys.
4. Forecast the traffic volume expected to use a transportation facility using trend analysis, and price elasticities of travel demand
5. Apply the methods of linear regression analysis, cross-classification analysis, and the ITE Trip Generation Report to predict the volume of traffic generated by the land use activities in a traffic zone
6. Apply the gravity model, and the biproportional model (Fratar) to forecast the spatial distribution of travel
7. Apply the multinomial logit model to predict the volume of trips to be made by the competing modal alternatives in a region
8. Apply the user-equilibrium principle to assign traffic to the routes of a highway network
9. Predict the noise levels from vehicular traffic on transportation facilities using the FHWA model.
10. Estimate transportation performance measures
11. Predict carbon monoxide levels from road vehicle operations
12. Know how to evaluate transportation alternatives

Appendix B

Grading and Evaluation Procedures

Table B-1: Course Activity and Points Associated with Activity

Activity	Points
Problem Sets (Homework)	15 percent
Team Project	15 percent
Test 1	15 percent
Test 2	15 percent
Test 3	15 percent
Final Exam	25 percent

Course Topics

Table B-2: Course Topic and Corresponding Chapter in Course Text

Topic	Chapter in Course Text
Context for Urban Transportation Planning	Chapter 7 and Notes
Legislation Governing Urban Transportation Planning	Chapter 7.3
The Planning Process: Basic Definitions & Concepts	Chapters 6 and 7, and Notes
Urban Transportation System Characteristics and Planning Issues	Chapters 6 and 7, and Notes
Planning & the Decision-Making Process	Handout
Demand Analysis 1: Basic Concepts and Simplified Methods	Chapter 8 Section 8.7.5
Modeling Trip Generation with ITE Trip Generation Report, Linear Regression Analysis, and Cross Classification Analysis	Chapter 8 Sections 8.2 and Chapter 9 Section 9.2
Demand Analysis 2: Modeling Trip Distribution with the biproportional updating method, the proportional flow model, and singly constrained gravity models.	Chapter 8 Section 8.3 and Chapter 9 Section 9.2
Demand Analysis 3: Modeling Mode Choice with the Multinomial logit model. Undertaking policy analysis with disaggregate models, and undertaking aggregate forecasting with disaggregate models	Chapter 8 Sections 8.4 and 8.6
Demand Analysis 4: Traffic Assignment	Chapter 8, Section 8.5 and Chapter 9, Section 9.2
Traffic Impact Studies	Chapter 9
Supply Analysis: Performance, Costs and Impacts, Noise Prediction, Air Quality, Analysis of Deterministic Queuing Systems, Road safety performance measures	Chapters 4, 10, 14, and Notes
Transportation Data Collection & Management	Chapter 4 Section 8 and Notes
Economic Evaluation of Transport Projects	Chapter 11 & Handout

Appendix B

Tennessee Technological University

Department of Civil and Environmental Engineering

CEE 6470 Transportation Demand Analysis

Section: 001 **Meeting Days:** Tuesdays and Thursdays **Class Meeting Times:** 12:25 p.m. – 1:15 p.m.
Room: PRSC 425 **Semester:** Spring 2017
Instructor: Dr. Daniel Badoe **Room:** PRSC 434 **Phone:** 372-3490 **Email:** dbadoe@tntech.edu
Office Hours: 9 a.m. – 11 a.m. on Monday, Wednesday, and Friday

Prerequisites
1. CEE4660/5660: Transportation Planning
2. Introductory course in probability and statistics

Texts and References:
Course Text: Modeling Transport, 4th Edition by J. de D. Ortuzar and L. G. Willumsen
References: Urban Transportation Modeling and Planning (1975) by P.R. Stopher and A.H. Meyburg
1. Discrete Choice Analysis (1985) by Ben-Akiva, M. and S. Lerman
2. Urban Transportation Planning 2nd edition (2001) by Meyer, M. and E. Miller
3. Transportation Research Record series on travel behavior and travel demand modeling
4. NCHRP report 716 (2012) – Travel Demand Forecasting Parameters and Techniques
5. NCHRP Report 365 – Travel Estimation Techniques for Urban Planning
6. Any good introductory text on probability and statistics

Course Description: The course covers in-depth the theory and development of models of trip generation, trip distribution, mode choice, and traffic-assignment. Also covered are transportation supply, and travel survey methods. Extensions to intercity-passenger travel-demand models, freight transportation models, and the demand for air transportation are discussed.

Course Objective: This course provides students with an in-depth treatment of the quantitative modeling of transportation demand for transportation planning purposes. The course principally deals with urban passenger demand, although intercity passenger demand models are also discussed. Topics addressed include theory of transportation demand, aggregate and disaggregate models, and an introduction to the activity-based approaches. An understanding of the theory of the demand for transportation is coupled with practical experience in the specification, estimation, and use of transportation demand models.

Appendix B

Grading and Evaluation Procedures

Table B-3: Course Activity and Points Associated with Activity

Activity	Points
Problem Sets	22.5 points
Term paper 1	17.5 points
Project or Term paper 2	20.0 points
Midterm Test	17.5 points
Final Exam	22.5 points

Course Topics

Table B-4: Course Topics and Chapter in the Course Text it is Covered

Topic	Chapter in Course Text
1. Review of probability theory. This is to be done by students.	Chapter 2: Section 5 and Introductory Probability text
2. Multiple regression analysis	Chapter 4: Sec.2
3. Microeconomic theory applied to travel demand - introduction	Chapter 1
4. Trip Generation Analysis (Theory and Estimation)	Chapter 4
5. Trip Distribution Analysis (Theory and Estimation)	Chapter 5
6. Modal Split and Direct Demand Modeling (Theory and Estimation)	Chapter 6
7. Discrete Choice Models (Binary & Multinomial Logit) – Theory	Chapter 7
8. Discrete Choice Models (Binary & Multinomial Logit) – Estimation	Chapter 8
9. Discrete Choice Models – Aggregation	Chapter 9
10. Traffic Assignment	Chapters 10 & 11
11. Travel Surveys	Chapter 3
12. Time of Day Modeling	Chapter 7
13. Freight/Truck Demand Models	Chapter 13
14. Pedestrian/Bicycle Mode Demand Models	Paper
15. Introduction to activity-based approach to travel demand modeling	Chapter 14

CEE 4130 (5130) MATRIX AND FINITE ELEMENT METHODS

Elective Course

Catalog Description:
Lec. 3. Credit 3.

Prerequisite: CEE3320 or ME4640(5640) and MATH 2010 or MATH4510(5510). Matrix formulations using flexibility and stiffness methods for structural analysis of skeletal structures. Finite Element formulations and applications.

Math & Basic Sciences:	0	Credits	Course Coordinator:	Guillermo Ramirez
Engineering Topics:	3	Credits	Contains Significant Design:	No
General Education:	0	Credits	Updated:	09/30/2013
Other:	0	Credits	Specify Type if Other:	

Text Book(s) and Supplemental Material(s):
Sennett, Robert E., Matrix Analysis of Structures, Waveland Press, Inc., 2000.

Course Goal(s):
To extend the students' understanding of the analysis of structural systems using matrix and finite element methods. To develop the ability to use computer programs to perform structural analysis calculations.

Instructional Outcomes for the Course:
Students will be expected to

1. Be able to use energy methods to find internal forces and deflections in simple planar structural systems.
2. Be able to analyze planar trusses, continuous beams, and planar frames using matrix methods, in particular the stiffness method.
3. Be able to model and solve structural systems having non-prismatic members, inclined supports and/or spring supports.
4. Be able to implement the stiffness method in computer language and use it to solve planar structural systems.
5. Be able to interpret the data resulting from analyzing structural systems with computer programs.
6. Be able to understand the basics of the finite element methods

Criterion 3 Student Outcomes addressed by this Course:

a) An ability to apply knowledge of mathematics, science, and engineering (Level 3)

c) 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, and sustainability (Level 3)

e) An ability to identify, formulate, and solve engineering problems (Level 4)

k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (Level 3)

Appendix B

Program Criteria addressed by this Course:

1. Apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives (Level 3)
2. Apply knowledge of four technical areas appropriate to civil engineering (Level 3)
3. Design a system, component, or process in more than one civil engineering context (Level 3)

Course Topics:

1. Introduction to computer methods for the analysis of structural systems: flexibility "vs." stiffness methods (5%)
2. Introduction to energy methods (10%)
3. Development of the stiffness method for planar trusses and implementation of the method in computer language (25%)
4. Development of the stiffness method for continuous beams and implementation of the method in computer language (25%)
5. Development of the stiffness method for planar frames and implementation of the method in computer language (25%)
6. Introduction to finite element procedures in the analysis of structural systems (10%)

Additional Topics/Assignments for dual-level (4000/5000) courses:

The students registered in 5000 level will have additional computer programming tasks such as writing subroutines to include different types of member loads in the structural systems and run their programs to analyze different structural systems exploiting the symmetry of the structural system

Appendix B

TENNESSEE TECHNOLOGICAL UNIVERSITY
Department of Civil and Environmental Engineering

Spring 2017

CEE6350 FINITE ELEMENT ANALYSIS

Lecture: PRSC 226 Prescott Hall 10:10AM -11:05AM MWF

Instructor: Dr. Guillermo Ramirez

Office: PH415 Prescott Hall Phone number: 372-3261

Office hours: MWF 8:00pm -8:55pm; TR 9:30am -11:00am

Prerequisite: CEE4130/5130: Matrix and Finite Element Methods or CEE4190/5190: Advanced Mechanics of Materials or ME4180/5180: Finite Element Methods in Mechanical Design or Consent of Instructor

Textbook: Buchanan, G. R., Finite Element Analysis, McGraw-Hill, 1995

Course Objectives: To introduce the theory of the finite element method as applied to linear, one-and two-dimensional problems of engineering and applied sciences. The course will emphasize on the formulation and understanding of how the finite element method works (how it is used to solve the differential equations that described a physical phenomenon) rather than on black-box recipes

Anticipated Topics:

- Introduction and brief history of finite element methods.
- Mathematical preliminaries, weighted residual methods, weak form.
- One-dimensional problems.
- Two-dimensional problems (single variable).
- Gauss quadrature technique for numerical integration.
- Isoparametric Formulation.
- Plane Problems: Introduction to coupled partial differential equations.
- Computer implementation and error analysis.

Grading Algorithm: Homework and class participation: 30%

Midterm exam: 35%

Final exam: 35%

At a minimum, final grades will be assigned on a traditional basis, i.e.

A = 90 − 100, B = 80 − 89, C = 70 − 79, etc.

Comments:

- Some of the homework will be relatively lengthy. Start early and turn it in on time. Late homework will not be accepted unless unusual circumstances. The way in which you present your work can be as important as the final result. Show a clear and logical approach to your solution. This will make your homework sets a better reference for you and will make it easier for me to give you partial credit in cases of incorrect conclusions.
- Do not get behind in your study of the notes and references. One idea might be to try to recopy your notes after each class, making sure you understand each step.
- Participate in class and be prepared to ask questions and answer those asked by the instructor.
- I am not responsible for material that you miss in class. Consult a colleague to obtained missed handouts and/or lecture notes.
- Professional behavior is expected during class. Tardiness, unexcused absences, working on other coursework during class, and disruptive behavior are examples of inappropriate behavior.
- Talk about finite element analysis with anyone who is interested. The more you discuss terms and concepts with colleagues or the instructor, the more comfortable you become with the material.

References:

1. Buchanan, G. R., Finite Element Analysis, McGraw-Hill, 1995.
2. Reddy, J.N., Applied Functional Analysis and Variational Methods in Engineering, McGraw-Hill, 1986.
3. Huebner H. Kenneth, D.L. Dewhirst, D.E. Smith, and T.D. Byron, The Finite Element Method for Engineers, Wiley-Interscience Publication, 2001.
4. Hughes, T. Jr., The Finite Element Method: Linear Static and Dynamic Finite Element Analysis, Prentice-Hall, Inc., 1987.
5. Reddy, J.N., An Introduction to the Finite Element Method, McGraw-Hill, 1993.
6. Zienciewicz, O.C. and R.L Taylor, The Finite Element Method, vol 1, Basic Formulation and Linear Problems, McGraw-Hill, 1989.
7. Rao, S. S.,The Finite Element Method in Engineering, Pergamon Press, 1982.

CEE 3420 HYDRAULICS
Required Course

Catalog Description:
CEE 3420 - Hydraulics (Lec. 3. Credit 3.)

Prerequisite: ME 3720. Fundamental principles and design of water and wastewater supply, stormwater and sanitary sewer systems and their components, including pipes, pumps, storage facilities, detention basins, open-channels, and culverts.

Math & Basic Sciences:	0	Credits	Course Coordinator:	Alfred J. Kalyanapu
Engineering Topics:	3	Credits	Contains Significant Design:	Yes
General Education:	0	Credits	Updated:	09/12/2013
Other:	0	Credits	Specify Type if Other:	

Text Book(s) and Supplemental Material(s):
Chin, A. D. (2013). *Water Resources Engineering*. Third Edition. Pearson Prentice Hall™., Upper Saddle River, New Jersey, ISBN: 9780132833219

Young, D.F., Munson, B. R., and Okiishi, T. H. *A Brief Introduction to Fluid Mechanics*. Third Edition, John Wiley & Sons, Inc., Hoboken, NJ. ISBN: 0471457574

Course Goal(s):
The goal of this course is to introduce students to the fundamental principles of hydraulics and to provide you with the basic knowledge and tools necessary to accurately analyze and design civil engineering hydraulic systems (e.g., water distribution, wastewater/stormwater collection, and pumping applications).

Instructional Outcomes for the Course:
Students will be expected to:

1. Analyze and design closed-conduit hydraulic systems including pipes, valves, fittings, and pumps.
2. Analyze open channel hydraulic systems operating under uniform and varied flow conditions.
3. Design culverts.
4. Design stormwater detention basins.
5. Design storm and sanitary sewer systems.
6. Interpret hydraulic design requirements, consider alternative designs, justify design choices, and critique hydraulic designs.

Criterion 3 Student Outcomes addressed by this Course:
a) An ability to apply knowledge of mathematics, science, and engineering (Level 3)

c) 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, and sustainability (Level 4)

e) An ability to identify, formulate, and solve engineering problems (Level 3)

k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (Level 3)

Program Criteria addressed by this Course:

- Apply knowledge of mathematics through differential equations, calculus-based physics, chemistry, and at least one additional area of basic science, consistent with the program educational objectives (Level 3)
- Conduct civil engineering experiments and analyze and interpret the resulting data (Level 3)
- Design a system, component, or process in more than one civil engineering context (Level 4)

Course Topics:

1. Introuction and Fluid Mechanics Review (2%)
2. Continuity Equation (2%)
3. Bernoulli Equation and General Energy Equation (10%)
4. Linear Momentum (6%)
5. Viscous Flows and Losses in Pipes (8%)
6. Pipeline Systems (11%)
7. Computer Modeling (11%)
8. Pumps, Selection and Operation (18%)
9. Open Channel Flow - Introduction and Flow Classification (14%)
10. Culverts (10%)
11. Stormwater System Design (8%)

Additional Topics/Assignments for dual-level (4000/5000) courses:
N/A

Appendix B

CEE 6520: Open Channel Hydraulics

Room: PRSC 226

Instructor: Alfred J. Kalyanapu, Associate Professor of Civil Engineering

Office hours: by appointment; Location: PH 334

Phone: (931) 372-3561. **Email**: AKalyanapu@TnTech.edu

Prerequisite: CEE 3420 Hydraulics (or equivalent)

Schedule: TR 12:00 PM to 1:20 PM

Textbook: Chin, A. D. (2013). Water Resources Engineering. Third Edition. Pearson Prentice Hall™., Upper Saddle River, New Jersey, ISBN: 9780132833219.

Final Exam December 6th, 2016; 10:30 AM – 12:30 PM

Course Goals: The goal of this course is to introduce students to the fundamental principles of open channel flow and to provide them with the basic knowledge and tools necessary to accurately analyze and design open channels. After completing this course, students will be able to:

1. Describe the conditions that represent steady, unsteady, uniform, and gradually varying flow.

2. Explain the procedure for calculating flows in open channels under a variety of conditions.

3. Calculate water surface profiles under a range of flow conditions.

4. Analyze flow for a variety of open channel geometries.

5. Design an open channel for specified flow and/or energy conditions.

Homework: Homework will be due at the beginning of the class period.

Quizzes: Quizzes will be given throughout the semester and will be closed book, closed note format. Quizzes will cover learning objectives from recent class periods.

Exams: The course includes one mid-term exam and a cumulative final exam that will test student mastery of the stated learning objectives. The final exam is comprehensive. Exams are closed book and notes.

Team Project: A team project is assigned at the midpoint of the semester. The project will encompass a significant design or analysis element directly related to open channel flow. Completion of the project requires preparing a comprehensive engineering report.

Computer Usage: The course includes working with computer for homework problems, project report, browsing internet for articles, and modeling using HEC-RAS and other relevant engineering software.

Grading

Course Activity	Weighting	Final Grade Scale	
Homework	15%	90 - 100	A
Quizzes	10%	80 - 89	B
Group Project	25%	70-79	C
Exam – 1	25%	60-69	D
Exam – 2	25%	<60	F

Course Topics

- Introduction to Open Channel Flow; Flow Classification/Conservation of Mass
- Conservation of Energy; Specific Energy; Specific Energy Problems
- Specific Energy - II
- Specific Energy: Channel Transitions I
- Specific Energy: Channel Transitions II
- Specific Energy: Weirs
- Momentum: Hydraulic Jumps I
- Momentum: Hydraulic Jumps II
- Uniform Flow I
- Uniform Flow II
- HEC-RAS – Tutorial & Modeling
- Uniform Flow: Compound Channels/Gravity Sewers
- Uniform Flow: Design of Stable Channels
- Gradually Varied Flow: Water Surface Profiles I
- Gradually Varied Flow: Direct Step Method
- Gradually Varied Flow: Standard Step Method
- Hydraulic Structures: Culverts
- Hydraulic Structures: Spillway Design
- Hydraulic Structures: Bridges
- Flow in Alluvial Channels: Sediment Properties; Sediment Transport
- HEC-RAS Modeling – Bridges
- HEC-RAS Modeling – Culverts
- HEC-RAS Modeling – Unsteady Flow
- HEC-RAS Modeling – Culverts & Spillway

APPENDIX C

Curriculum Vitae of Graduate Faculty in Civil and Environmental Engineering

Appendix C

Tennessee Tech University **Dec. 2017**

CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT

1. **Name:** *Badoe, Daniel, A*
2. **Education:**

PhD	*Civil Engineering*	*University of Toronto*	*1994*
MSc	*Civil Engineering*	*University of New Brunswick*	*1988*
BSc	*Civil Engineering*	*University of Science and Technology*	*1984*

3. **Academic Experience (FT= Full-time; PT = Part-time):**

Tennessee Tech University	*Professor*	*CEE Faculty*	*2008-Present*	*FT*
Tennessee Tech University	*Assoc. Prof.*	*CEE Faculty*	*2003-2008*	*FT*
Tennessee Tech University	*Asst. Prof.*	*CEE Faculty*	*1998-2003*	*FT*
University of Toronto	*Special Lect.*	*CEE Dept.*	*1995F&1996F*	*PT*
University of Toronto	*Post Doc. Assoc.*	*Joint Prog. in Trans.*	*1994-1995*	*FT*
University of Toronto	*Teach. & Res. Asst.*	*CEE Dept.*	*1990–1994*	
Univ. of Science and Tech.	*Teaching Asst.*	*CE Faculty*	*1984-1986*	*FT*

4. **Non-Academic Experience (FT= Full-time; PT = Part-time):**

University of Toronto	*Res. Assoc.*	*Data Mgmt. Group*	*1995-1997*	*FT*
Twum Boafo & Partners	*Highway Engr.*	*Roadway Planning &Design*	*1988-1990*	*FT*
TAHAL Cons. Eng. Ltd.	*Asst. Engr.*	*Site Engr.*	*1984-1984*	*FT*

5. **Certifications and Professional Registrations (current):** *Not applicable*
6. **Membership in Professional Organizations (current):**

ITE	*Institution of Transportation Engineers*	*Member*

7. **Honors and Awards:**

Excellence in First Year Experience Instruction	*Tennessee Tech University*	*2015*
Outstanding Faculty Award in Teaching	*Tennessee Tech University*	*2011*
Kinslow Engineering Research Award	*Tennessee Tech University, CoE*	*2003*
Univ. of Toronto Doctoral Fellowship	*University of Toronto*	*1991-1993*
Canadian Commonwealth Fellowship	*University of New Brunswick*	*1986-1988*

8. **Service Activities - Internal and External (last 5 years):**

Associate Editor	*ASCE Journal of Urban Planning& Devp.*	*2011-Present*
Journal Paper Reviewer	*Journal of the Transportation Res. Board*	*2009-Present*
Journal Paper Reviewer	*Int. Journal of Sustainable Transportation*	*2009-Present*
Chair	*CEE Research and Graduate Affairs Comm.*	*2014-Present*
Member/Chair	*University Library Comm.*	*2014-Present*
Graduate Executive Committee	*TTU College of Engineering*	*2012-Present*

9. **Notable Publications and Presentations (last 5 years):**

1. Edwards, M., Badoe, D.A., and Lee, D. (2017). **Comparison of Two Short Period Traffic Count Duration/Cycle Specifications in the Accuracy of their Predictions of Annual Average Daily Traffic at Coverage Stations**. Accepted for Presentation at the 97th *Annual Transportation Research Board Conference*, January 7 – 11, 2018, Washington, DC
2. Badoe, D. A. and A. A. Biney (2017), **Receipt of Travel Survey Advance-Letter and its Impact on Reported Trips and Phone-Calls for Survey Completion in Telephone-Surveys**. *ASCE Journal of Urban Planning and Development*, Volume 143, Issue 2

3. Locum, J.T., Crouch, L.K., and Badoe, D.A**.** (2017). **Universal CLSM Using High LOI Fly Ash and Limestone Screenings without Portland Cement.** Presented at the World of Coal Ash 2017 Conference in Lexington, Kentucky. May 8-11, 2017
4. Locum, J.T., Crouch, L.K., and Badoe, D.A**.** (2017). **Excavatable and Early Strength CLSM Using High LOI Fly Ash and Limestone Screenings**. Presented at the World of Coal Ash 2017 Conference in Lexington, Kentucky. May 8-11, 2017
5. Dillon, S.A., Crouch, L.K., Browning, A. and Badoe, D.A. (2015), **Modification of an East Tennessee High Plasticity Silt with Lime and Substandard Fly Ash**. Presented at the 94th *Annual Transportation Research Board Conference,* Washington D.C., January 2015
6. Mwakalonge, J. and Badoe, D.A. (2014) **Trip Generation Modeling using Data Collected in Single and Repeated Cross-sectional Surveys.** *Journal of Advanced Transportation*, Volume 48, Issue 4, June 2014, pp. 318-331
7. Crouch, L.K., Crowley, A., Badoe, D.A (2014). **Preliminary Research on Development of Surface Resistivity as a Function of Heat Evolution.** Presented at the *American Concrete Institute Fall 2014 National Convention on Improving Early-Age Properties of Concrete with Supplementary Cementitious Materials,* Washington D.C., October 2014
8. Crouch, L.K., Hendrix, J., Sparkman, A. and Badoe, D.A. (2014). **Optimizing Pervious Concrete Engineering Properties with the Tennessee Concrete Association Mixture Adjustment Method**, Presented at the Biannual Pervious in Paradise Conference, San Diego, California, August 5-8th, 2014
9. Crouch, L.K., Crowley, A., Badoe, D.A., and Hall, H.P. (2014). **A High Volume Fly Ash Concrete Mixture for Tennessee Bridge Decks.** Presented at the *93rd Annual Transportation Research Board Conference,* Washington D.C., January 2014
10. Crouch, L.K., Browning, A., Badoe, D.A., Kelly, K. Crowley, A., and Hall, H.P. (2013). **Comparison of Gravimetric and Hardened Air Contents with the Pressure Method Air Content of a Tennessee Bridge Deck Mixture**. Presented at the *92nd Annual Transportation Research Board Conference,* Washington D.C., January 2013
11. Crouch, L.K., Browning, A., Badoe, D.A., Crowley, A., and Hall, H.P. (2013). **The Effect of Air Content on Rapid Chloride Permeability**. Presented at the *92nd Annual Transportation Research Board Conference,* Washington D.C., January 2013
12. Ivey, S.S., Badoe, D.A., and Edwards, S. (2012) **National Household Travel Survey Add-On Program: Experience of Stakeholders and Best Practices for Maximizing Program Benefits.** *Transportation Research Record No. 2291***:** *Journal of the Transportation Research Board*, *pp. 102 – 110*
13. Crouch, L. K., Hendrix, J. P., Sparkman, Alan and Badoe, D.A. (2012), **Variability of Fresh and Hardened Voids of Pervious Concrete.** *Pervious Concrete, ASTM STP 1551*, Editors: Heather J. Brown and Matthew Offenberg, American Society for Testing and Materials, West Conshohocken, PA, 2012, pp. 52-68
14. Mwakalonge, J. and Badoe, D.A. (2012), **Comparison of Alternative Methods for Estimating Household Trip Rates of Cross-Classification Cells with Inadequate Data***, Journal of the Transportation Research Forum, Volume 51 No. 2, pp. 5-2*

10. Professional Development Activities (last 5 years):

- Attended workshop on the use of TransCAD Travel Demand Modeling Software for regional travel demand modeling, 2016
- Attended workshop on the use of TransCAD Travel Demand Modeling Software for regional travel demand modeling, 2013
- Attended Transportation Research Board Conference on Transportation Data, Travel Behavior Analysis and Travel Demand Forecasting, 2013
- Attended Transportation Research Board Conference on Transportation Data, Travel Behavior Analysis and Travel Demand Forecasting, 2012
- Attended workshop on the use of US Decennial Census Data for regional transportation planning, 2012

Tennessee Tech University **Dec. 2017**

CIVIL & ENVIRONMENTAL ENGINEERING DEPT

1. Name: *Click, Steven M.*

2. Education:

PhD	*Transportation Engineering*	*North Carolina State University*	*2001*
MS	*Civil Engineering*	*North Carolina State University*	*1996*
BS	*Civil Engineering*	*Tennessee Tech University*	*1993*
BS	*Mathematics*	*Tennessee Tech University*	*1993*

3. Academic Experience (FT = Full Time; PT = Part Time):

Tennessee Tech University	*Assoc. Prof.*	*CEE Faculty*	*2010-Present*	*FT*
Tennessee Tech University	*Asst. Prof.*	*CEE Faculty*	*2005-2010*	*FT*

4. Non-Academic Experience (FT = Full Time; PT = Part Time):

Traffic Signals & Signal Systems	*Part-Time Consultant*	*2005-Present*	*FT*
NCDOT Signals & Geometrics Section	*Senior Systems Engineer (TE III)*	*2001-2005*	*FT*
NCDOT Signals & Geometrics Section	*Project Engineer (TE II)*	*2000-2001*	*FT*
NCDOT Signals & Geometrics Section	*Design Engineer (TE I)*	*1999-2000*	*FT*
NCDOT Signals & Geometrics Section	*Design Technician (Tech IV, temp)*	*1998-1999*	*FT*

5. Certifications and Professional Registrations (current):

Professional Engineer 00110910n	*Tennessee*	*2006-Present*
Professional Engineer 027470	*North Carolina*	*2002-Present*

6. Membership in Professional Organizations (current):

TRB	*Transportation Research Board*	*Member*
TRB	*Traffic Signal Systems Committee*	*Member*
ITE	*Institute of Transportation Engineers*	*Member*
ASEE	*American Society for Engineering Education*	*Member*

7. Honors and Awards:

Exceptional Paper Award	*TRB Committee on Traffic Signal Systems*	*2008*
Tablet Initiative Recipient	*Tennessee Technological University*	*2007-08*
Exemplary Course Award	*Tennessee Technological University*	*2007*
Teaching/Learning Enhancement Grant to Support the QEP		*2006*
Eno Transportation Foundation Fellow		*Inducted April 1995*
The Honor Society of Phi Kappa Phi		*Inducted 1993*
Tau Beta Pi		*Inducted 1992*
Chi Epsilon,		*Inducted 1992*
Kappa Mu Epsilon		*Inducted 1991*

8. Service Activities –Internal and External (last 5 years):

Student Advising

Chair, Departmental Recruitment and Retention Committee	*2008-present*
Departmental Curriculum Committee	*2006-present*
Member, Traffic Signal Systems Committee of Transportation Research Board	*2008-present*
Proctor, Fundamentals of Engineering Exam	*2006-present*
Reviewer of Papers for the Annual Meeting of Transportation Research Board	*2006-present*

9. Notable Publications and Presentations (last 5 years):

1. "FRE Interchange: Capacity and Performance." C. Berry and S. Click. *Proceedings of the Transportation Research Board*'s 91st Annual Meeting, 2012.
2. "Applicability of Bluetooth Data Collection Methods for Collecting Traffic Operations Data on Rural Freeways." S. Click with T. Lloyd. *Proceedings of the Transportation Research Board's* 91st Annual Meeting, 2012.
3. "Evaluating the Three-Year Rule for Retiming Coordinated Traffic Signals using Simulation with Real-World Traffic Data." E. Humphreys and S. Click. Accepted for *presentation at the Transportation Research Board*'s 97st Annual Meeting, 2018.

Appendix C

Tennessee Tech University **Dec. 2017**

CIVIL & ENVIRONMENTAL ENGINEERING DEPT

1. Name: *Crouch, Lewis K.*

2. Education:

PhD	*Civil Engineering*	*University of Missouri-Rolla*	*1990*
MS	*Geological Engineering*	*University of Missouri-Rolla*	*1986*
BS	*Geological Engineering*	*University of Missouri-Rolla*	*1986*
BS	*Geology*	*Murray State University*	*1984*

3. Academic Experience (FT = Full Time; PT = Part Time):

Tennessee Tech University	*Professor*	*CEE Faculty*	*2000-Present*	*FT*
Tennessee Tech University	*Assoc. Prof.*	*CEE Faculty*	*1995-2000*	*FT*
Tennessee Tech University	*Asst. Prof.*	*CEE Faculty*	*1990-1995*	*FT*

4. Non-Academic Experience (FT = Full Time; PT = Part Time):

Kentucky DOT	*Engr. Aide*	*Const. Division*	*1977-1981*	*FT*

5. Certifications and Professional Registrations (current):

Professional Engineer TN#101274	TN Dept. of Commerce & Ins.	1994-Present

6. Membership in Professional Organizations (current):

ACI	*American Concrete Institute International*	*Member*
ASTM	*American Society for Testing and Materials*	*Member*

7. Honors and Awards:

Brown-Henderson Outstanding Engr. Faculty Award	*TTU CoE*	*1998*
Caplenor Faculty Research Award	*TTU*	*2006-2007*

8. Service Activities –Internal and External (last 5 years):

Facilities Committee Chair	*CEE*
ABET 2000 Committee	*CEE*
Tenure and Promotion Committee	*CEE*

9. Notable Publications and Presentations (last 5 years):

1. Crouch, L. K., Dillon, Sarah., and Knight, Marcus L., **"Tennessee Lime-Fly Ash-Stabilized Base Using a High Loss-on-Ignition Fly Ash,"** *Lime: Building on the 100-Year Legacy of The ASTM Committee C07, ASTM STP 1557*, Margaret L. Thomson, and Joseph H. Brisch, Eds., American Society for Testing and Materials, West Conshohocken, PA, 2012, pp. 60-75.

2. Crouch, L. K., Hendrix, J. P., Sparkman, Alan and Badoe, Daniel, **"Variability of Fresh and Hardened Voids of Pervious Concrete,"** *Pervious Concrete, ASTM STP 1551*, Heather J. Brown and Matthew Offenberg, Eds., American Society for Testing and Materials, West Conshohocken, PA, 2012, pp. 52-68.
3. Crouch, L. K. and Brown, H. J., **"Evaluating Polish Resistance of Tennessee Bituminous Surface Aggregates,"** *Pavement Performance: Trends, Advances, and Challenges, ASTM STP 1555*, Bouzid Choubane, Ed., American Society for Testing and Materials, West Conshohocken, PA, 2012, pp. 1-19.
4. Crouch, L. K., Crowley, Aaron, Badoe, Daniel and Hall, Heather P., "**A High Volume Fly Ash Concrete Mixture for Tennessee Bridge Decks**," Transportation Research Board 2014 Annual Meeting Compendium of Papers, January 2014.
5. L. K. Crouch, Aaron Crowley, Daniel Badoe, Heather P. Hall, and Alan Sparkman, "**A High Volume Fly Ash Concrete Mixture for Tennessee Bridge Decks"** 2014 International Concrete Sustainability Conference, USA May 12-15 2014 - Boston, USA (National Ready Mixed Concrete Association). Downloaded 6/6/14 from http://www.nrmcaevents.org/?nav=display&file=660 .
6. Dillon, Sarah, Crouch, L. K., Browning, Allen, and Badoe, Daniel, "**Modification of an East Tennessee High Plasticity Silt with Lime and Substandard Fly Ash**", Transportation Research Board 2015 Annual Meeting Compendium of Papers, January 2015.
7. Dillon, Sarah, Crouch, L. K., and Ferguson (Kelly), Kayla, "**High Volume Substandard Fly Ash Roller-Compacted Concrete**," Ash Library Website www.flyash.info , May, 2015. Downloaded 5/05/15
8. Dillon, Sarah, Crouch, L. K., and Young, Kevin, "**Full-Depth Reclamation with Lime and Substandard Fly Ash**," Ash Library Website www.flyash.info , May, 2015. Downloaded 5/05/15

10. Professional Development Activities (last 5 years):

Attended Tennessee Concrete Pavement & Cement-Based Pavement Solution Conference 1/31/14

Appendix C

Tennessee Tech University **Dec. 2017**

CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT

1. NAME: *Datta, Tania*

2. EDUCATION:

PhD	*Civil and Environmental Engineering*	*University of Utah*	*2010*
ME	*Civil and Environmental Engineering*	*University of Utah*	*2006*
BE	*Chemical Engineering*	*R.V College of Engineering, India*	*2002*

3. ACADEMIC EXPERIENCE

Tennessee Tech University	*Assistant Professor*	*CEE/Water Center*	*2013- Present*
University of Utah	*Graduate Research Assistant*	*CEE*	*2005 - 2009*

4. NON-ACADEMIC EXPERIENCE

CH2M HILL	*Project Engineer Wastewater Processes*	*2009 –2012*
J Ray McDermott International	*Process Engineer – Oil and Gas*	*2002 –2004*

5. PROFESSIONAL REGISTRATIONS

-	*Fundamentals of Engineering (FE/EIT)*	*State of Utah*	*2007*

6. MEMBERSHIP IN PROFESSIONAL ORGANIZATION

WEF	*Water Environment Federation*	*Member*
IWA	*International Water Association*	*Member*
AEESP	*Association of Environmental Engineering and Science Professors*	*Member*
AAEES	*American Academy of Environmental Engineers and Scientists*	*Member*
EWB	*Engineers without Borders*	*Member*
AWRA	*American Water Resource Association*	*Member*
ASEE	*American Society of Engineering Education*	*Member*
Sigma Xi	*Sigma Xi Research Honor Society*	*Member*

7. HONORS AND AWARDS

Distinguished Service Learning Award	*Tennessee Tech University*	*2017*
Outstanding Young Professional	*Water Environmental Association of Utah*	*2009*
1st Place in WEFTEC Poster Session	*Water Environmental Federation*	*2008*
Robert Okey Scholarship	*Water Environmental Association of Utah*	*2007*

8. SERVICE ACTIVITIES (Internal and External)

University Safety Committee Member	*Tennessee Tech University*	*2016-Present*
University Stormwater Committee	*Tennessee Tech University*	*2016-Present*
CEE Graduate Affairs Committee	*Tennessee Tech University*	*2013-Present*
CEE Facilities Committee	*Tennessee Tech University*	*2013-Present*
Faculty Advisor	*Engineers without Borders, TTU*	*2013-Present*
Faculty Co-Advisor	*Water Professional Chapter, TTU*	*2013-Present*
Ad-Hoc Vice Chair	*WEF Residuals and Biosolids Committee*	*2012 -2015*
Task Force Vice Chair	*WEF Volunteer of the Future Focus Group*	*2013 – 2016*

9. SELECTED PUBLICATIONS AND PRESENTATIONS

1. Ohemeng-Ntiamoah, J., Datta, T. (2018). Evaluating analytical methods for the characterization of lipids, proteins and carbohydrates in organic substrates for anaerobic co-digestion. *Bioresource Technology*, 247, 697-704.
2. Mikawa, M., Datta, T., Amano, Y., & Machida, M. (2017). Dominant Characteristics Between Microcystis aeruginosa and Cyclotella Sp. Accompanying Dilution Process in Eutrophic Lake. *Water, Air, & Soil Pollution*, 228(5), 174.
3. Abegaz, B. W., Datta, T., Mahajan, S. M. (2017). Sensor technology for the energy-water nexus: A Review. *Applied Energy*.
4. Sato, M., Omori, K., Datta, T., Amano, Y., and Machida, M. (2017). Influence of Extracellular Polysaccharides and Calcium Ion on Colony Formation of Unicellular *Microcystis aeruginosa*. *Environmental Engineering Science*. 34(3), 149 – 157.
5. Kim, E. S., Datta, T., Kim, J. B., Lee, G., and Choi, J. (2016). Biological Fixed Film. *Water Environment Research*, 88(10), 1021-1050.
6. Daigger, G. T., Datta, T., Stensel, H. D., Whitlock, D. D., & Mackey, J. K. (2014). Evaluating the Role of Point Source Discharges Informs Statewide Nutrient Control Policy in Utah. *Water Environment Research*, 86(6), 559-572.
7. Kalyanapu, A., Datta, T., Dodson, D., Bynum, K. and Harrington, B. (2015). "A Collaborative Effort towards Real-time Water Quality Equipment Demonstration at Falling Water River, Tennessee". Tennessee American Water Resources Association, Montgomery Bell State Park, TN, April 2015.
8. McClellan, G.E., and Datta, T. (2015). "An Approach towards Linking Diversity of Polyphosphate Accumulation Organisms to Improved Functional Stability of the Enhanced Biological Phosphorus Removal Process." Tennessee American Water Resources Association, Montgomery Bell State Park, TN, April 2015.
9. R. Reardon, T. Datta, C. Stacklin (2014). "Advancing Resource Recovery from Wastewater - The Next Generation of Technologies", IWA Conference on Global Challenges: Sustainable Wastewater Treatment and Resource Recovery, October 26th – 30th, 2014, Kathmandu, Nepal.
10. Guy-Baker, C., Datta, T., Kalyanapu, A. (2017). "Toward Development of a Systematic Framework and Decision-Making Tool for Sustainable Watershed Management with Karst Geology." Association of Environmental Engineering and Science Professors (AEESP) Conference, University of Michigan, June 20th – 22nd, 2017.
11. Moffet, M., Wigner, R., Davis, A., Wright, T., Datta, T. (2017). "Does Atmospheric Deposition of Nitrates Play a Role in Increasing Nitrogen Pollution from Highway Stormwater Runoff?" Association of Environmental Engineering and Science Professors (AEESP) Conference, University of Michigan, June 20th – 22nd, 2017.
12. Ohemeng-Ntiamoah J., Moffet M. and Datta T. (2015). "Linking Complex Organic Feedstock Characteristics To Microbial Metabolic Activities In Anaerobic Co-digesters." Association of Environmental Engineering and Science Professors (AEESP) Conference, Yale University, CT, June 13th – 16th, 2015.
13. T. Datta (2013). "Sidestream Treatment Alternatives for Nutrient Removal and Recovery at Wastewater Treatment Facilities", 23rd Tennessee Water Resources Symposium, TN AWRA, November 4th – 6th, 2013, Montgomery Bell Park.

Appendix C

Tennessee Tech University **Dec. 2017**

CIVIL AND ENVIRONMENTAL ENGINEERING DEPT.

1. Name: *Henderson, Robert Craig*

2. Education:

PhD	*Structural Engineering*	*The University of Tennessee*	*1994*
MS	*Structural Engineering*	*The University of Tennessee*	*1987*
BS	*Civil Engineering*	*The University of Tennessee*	*1985*

3. Academic Experience (FT= Full-time; PT = Part-time):

Tennessee Tech University	*Professor*	*CEE Faculty*	*2007-Present*	*FT*
Tennessee Tech University	*Assoc. Prof.*	*CEE Faculty*	*2000-2007*	*FT*
Tennessee Tech University	*Assist. Prof.*	*CEE Faculty*	*1995-2000*	*FT*

4. Non-Academic Experience (FT= Full-time; PT = Part-time):

Gilbert Commonwealth	*Lead Eng./Proj. Eng.*	*Seismic Design*	*1993-1995*	*FT*
Lockheed Martin	*Lead Eng./Proj. Eng.*	*Seismic Design & Testing*	*1991-1993*	*FT*
Lockwood Greene Eng.	*Associate Eng.*	*Seismic Design*	*1989-1991*	*FT*

5. Certifications and Professional Registrations (current):

Professional Engineer, TN #100606 *TN Dept. of Commerce & Ins. 1998-Present*

6. Membership in Professional Organizations (current):

7. Honors and Awards:

Kinslow Creativity Award	*Tennessee Tech University, CoE*	*1999*

8. Service Activities - Internal and External (last 5 years):

Curriculum Committee	*Tennessee Tech University*	*2008-2017*
ABET Committee	*Tennessee Tech University*	*2013-2017*
Tenure & Promotion Committee	*Tennessee Tech University*	*2010-2017*
Graduate Affairs Committee	*Tennessee Tech University*	*2012-2017*
Technology Committee	*Tennessee Tech University*	*1995-2017*

9. Notable Publications and Presentations (last 5 years):

1. Kidwell, T. and Kerley, R, **Henderson, R.C.,** Huff, T., (accepted for publication) "Non-linear Investigation of Plastic Hinge Formation in Steel and Concrete Piles", *ASCE Practice Periodical on Structural Design and Construction.* [Kidwell and Kerley are former TTU CEE grad students.
2. **Henderson, R.C.,** Mohr, B., Bane, D. and Bennett, R, (under review) "Material and Structural Properties of Light weight Masonry Grout", *ACI Materials Journal*.

10. Professional Development Activities (last 5 years):

American Concrete Institute Seminar on ACI 318 *Building Code Requirements for Structural Concrete,* (2014)

Appendix C

Tennessee Tech University **Dec. 2017**

CIVIL & ENVIRONMENTAL ENGINEERING DEPT.

1. **Name:** *Huddleston, David H.*

2. **Education:**
   Ph.D., Engineering Science, University of Tennessee, 1989
   M. S., Engineering Science and Mechanics, Virginia Polytechnic Institute and State University, 1978
   B. S., Engineering Science, Tennessee Technological University, 1977

3. **Academic Experience (FT= Full-time; PT = Part-time):**
   Professor, Civil & Environmental Engineering, Tennessee Technological University, August 2004 – Present, FT
   Interim Dean, College of Engineering, Tennessee Technological University, July 2007-August 2011, FT
   Professor and Chairperson, Civil & Environmental Engineering, Tennessee Technological University, August 2004 – June 2012, FT
   Professor, Civil Engineering, Mississippi State University, 2003-2004, FT
   Associate Professor, Civil Engineering, Mississippi State University, 1995-2003, tenured 1999, FT
   Research Engineer, NSF Engineering Research Center, Mississippi State University, 1991-1995, FT

4. **Non-Academic Experience (FT= Full-time; PT = Part-time):**
   Senior Engineer, Sverdrup Technology, Inc. AEDC Group, 1983-1991, FT
   Engineering Analyst, Pan-Am World Services, Inc. Engineering Services Section, 1981-1983, FT
   Manufacturing/Quality Control Engineer, TRW, Ross Gear Division, 1978-1981, FT

5. **Certifications and Professional Registrations (current):**
   Professional Engineer Registration, Mississippi I. D. 14068

6. **Membership in Professional Organizations (current):**

7. **Honors and Awards:**
   Hearin-Hess Distinguished Professor, College of Engineering, Mississippi State University (1997-98)
   Hearin-Hess Distinguished Professor, College of Engineering, Mississippi State University (1996-97)
   Outstanding Instructional Paper, College of Engineering, Mississippi State University (1996-97)

8. **Service Activities - Internal and External (last 5 years):**
   ABET program evaluator, 2008/-present
   Southern Association of Colleges and Schools (SACS) program evaluator, 2011-present
   Member, ASEE Engineering Deans' Council Public Policy Committee, June 2009 – June 2012
   Chair, ASCE/EWRI Computational Hydraulics Committee (Hydraulics & Waterways Council), 2006-2008, member, 2000-present
   Tau Beta Pi Faculty advisor, Tennessee Gamma Chapter, August 2004-present
   Tennessee Technological University Curriculum Committee (2005-2012)

9. **Notable Publications and Presentations (last 5 years):**
   1. Nixon, B., Huddleston, D. H., Elizandro, D., Liu, J., Ramirez, G., Hutchins, E. (2016). *Mastering Engineering Mechanics of Materials educator study investigates student performance in a hybrid format at Tennessee Technological University.* Retrieved from

http://www.pearsoned.com/results/masteringengineering-mechanics-materials-educator-study-investigates-student-performance-hybrid-format-tennessee-technological-university/.

2. Nixon, B., Huddleston, D. H., Elizandro, D., Liu, J., Ramirez, G., Hutchins, E. (2016). *Mastering Engineering Statics educator study investigates student performance in a hybrid format at Tennessee Technological University*. Retrieved from http://www.pearsoned.com/results/masteringengineering-educator-study-investigates-student-performance-hybrid-format-tennessee-technological-university/.
3. Elizandro, D., Huddleston, D. H., Liu, J., Ramirez, G., Hutchins, E. (2016), "An Academic Program Assessment Methodology to Leverage the Integrated Higher Education Environment Created by the Complete College Tennessee Act (CCTA)," *2016 ASEE Annual Conference,* New Orleans, LA. June.

10. Professional Development Activities (last 5 years):
Multiple ABET and SACS training activities

Appendix C

Tennessee Tech University **Dec. 2017**

CIVIL AND ENVIRONMENTAL ENGINEERING DEPT.

1. Name: *Huff, Timothy, E*

2. Education:

PhD	*Civil Engineering*	*University of Tennessee*	*2013*
MS	*Mathematics*	*Tennessee State University*	*2006*
MS	*Civil Engineering*	*Tennessee Tech University*	*1985*
BS	*Civil Engineering*	*Tennessee Tech University*	*1984*

3. Academic Experience (FT= Full-time; PT = Part-time):

Tennessee Tech University	*Lecturer*	*CEE Faculty*	*2017-Present*	*FT*
Tennessee Tech University	*Adjunct*	*CEE Faculty*	*2016-2017*	*PT*
Tennessee State University	*Adjunct*	*CEE Faculty*	*2007-2015*	*PT*

4. Non-Academic Experience (FT= Full-time; PT = Part-time):

TN DOT	*CE Manager*	*Structures Division*	*2004-2017*	*FT*
TN DOT	*Structural Specialist*	*Structures Division*	*2001-2004*	*FT*
Self Employed	*Structural Engineer*	*Knoxville TN*	*1997-2001*	*FT*
Lockheed Martin	*Structural Engineer*	*Oak Ridge TN*	*1989-1997*	*FT*

5. Certifications and Professional Registrations (current):

Professional Engineer, TN #020407	*TN Dept. of Commerce & Ins.*	*1988-Present*

6. Membership in Professional Organizations (current):

SSA	*Seismological Society of America*	*Life Member*
EERI	*Earthquake Engineering Research Institute*	*Member*

7. Honors and Awards:

TN Govt. Engineer of the Year	*Tennessee Society of Professional Engineers*	*2015*

8. Service Activities - Internal and External (last 5 years):

Panel Member: National Cooperative Highway Research Program (NCHRP)

Project 12-114	*Seismic Site Response Software*	*2017-Present*
Project 12-106	*Performance Based Seismic Design*	*2016-Present*
Project 12-105	*Accelerated Construction - Seismic*	*2015-Present*
Project 20-07	*Seismic Hazard Map Update*	*2016-Present*
Associate Editor	*ASCE Practice Periodical*	*2015-Present*

9. Notable Publications and Presentations (last 5 years):

1. "Inelastic Seismic Displacement Amplification for Bridges: Dependence Upon Various Intensity Measures," ASCE Practice Periodical on Structural Design and Construction, November 30 2017.

2. "Partial Isolation of a Bridge on Interstate 40 in the New Madrid Seismic Zone"; with Jonathan Shoulders; 34th International Bridge Conference, National Harbor, Maryland, June 4-8, 2017.
3. "Structural Health Monitoring of the Hernando De Soto Bridge"; with Matt Yarnold and Justin Alexander; 34th International Bridge Conference, National Harbor, Maryland, June 4-8, 2017.
4. "A Comparison of Nonlinear Static Procedures and Modeling Assumptions for Seismic Design of Ordinary Bridges", with Ali Hajihashemi and Shahram Pezeshk; Practice Periodical on Structural Design and Construction, American Society of Civil Engineers (ASCE); 10.1061/(ASCE)SC.1943-5576.0000309, 04016022, November 2016.
5. "Structural Demand on Bridges Subjected to Bidirectional Ground Motions", Practice Periodical on Structural Design and Construction, American Society of Civil Engineers (ASCE); 10.1061/(ASCE)SC.1943-5576.0000299 , 04016007. August, 2016.
6. "Issues in the Prediction of Inelastic Behavior in Bridges during Earthquakes", Practice Periodical on Structural Design and Construction, American Society of Civil Engineers (ASCE); 10.1061/(ASCE)SC.1943-5576.0000289 , 04016007. February, 2016.
7. "Estimating Residual Seismic Displacements in Bi-Linear Oscillators", Practice Periodical on Structural Design and Construction, American Society of Civil Engineers (ASCE); 10.1061/(ASCE)SC.1943-5576.0000282 , 04016003, January, 2016.
8. "Site Specific Seismic Analysis at the Vicinity of A Bridge Located Within the Mississippi Embayment", with Ashraf El Sayed and Shahram Pezeshk; Eastern Section Seismological Society of America, Annual Meeting, 2015.
9. "Inelastic Displacement Spectra for Bridges Using the Substitute-Structure Method", with Shahram Pezeshk; Practice Periodical on Structural Design and Construction, American Society of Civil Engineers (ASCE); 10.1061/(ASCE)SC.1943-5576.0000279; December 30, 2015.
10. "Partial Isolation as a Seismic Design Strategy for Pile Bent Bridges in the New Madrid Seismic Zone", Practice Periodical on Structural Design and Construction, American Society of Civil Engineers (ASCE); 10.1061/(ASCE)SC.1943-5576.0000277; December 30, 2015.
11. "Seismic Displacement Estimates for Bridges in the New Madrid Seismic Zone", Practice Periodical on Structural Design and Construction, American Society of Civil Engineers (ASCE); 10.1061/(ASCE)SC.1943-5576.0000269; December 30, 2015.
12. "Spanning the Wolf River Wetlands", Aspire - The Concrete Magazine, Fall 2014, pp. 14-17.

10. Professional Development Activities (last 5 years):

Presented at 34th International Bridge Conference in National Harbor, Maryland, June 4-8, 2017.

Presented at the PCI National Bridge Conference, 2014.

Presented at the 7th National Seismic Conference on Bridges and Highways, May 2013, Oakland, California.

Presented at the Earthquake Engineering Research Institute Annual meeting, 2012, Memphis, TN.

Appendix C

Tennessee Tech University **Dec. 2017**

CIVIL AND ENVIRONMENTAL ENGINEERING DEPT.

1. Name: *Kalyanapu, Alfred, J*

2. Education:

PhD	*Civil Engineering*	*University of Utah*	*2011*
MS	*Civil Engineering*	*University of Utah*	*2007*
BTech.	*Civil Engineering*	*National Institute of Technology, Warangal, India*	*2003*

3. Academic Experience (FT= Full-time; PT = Part-time):

Tennessee Tech University	*Assoc. Prof.*	*CEE Faculty*	*2017-Present*	*FT*
Tennessee Tech University	*Asst. Prof.*	*CEE Faculty*	*2011-2017*	*FT*

4. Non-Academic Experience (FT= Full-time; PT = Part-time):

University of Utah	*Grad. Res Asst..*	*Civil & Env. Engineering*	*2004-2011*	*FT*
Los Alamos National Lab	*Grad. Res Asst..*	*Systems Engineering&Integration*	*2006-2007*	*FT*

5. Certifications and Professional Registrations (current):

Engineer in Training, UTAH Registration *2007-Present*

6. Membership in Professional Organizations (current):

ASCE	*American Society of Civil Engineers*	*Member*
AGU	*American Geophysical Union*	*Member*
TNAWRA	*American Water Resources Association, Tennessee Section*	*Member*

7. Honors and Awards:

Kinslow Research Paper Award	*Tennessee Tech University, CoE*	*2016*
Outstanding Young Alumni Professional Achievement Award NITW		*2015*
Sigma Xi Faculty Research Award	*Tennessee Tech Chapter*	*2014*
Commended Paper	*Journal of Flood Risk Management*	*2013*

8. Service Activities - Internal and External (last 5 years):

CEE ABET Committee	*Tennessee Tech University*	*2017-Present*
Engineering A Future Activity Leader	*Tennessee Tech University*	*2012-Present*
Computational Hydraulics Committee	*American Society of Civil Engineers*	*2012-Present*
President	*TN American Water Resources Association*	*2017-Present*
Executive Committee Member	*TN American Water Resources Association*	*2011-2016*

9. Notable Publications and Presentations (last 5 years) (* indicates students):

1. **Bhuyian***, Md. N. M., Kalyanapu, A. J., and Hossain, F. (2017). "Evaluating Conveyance-Based DEM Correction Technique on NED and SRTM DEMs for Flood Impact Assessment of the 2010 Cumberland River Flood" Geosciences, 7, 132; doi:10.3390/geosciences7040132.
2. **Dullo***, T. T., **Kalyanapu**, A. J., and Teegavarapu, R. S. V. (2017). "Evaluation of Changing Characteristics of Temporal Rainfall Distribution within 24-hour Duration Storms and their influences on Peak Discharges: A Case Study of Asheville, North Carolina" Journal of Hydrologic Engineering, 22(11):05017022.
3. **Bhuyian***, Md. N. M., and **Kalyanapu**, A. J. (2017). "Accounting Digital Elevation Uncertainties for Flood Consequence Assessment" Journal of Flood Risk Management, DOI: 10.1111/jfr3.12293

4. **Ahmadisharaf***, E. A.**, Kalyanapu,** A. J., and Chung, Eun-Sung. (2017). "Sustainability-Based Flood Hazard Mapping of the Swannanoa River Watershed", Sustainability, 9, 1735, doi:10.3390/su9101735.
5. **Ahmadisharaf***, E., and **Kalyanapu**, A. J., Thames, B. A., and Lillywhite, J. (2016). "Application of a probabilistic framework for comparison of dam breach prediction methods", Environmental Modelling and Software, doi: 10.1016/j.envsoft.2016.09.022.
6. **Ahmadisharaf***, E., **Kalyanapu**, A, J., and Chung, E. –S. (2015). "Spatial probabilistic multi-criteria decision making for assessment of flood management alternatives", Journal of Hydrology, Vol. 533, 365-378, doi: 10.1016/j.jhydrol.2015.12.031
7. **Ahmadisharaf***, E., **Kalyanapu**, A. J., and Chung, E. –S. (2015). "Evaluating the effects of flood duration and velocity on selection of flood management alternatives using multi-criteria decision making" Water Resources Management, 29(8), pp 2543-2561.
8. **Bhuyian***, Md. N. M., and **Kalyanapu**, A. J. "An Approach for DEM Correction by Improving Channel Conveyance" Journal of Hydrologic Engineering, doi: 10.1061/(ASCE)HE.1943-5584.0001020
9. **Kalyanapu**, A.J., Judi, D.R., McPherson, T.N. and Burian, S.J. (2014), Annualised risk analysis approach to recommend appropriate level of flood control: application to Swannanoa river watershed. Journal of Flood Risk Management. doi: 10.1111/jfr3.12108
10. **Kalyanapu, A. J.**, Hossain, F., Yigzaw, W., Hossain, A., and C. K. Shum. (2013). "Investigating the performance of American River Flood Control System under changes in Probable Maximum Flood due to effects of Artificial Reservoir Size and Land Use/Land Cover Patterns" Earth Interactions Journal, Special Issue. (AGU-AMS-AAG),17, 1–24. doi: http://dx.doi.org/10.1175/2012EI000496.1.
11. Yigzaw, W., Hossain, F., and **Kalyanapu, A. J.** (2013). "Comparison of PMP-driven Probable Maximum Floods with Flood Magnitudes due to Increasingly Urbanized Catchment: The Case of American River Watershed", in Special Issue Edition: "Human Impact on Climate Extremes for Water Resources Infrastructure Design, Operations and Risk Management", Earth Interactions Journal, AGU-AMS-AAG, 17, 1–15. doi: http://dx.doi.org/10.1175/2012EI000497.1.
12. Burian, S.J., Walsh, T., **Kalyanapu, A.J.**, and Larsen, S.G. (2013). "Climate vulnerabilities and adaptation of urban water infrastructure systems." In: Climate Vulnerability (Pielke, R. Sr, Editor in Chief), Volume 5: Vulnerability of Water Resources to Climate, Hossain, F. (Editor), Elsevier Inc., Academic Press, 87-107p.
13. Hossain, F., and **Kalyanapu**, A. J. (2012). "Cities, Dams and Extreme Weather" Civil Engineering – ASCE, 82(12), December 2012, 68-71.
14. Yigzaw, W., Hossain, F., and **Kalyanapu, A. J.** (2012). "Impact of artificial reservoir size and land use/land cover patterns on estimation of probable maximum flood: The case of Folsom Dam on American River" Journal of Hydrologic Engineering, 10.1061/(ASCE)HE.1943-5584.0000722.

10. Professional Development Activities (last 5 years):

Attended CUAHSI Sensor Network Bootcamp, 2017

Attended EWRI Verification & Validation Workshop, 2017

Attended NSF Career Proposal Writing Workshop, 2013

Attended Tennessee Board of Regents Research Academy, 2012

Appendix C

Tennessee Tech University **Feb. 2018**

CIVIL AND ENVIRONMENTAL ENGINEERING DEPT

1. Name: *Liu, Y. Jane*

2. Education:

PhD	*Structural Engineering*	*University of Hawaii, Honolulu, U.S.A.*	*2002*
MS	*Structural Engineering*	*University of Hawaii, Honolulu, U.S.A.*	*1998*
BS	*Engineering Mechanics*	*Hohai University, Nanjing, P.R. China*	

3. Academic Experience (FT= Full-time; PT = Part-time):

Tennessee Tech University	*Professor*	*CEE Faculty*	*2012-Present*	*FT*
Tennessee Tech University	*Assoc. Prof.*	*CEE Faculty*	*2007-2012*	*FT*
Tennessee Tech University	*Assist. Prof.*	*CEE Faculty*	*2002-2007*	*FT*

4. Non-Academic Experience (FT= Full-time; PT = Part-time):

University of Hawaii	*Research Assist.*	*CEE Department*	*1995-2002*	*PT*
University of Hawaii	*Lecturer*	*CEE Department*	*2000-2002*	*PT*

5. Certifications and Professional Registrations (current):

FE Certified,	*State of Hawaii*	*1997*

6. Membership in Professional Organizations (current):

ASME	*American Society of Mechanical Engineers*	*Member*
USACM	*US Association for Computational Mechanics*	*Member*

7. Honors and Awards:

Faculty Productivity Award	*Tennessee Tech University, CoE*	*2010*
Faculty Productivity Award	*Tennessee Tech University, CoE*	*2009*
Faculty Productivity Award	*Tennessee Tech University, CoE*	*2008*

8. Service Activities - Internal and External (last 5 years):

The University Faculty Senate	*Tennessee Tech University*	*2015-present*
The University Administrative Council	*Tennessee Tech University*	*2015-present*
The Uni. Student Affairs Committee	*Tennessee Tech University*	*2015-present*
The University Art Committee	*Tennessee Tech University*	*2015-present*
The Uni. Faculty Research Committee	*Tennessee Tech University*	*2013-2014*
Rising Engineer Faculty Scholar Award	*Tennessee Tech University, CoE*	*2017-present*
Outstanding Alumnus Award Committee	*Tennessee Tech University, CoE*	*2013-2016*
Renaissance Spectrum Award Commit.	*Tennessee Tech University, CoE*	*2012-2013*
Departmental Curriculum Committee	*Tennessee Tech University, CEE*	*2012-present*
Departmental Computer Committee	*Tennessee Tech University, CEE*	*2012-present*
Departmental Equipment Committee	*Tennessee Tech University, CEE*	*2012-present*
Departmental ABET Committee	*Tennessee Tech University, CEE*	*2012-present*
Undergraduate Research Committee	*Tennessee Tech University, CEE*	*2016-present*

9. Notable Publications and Presentations (last 5 years):

1. "A Parametric Study of Linear and Nonlinear Models for Moisture Diffusion in Composite Sandwich Structures", with Shane Paulson, John Peddieson, and Steve Mills, Journal of Composite Materials, August 8, 2017.

2. "Axisymmetric Deformation of a Materially Nonlinear Circular Plate," with John Peddieson, Meccanica, An International Journal of Theoretical and Applied Mechanics AIMETA, Springer, March 2017, Issue 4-5, pp 1035-1050.
3. "Evaluation of Groebner Basis Methodology as an Aid to Harmonic Balance," with John Peddieson, ASME Journal of Vibration and Acoustics, April 2014, Vol.136 / 024502-4.
4. "Application of Groebner Bases to Nonlinear Mechanics Problems," with John Peddieson, Mathematical Software – ICMS 2014, Volume 8592 of the Series Lecture Notes in Computer Science pp 398-405, Springer.
5. "Application of Groebner Basis Methodology to Nonlinear Static Cable Analysis," with George Buchanan, and John Peddieson, ASME Journal of Offshore Mechanics and Arctic Engineering, November 2013, Vol,135 / 041601-1.
6. "An Academic Program Assessment Methodology to Leverage the Integrated Higher Education Environment Created by the Complete College Tennessee Act (CCTA)," with David Elizandro, David Huddleston, Guillermo Ramirez, and Elizabeth Hutchins, Proceeding of the ASEE's 123rd National Conference 2016, New Orleans, LA, USA, June 26-29, 2016.
7. "An Application of the Method of Groebner Bases to a Geometrically Non-linear Free Vibration Analysis of Composite Plates" with Aravind Shanmugasundaram and John Peddieson, Presented at the 7th International Conference on Computational Methods ICCM 2016, Berkeley, CA, USA, August 1-4, 2016.
8. "Examples of Non-commutative Groebner Bases to Plate Bending Analysis" with Bruno Buchberger, Markus Rosenkranz, and Alexander Maletzky, Presented at the 7th International Conference on Computational Methods ICCM 2016, Berkeley, CA, USA, August 1-4, 2016.
9. "Two-Point Boundary problems with One Mile Singularity and an Application to Graded Kirchhoff plates," with Markus Rosenkranz, Alexander Maletzky, and Bruno Buchberger, Proceeding of Computer Algebra in Scientific Computing (CASC) September, 2015, Aachen, Germany.
10. "Torsional Property Measurement for Polycarbonate Using DIC Technique with 3D Printed Specimens," with Kallie Curtis, Tim Harrell, and John Peddieson, presented at the 1st International Digital Image Correlation Society Conference & Workshop, November, 2015, Columbia, SC, USA.
11. "Equi-Biaxial Loading of Rohacell 200WF," with Tim Harrell, Steve Mills, and David Mills, Presented at JEC Conferences Americas 2015, Houston, June, 2015**,** Houston, TX, USA.
12. "Application of Non-commutative Groebner Bases to Kirchhoff Circular Plates with Functionally Graded Materials," with Bruno Buchberger, Markus Rosenkranz, Alexander Maletzky, Loredana Tec, Wolfgang Windsteiger, Presented at the 8th MSJ SI 2015, Seasonal Institute, Current Trends on Groebner Bases: the 50th Anniversary of Groebner Bases, August, 2015, Osaka, Japan.
13. "Quadrature Solutions for Large Deflection Statics Cable Problems," with John Peddieson, Proceeding of the ASME 2014 33rd International Conference on Ocean, Offshore and Arctic Engineering, June 2014, San Francisco, CA, USA.
14. "Application of Groebner Bases to Nonlinear Mechanics Problems," with John Peddieson, Proceeding of the ICMS 2014, 4th International Congress on Mathematical Software, August, 2014, Seoul, Korea.
15. "Groebner Bases in Teaching Computational Methods in Engineering," with Rafal Ablamowicz, Proceeding of the ICMS 2014, 4th International Congress on Mathematical Software, August, 2014, Seoul, Korea.

10. Professional Development Activities (last 5 years):

1. Invited research associate at RISC (Research Institute for Symbolic Computation), JKU (Johannes Kepler University), Linz, Austria, Jan. 2015
2. Participated TBR course revitalization, 2013

Tennessee Tech University **Dec. 2017**

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

1. Name: *Mohr, Benjamin J.*

2. Education:

PhD	*Civil Engineering*	*Georgia Institute of Technology*	*2005*
MS	*Civil Engineering*	*Georgia Institute of Technology*	*2002*
BS	*Civil Engineering*	*University of Delaware*	*2001*

3. Academic Experience (FT= Full-time; PT = Part-time):

Tennessee Tech University	*Assoc. Prof*	*Chair*	*2017-Present*	*FT*
Tennessee Tech University	*Assoc. Prof*	*Interim Chair*	*2012-2017*	*FT*
Tennessee Tech University	*Assoc. Prof.*	*CEE Faculty*	*2010-Present*	*FT*
Tennessee Tech University	*Assist. Prof.*	*CEE Faculty*	*2005-2010*	*FT*

4. Non-Academic Experience (FT= Full-time; PT = Part-time):
N/A

5. Certifications and Professional Registrations (current):

Professional Engineer, TN #00116651	*TN Dept. of Commerce & Ins.*	*2013-Present*

6. Membership in Professional Organizations (current):

ASCE	*American Society of Civil Engineers*	*Member*
ACerS	*American Ceramic Society, Cements Division*	*Member*
ACI	*American Concrete Institute*	*Member*
	ACI Committee 231 Properties of Concrete at Early Ages	*Voting Member*
	ACI Committee 236 Materials Science of Concrete	*Voting Member*
	ACI Committee 308 Curing Concrete	*Associate Member*

7. Honors and Awards:

Peter G Hoadley Award for Outstanding Engineering Educator	*ASCE Tennessee Section*	*2011*
Kinslow Award	*Tennessee Tech University*	*2011*
ExCEEd Fellow	*ASCE*	*2010*
Ralph E Powe Junior Faculty Enhancement Award	*Oak Ridge Associated Universities*	*2007*
Sigma Xi Research Award	*Tennessee Tech University Sigma Xi Chapter*	*2007*
New Faculty Research Award (2nd place)	*ASEE-SE Section*	*2007*

8. Service Activities - Internal and External (last 5 years):

ASCE Student Chapter Faculty Advisor	*Tennessee Tech University*	*2006-Present*
Program Chair	*ACerS Cements Division*	*2013-2014*
Chair	*ACerS Cements Division*	*2012-2013*
Chair-Elect	*ACerS Cements Division*	*2011-2012*

URECA! Grant Committee	*Tennessee Tech University*	*2011-2012*
Curriculum Committee	*Tennessee Tech University*	*2012-Present*
Curriculum Committee	*TTU College of Engineering*	*2012-Present*
Chair, Curriculum Committee	*TTU CEE*	*2011-Present*
Graduate Executive Committee	*Tennessee Tech University*	*2012-Present*
Graduate Executive Committee	*TTU College of Engineering*	*2012-Present*
Chair, ABET Committee	*TTU CEE*	*2012-Present*
Recruitment and Retention Committee	*TTU CEE*	*2007-Present*
Facilities Committee	*TTU CEE*	*2005-Present*

9. Notable Publications and Presentations (last 5 years):

1. Mohr, B.J., Bryant, L.B. "Utilization of Quarry By-Products for Reduction of Expansion Due to Alkali-Aggregate Reaction." *Cement and Concrete Composites*, 2016; 73: 235-240.
2. Keaton, D.G., Mohr, B.J. "Nanoscale Pore Structure Analysis of Mortars Undergoing Delayed Ettringite Formation." *American Ceramic Society, Cements Division, 3rd Advances in Cement-based Materials: Characterization, Processing, Modeling and Sensing*, Austin, TX, June 10-12, 2012.

10. Professional Development Activities (last 5 years):

ASCE Department Heads Conference, 2014

ABET Program Assessment Workshop, 2012

Appendix C

Tennessee Tech University **Dec. 2017**

CIVIL AND ENVIRONMENTAL ENGINEERING DEPARTMENT

1. Name: *Ramirez, Guillermo*

2. Education:

PhD	*Civil Engineering*	*Colorado State University*	*1998*
MS	*Civil Engineering*	*Colorado State University*	*1994*
BS	*Civil Engineering*	*Universidad Nacional de Colombia*	*1985*

3. Academic Experience (FT= Full-time; PT = Part-time):

Tennessee Tech University	*Assoc. Prof.*	*CEE Faculty*	*2005-Present*	*FT*
Tennessee Tech University	*Asst. Prof.*	*CEE Faculty*	*2000-2005*	*FT*
Naval Postgraduate School	*NRC Fellow*	*Aero-Astro Dept*	*1998-1999*	*FT*
Naval Postgraduate School	*Visiting Prof.*	*Aero-Astro Dept*	*Summer 2001-2009*	*PT*
Universidad Nacional de Colombia	*Visiting Prof.*	*CEE Faculty*	*Summer 2010-2012*	*PT*
Colorado State University	*Instructor*	*CEE Faculty*	*1996-1998*	*PT*

4. Non-Academic Experience (FT= Full-time; PT = Part-time):

Bolivar Aliadas, Colombia	*Project Engineer*	*1987-1989*	*FT*
Concrete Engr, Colombia	*Structural Design Engineer*	*1985-1987*	*FT*

5. Certifications and Professional Registrations (current):

6. Membership in Professional Organizations (current):

Sigma Xi	*Scientific Research Society*	*Member*
Phi Kappa Phi	*National Honor Society*	*Member*

7. Honors and Awards:

NRC Research Associateship Award	*Naval Postgraduate School*	*1998-1999*
Chi Epsilon Golden Key Award	*Colorado State University*	*1998*
Outstanding Teaching Asst. Award	*Colorado State University*	*1997*

8. Service Activities - Internal and External (last 5 years):

CEE Computer Committee	*Tennessee Tech University*	*2000-Present*
CEE Curriculum Committee	*Tennessee Tech University*	*2008-2011*
CEE Library Committee	*Tennessee Tech University*	*2000-Present*
CEE Graduate Affairs Committee	*Tennessee Tech University*	*2013-Present*
CEE Faculty Search Committee, Chair	*Tennessee Tech University*	*2012*
Student Advising	*Tennessee Tech University*	*2001-Present*
Reviewer, Several Technical Journals		*1998-Present*
Reviewer and evaluator	*Mountain-plains Consortium(MPC)*	*2013*
Solar Sail Propulsion Project	*NASA*	*2005*

9. Notable Publications and Presentations (last 5 years):

1. "An Academic Program Assessment Methodology to Leverage the Integrated Higher Education Environment Created by the Complete College Tennessee Act (CCTA)," with D. Elizandro, J. Liu, E. Hutchins, published at the ASEE's 123rd National Conference 2016, June 26-29, 2016, New Orleans, LA, USA.

10. Professional Development Activities (last 5 years):

Tennessee Tech University **Dec. 2017**

CIVIL AND ENVIRONMENTAL ENGINEERING DEPT

1. Name: *VandenBerge, Daniel R.*

2. Education:

PhD	*Civil Engineering*	*Virginia Polytechnic Institute*	*2014*
MS	*Civil Engineering*	*Michigan Technological University*	*2003*
BS	*Civil Engineering*	*Michigan Technological University*	*2001*

3. Academic Experience (FT= Full-time; PT = Part-time):

Tennessee Tech University	*Asst. Prof.*	*CEE Faculty*	*2015-Present*	*FT*
Virginia Polytechnic Institute	*Post-Doc.*	*CEE Faculty*	*2014-2015*	*FT*
Virginia Polytechnic Institute	*Instructor*	*CEE Faculty*	*2013*	*PT*
Lakeland Community College	*Instructor*	*CET Faculty*	*2009-2010*	*PT*

4. Non-Academic Experience (FT= Full-time; PT = Part-time):

Engineering Consultant		*2013-Present*	*PT*
EDP Consultants, Inc.	*Staff Engr. / Project Manager*	*2003-2010*	*FT*

5. Certifications and Professional Registrations (current):

Professional Engineer, PA #075620 *PA Bur. Prof. & Occup. Affairs2008-Present*

6. Membership in Professional Organizations (current):

ASCE	*American Society of Civil Engineers*	*Member*
	Embankments, Dams, and Slopes (EDS) Committee	*Member*
ASEE	*American Society of Engineering Education*	*Member*
ADSC	*Association of Drilled Shaft Contractors*	*Member*
ASDSO	*Association of State Dam Safety Officials*	*Member*
USSD	*United States Society on Dams*	*Member*

7. Honors and Awards:

Student Paper Award	*ASDSO Dam Safety 2014*	*2014*
ASCE Geo-Institute Nominee	*5th Intl. Young Geotechnical Eng. Conf.*	*2013*
Doctoral Scholar	*Institute for Critical Tech. & Applied Science*	*2010-2014*
Via Fellowship	*Virginia Tech Civil Engineering Dept.*	*2010-2013*

8. Service Activities - Internal and External (last 5 years):

IREM Committee	*Tennessee Tech – Coll. Of Engineering*	*2017-Present*
Editor	*Landslides (Journal)*	*2017-Present*
Research Fair Judge	*TTU Annual Research Day*	*2017*
Conference Session Organizer	*ASCE Geo-Institute*	*2017*
Reviewer	*Computers and Geotechnics*	*2016-Present*
Acad. Integrity Strategic Doing Team	*TTU College of Engineering*	*2015-2016*
Reviewer and Panelist (ad hoc)	*National Science Foundation*	*2015-Present*
Graduate Affairs Committee	*Tennessee Tech – CEE Dept.*	*2015-Present*
Undergraduate Curriculum Comm.	*Tennessee Tech – CEE Dept.*	*2015-Present*
Reviewer	*ASCE J. Geot. Geoenviron. Eng.*	*2015-Present*
Reviewer	*ASTM Geot. Testing Journal*	*2015-Present*

9. Notable Publications and Presentations (last 5 years):

1. "Interpretation of shear strength uncertainty and reliability analyses of slopes," with M. McGuire, *Landslides*, http://dx.doi.org/10.1007/s10346-017-0836-5, 2017.
2. "Response surfaces for probabilistic analyses of slope stability," with M. McGuire, *Proc. of 19th Intl. Conf. Soil Mech. and Geotech. Eng.*, Seoul, 4 pp, 2017.
3. "Lessons Learned from Rapid Drawdown," J. M. Duncan Memorial Symposium, Presentation given at *GeoFrontiers*, 2017.
4. "Shear strength of remolded and compacted Beaumont Clay," with M. J. Thompson, *Proc. of GeoFrontiers,* 2017.
5. "V-Shaped failure surfaces in bearing capacity type limit equilibrium analyses," *Proc. of GeoFrontiers,* 2017.
6. "Practical considerations for measuring the shear strength of compacted clay," with J. M. Duncan and T. L. Brandon, *Proc. of GeoFrontiers*, 2017.
7. "Correlations for fully softened shear strength parameters," with B. A. Castellanos and T. L. Brandon, *Geotechnical Testing Journal*, 39(4), 1-16, 2016.
8. "An improved undrained strength interpolation scheme for rapid drawdown (Technical Note)," with S. G. Wright, *Journal of Geotechnical and Geoenvironmental Engineering*, 10.1061/(ASCE)GT.1943-5606.0001471, 06016002, 2016.
9. "South Carolina flooding and dam failures," with E. Reed, K. Poston, L. Munasque, and A. K. Kalyanapu, *ASDSO Dam Safety 2016*.
10. "Probabilistic analysis of rapid drawdown," *Proc. of the 12th International Symposium on Landslides*, Napoli, Italy, 2016.
11. "Shear strength of compacted Beaumont clay for consolidated-undrained conditions," with M. J. Thompson, D. J., Bentler, and T. L. Brandon, *USSD 2016 Annual Conference*, 2016.
12. "Use of fully softened shear strength in slope stability analysis," with B. A. Castellanos and T. L. Brandon, *Landslides*, DOI 10.1007/s10346-015-0597-y, 2015.
13. "Undrained strength of compacted clay under principal stress reorientation," with J. M. Duncan and T. L. Brandon, *Journal of Geotechnical and Geoenvironmental Engineering*, 10.1061/(ASCE)GT.1943-5606.0001332, 04015035, 2015.
14. "Highly organic fill for levee stability berms," with T. L. Brandon and M. P. Wielputz, *Geotechnical Testing Journal*, ASTM, 38(3), 10.1520/GTJ20140151, 1-13, 2015.
15. "Limitations of transient seepage analyses for calculating pore pressures during external water level changes," with J. M. Duncan and T. L. Brandon, *Journal of Geotechnical and Geoenvironmental Engineering*, 141(5), 04015005, 2015.
16. "Practical application of blanket theory and the finite element method to levee seepage analysis," with A. Batool and T. L. Brandon, *Journal of Geotechnical and Geoenvironmental Engineering*, 141(4), 04015001, 2015.
17. "Triaxial tests on compacted clays for consolidated-undrained conditions," with T. L. Brandon and J. M. Duncan, *Geotechnical Testing Journal*, ASTM, 37(4), DOI 10.1520/GTJ20130202, 705–716, 2014.
18. "Total stress rapid drawdown analysis of the Pilarcitos Dam failure using the finite element method," *Frontiers of Structural and Civil Engineering*, DOI 10.1007/s11709-014-0249-7, 115-123, 2014.

10. Professional Development Activities (last 5 years):

TTU College of Engineering IREM Workshop Participant, July 2016.

ADSC 2016 Foundation Engineering Faculty Workshop, June 2016.

Appendix C

Tennessee Tech University **Dec. 2017**

CIVIL AND ENVIRONMENTAL ENGINEERING DEPT.

1. Name: *Weathers, Lenly J*

2. Education:

PhD	*Civil and Environmental Engineering*	*The University of Iowa*	*1995*
MS	*Civil Engineering*	*Texas A&M*	*1990*
MS	*Mechanical Engineering*	*The University of Missouri*	*1987*
BS	*Mechanical Engineering*	*The University of Missouri*	*1982*

3. Academic Experience (FT= Full-time; PT = Part-time):

Tennessee Tech University	*Associate Professor*	*2002-Present*	*FT*
Tennessee Tech University	*Assistant Professor*	*1998-2002*	*FT*
The University of Maine	*Assistant Professor*	*1996-1998*	*FT*

4. Non-Academic Experience (FT= Full-time; PT = Part-time):

Hart Crowser, Inc.	*Remediation Engineer*	*1987-1989*	*FT*

5. Certifications and Professional Registrations (current):
None

6. Membership in Professional Organizations (current):
None

7. Honors and Awards:
None

8. Service Activities - Internal and External (last 5 years):

Quality Enhancement Plan Director	*Tennessee Tech University*	*2012-Present*
Faculty Head, Engineering Village	*Tennessee Tech University*	*2011-Present*
Educational Consultant	*Putnam County Schools*	*2014*

9. Notable Publications and Presentations (last 5 years):
None

10. Professional Development Activities (last 5 years):
Attended SACSCOC Conference on Accreditation Practices, 2014

APPENDIX D

Results of Surveys of MS Alumni and their Employers

Appendix D

Alumni Survey

During the fall of 2017, an electronic survey was undertaken of graduates of the TTU Civil and Environmental Engineering M.S. Program. A link to the survey was sent to 53 alumni of the program. The survey questions are listed below.

1. First and last name
2. State your current employer's name
3. Your job title
4. Home address
5. Email address
6. Telephone number
7. Year of MS graduation
8. Your direct supervisor's email
9. Area of specialization for MS degree in Civil Engineering
10. What are you currently involved in?
11. Did the CEE MS degree program provide you with the technical knowledge to be successful in civil engineering professional practice?
12. Did the CEE MS degree program provide you with the necessary communication skills to present work at professional meetings and/or publish work in scholarly journals?
13. Did the CEE MS degree program provide you with the ability to undertake technical work independently?
14. Did the CEE MS degree program provide you with the technical competence needed for advanced study at the doctoral level in civil engineering or a related area?
15. Did the CEE MS degree program provide you with the technical competence to pursue lifelong learning through continuing professional education?
16. Have you received any award from a professional civil engineering or related organization? If answered "yes," please provide details.
17. Would you recommend the TTU CEE MS degree program to other potential candidates in the future?
18. Please provide below any additional comments on TTU's CEE MS graduate program – in particular, any strengths and weaknesses you may have observed.
19. Were there to one technical and/or workplace skill you wished had been part of the CEE MS program curriculum, what would it be?

The survey results are summarized in the following tables:

- Respondent details (personal information omitted) – Table D-1. Note that two entries (#1 and #4) were empty or duplicated and have been omitted from the summary.
- Individual responses to Questions 11 to 17 – Table D-2

Appendix D

- Responses to second half of Question 16 – Table D-3
- Reponses to Question 18 – Table D-4
- Responses to Question 19 – Table D-5

Table D-1. Fall 2017 Survey Respondent Details

Survey Entry #	Current Employer (Question 2)	Current Job Title (Question 3)	MS Grad. Year (Q. 7)	Area in Civil Engr. (Question 9)	Current Type of Work (Question 10)
2	KCI Technologies	Design Engineer	2013	Transportation	Consulting
3	Purdue University	Research Assistant	2013	Structural Mechanics	Doctoral Studies
5	Barge Waggoner Sumner and Cannon Inc.	Engineer in Training	2016	Water Resources	Consulting
6	Tennessee Department of Transportation	Graduate Transportation Associate	2017	Transportation	Public sector
7	Tennessee Technological University	Graduate Research Assistant	2014	Water Resources	Doctoral Studies
8	Tennessee Department of Transportation (TDOT)	Transportation Project Specialist	2016	Materials	Public sector
9	Barnhart Crane and Rigging	R&D Engineer	2017	Structural Mechanics	Public sector
10	National Resource management LLC	Structural Analyst	2009	Structural Mechanics	Construction
11	TDOT	District Operations Specialists	2014	Materials	Construction
12	TDOT	Transportation project specialist	2015	Transportation	Environmental permitting
13	The University of Texas at Austin	Graduate Research Assistant	2014	Materials	Doctoral Studies
14	Tennessee Department of Transportation	District Operations Specialist	2016	Structural Engineering	Construction
15	Structural Design Group	Engineer	2016	Structural Engineering	Consulting
16	Tennessee Tech University	Doctorate Graduate Student	2015	Materials	Doctoral Studies
17	The Church International	Administrative Pastor	2013	Materials	Full time ministry
18	Lauren Shibakov	Apprentice/ Engineering Intern	3	Materials	AutoCad structural drawings of buildings factories and others
19	Keller Williams Foothills Realty	Realtor	2012	Materials	Real estate
20	University of Southampton	Marie Curie Research Fellow	2014	Structural Mechanics	Doctoral Studies
21	James C. Hailey and Company	Project Engineer	2013	Water Resources	Consulting
22	McGill University	PhD Candidate	2015	Water Resources	Doctoral Studies
23	Ross Bryan Associates	Structural Designer	2016	Structural Engineering	Consulting
24	TDOT	GTA	2017	Transportation	Public sector

Appendix D

Survey Entry #	Current Employer (Question 2)	Current Job Title (Question 3)	MS Grad. Year (Q. 7)	Area in Civil Engr. (Question 9)	Current Type of Work (Question 10)
25	U.S. Army Corps of Engineers	Hydraulic Engineer	2013	Water Resources	Public sector
26	Tennessee Department of Transportation	Transportation Project Specialist Supervisor 1	2012	Water Resources	Public sector
27	United States Army Corps of Engineers	Civil/Structural Engineer	2016	Structural Engineering	Government sector
28	University of Central Florida	PhD Student	2015	Environmental	Doctoral Studies
29	Virginia Department of Transportation	Senior Transportation Planning Specialist	2012	Transportation	Public sector
30	Strand Associates, Inc.	Project Manager	2012	Environmental	Consulting
31	Carpenter Wright Engineers	Engineer	2013	Structural Engineering	Consulting
32	Texas A&M University	Graduate Research Assistant	2017	Structural Engineering	Doctoral Studies
33	Structural Design Group	Structural Engineer	2012	Structural Engineering	Consulting
34	Dassault Systemes Simulia Corp.	Solutions Consultant	2012	Structural Engineering	Finite Element Analyst with obtained Ph.D. degree
35	Tennessee Department of Transportation	Transportation Project Specialist (Structures)	2014	Structural Engineering	Public sector
36	Schaefer	Design Engineer	2014	Structural Engineering	Consulting
37	Tennessee Valley Authority	Civil Design Engineer	2013	Structural Engineering	Power Utility

Table D-2. Individual Responses to Questions 11 to 17 (See question list for full question text).

Survey Entry #	Did the CEE MS degree program provide you with the					Received any award from a professional civil engineering or related organization?	Would you recommend the TTU CEE MS degree program
	Technical knowledge to be successful?	Necessary communication skills?	Ability to undertake technical work independently?	Technical competence needed for advanced study at the doctoral level?	Technical competence to pursue lifelong learning?		
2	Strongly Agree	Agree	Strongly Agree	Not Applicable	Agree	No	Yes
3	Strongly Agree	Strongly Agree	Agree	Strongly Agree	Strongly Agree	No	Yes
5	Strongly Agree	Strongly Agree	Strongly Agree	Not Applicable	Strongly Agree	No	Yes
6	Strongly Agree	Strongly Agree	Strongly Agree	Not Applicable	Strongly Agree	No	Yes
7	Agree	Agree	Agree	Strongly Agree	Agree	Yes	Yes
8	Strongly Agree	Strongly Agree	Strongly Agree	Not Applicable	Strongly Agree	No	Yes
9	Agree	Agree	Strongly Agree	Strongly Agree	Strongly Agree	No	Yes
10	Strongly Agree	Agree	Agree	Not Applicable	Strongly Agree	No	Yes
11	No opinion	Agree	Agree	Not Applicable	Agree	No	Yes
12	Strongly Agree	Strongly Agree	Strongly Agree	Not Applicable	Strongly Agree	No	Yes
13	Strongly Agree	Agree	Agree	Agree	Agree	Yes	Yes
14	Strongly Agree	Strongly Agree	Agree	Not Applicable	Strongly Agree	No	Yes
15	Agree	Strongly Agree	Strongly Agree	Not Applicable	Agree	No	Yes
16	Agree	Strongly Agree	Agree	Agree	Agree	Yes	Yes
17	Agree	Agree	Agree	Not Applicable	Not Applicable	No	Yes
18	Agree	Agree	Agree	Agree	Agree	No	Yes
19	Strongly Agree	Strongly Agree	Agree	Not Applicable	Agree	No	Yes
20	Agree	Disagree	Agree	Agree	Agree	Yes	Yes
21	Strongly Agree	Strongly Agree	Strongly Agree	Not Applicable	Strongly Agree	No	Yes
22	Agree	Agree	Strongly Agree	Strongly Agree	Agree	Yes	Yes
23	Strongly Agree	Strongly Agree	Strongly Agree	Not Applicable	Strongly Agree	No	Yes
24	Agree	Agree	Strongly Agree	Not Applicable	Strongly Agree	No	Yes
25	Agree	Agree	Agree	Not Applicable	Agree	No	Yes
26	Strongly Agree	Agree	Strongly Agree	Not Applicable	Agree	No	Yes
27	Strongly Agree	Strongly Agree	Strongly Agree	Not Applicable	Strongly Agree	No	Yes
28	Agree	Agree	Strongly Agree	Agree	Agree	Yes	Yes
29	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	No	Yes
30	Agree	Agree	Strongly Agree	Not Applicable	Strongly Agree	Yes	Yes
31	Agree	Strongly Agree	Agree	Agree	Agree	No	Yes
32	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	No	Yes
33	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	No	Yes
34	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Yes	Yes
35	Strongly Agree	Agree	Strongly Agree	Not Applicable	Agree	No	Yes
36	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	No	Yes
37	Agree	Agree	Agree	No opinion	Agree	Yes	Yes

Table D-3. Survey responses to Question 16

Survey Entry #	Responses to Question 16 - Awards from a professional civil engineering or related organizations
7	2014 Research Award (Masters Category) by College of Engineering, Tennessee Technological University; 2013 Best Student Paper by Dam Safety Conference, Providence, RI 2013 Ivan Hoe Fellowship by Ivan Hoe Foundation
13	NSBE Graduate Student Award
16	ASTM International - Recipient of the Katharine and Bryant Mather Scholarship Award World of Coal Ash - Midwest Coal Ash Association Student Oral and Poster Presentation Award
20	Young Scientist Award International Conference on Lightning and Static Electricity
22	NSERC
28	1) First place poster award, “Experimental investigation of nitrate removal using zero valent aluminum particles”, Kentucky/Tennessee Water Professionals Conference, Covington, KY, 2015; 2) Second place poster award, “Experimental investigation on the chemical reduction of nitrate, phosphate, and sulfate from storm water runoff by aluminum powder”, Kentucky/Tennessee Water Professionals Conference, Chattanooga, TN, 2014.
30	Daniel V. Terrell Award, ASCE Region 4 - The Region 4 Assembly of the American Society of Civil Engineers annually conducts the Daniel V. Terrell Paper Competition for Younger Members. This prestigious competition has been held for over 60 years and commemorates Dean Terrell's many years of work and service to the Society and especially his leadership in the establishment of the District Council System, the predecessor of the Region 4 Assembly. Benjamin's paper titled "Professional and Technical Qualifications for Engineering Faculty: An Important Decision" received second place in the competition. Daniel W. Mead Prize for Younger Members, ASCE National - The Daniel W. Mead Prize for Younger Members was established and endowed in 1939 by Daniel W. Mead, a former American Society of Civil Engineers president. The prize is awarded annually based on a national writing competition on a specific professional/ethical topic . Benjamin was selected as one of three participants to receive a certificate of commendation for his paper titled "Professional and Technical Qualifications for Engineering Faculty: An Important Decision."
34	First Place Award of the Computational Mechanics Student Poster Competition, ASCE 2015 Engineering Mechanics Institute Conference (2015)
35	Only received the F.E., but plan to take the P.E. soon.
36	Pending results of PE exam (taken 10/2017).
37	I became a PE summer 2016

Table D-4. Survey responses to Question 18

Survey Entry #	Responses to Q18 - Additional comments on TTU’s CEE MS graduate program, including any strengths and weaknesses you may have observed.
2	I had a wonderful experience as a MS student in the CEE department. Overall, I felt extremely prepared technically for the types of jobs I was pursuing, in part because I was chasing jobs that were directly related to my coursework. As a transportation-focused student, there were not enough classes in that topic area to fill an entire MS program. However, while some see that as a weakness, I think taking courses in other topic areas such as materials, water resources, and structures as well as those outside the CEE department (e.g., statistics), made me a more well-rounded candidate for jobs.
6	Strength: The TTU CEE MS program curriculum was challenging, which in turn allowed me to learn more and grow in the transportation profession. I commend the professors for their dedication and for investing their time into our education. Weakness: Due to the limited number of professors focused solely in transportation, it was difficult to be able to choose more transportation-related classes for our electives since they were not offered. It would be great to broaden the spectrum and provide other transportation-related classes.
9	While I thoroughly enjoyed concentrating in structural mechanics, it seems to me in hindsight that majoring in civil engineering and concentrating in structural mechanics don't quite go hand in hand. The field that I work in now is more like mechanical engineering than civil. So I get to apply what I learned from structural mechanics quite a bit. But for a student who goes to work in a more traditional civil engineering field, concentrating in structural mechanics would be of little benefit to them directly. He would gain a good understanding of solid mechanics, but probably be behind on modern structural design techniques. Although concentrating in structural mechanics has worked out well for me, it may be appropriate to rethink offering structural mechanics as part of the civil engineering curriculum. It may benefit future students to offer that concentration as part of the mechanical engineering curriculum instead.
12	I think the greatest strength of the program was the low student to teacher ratio and the availability of professors. I received a lot of help at the individual level and always felt welcome to ask as many questions as I needed until I understood a topic.

Appendix D

Survey Entry #	Responses to Q18 - Additional comments on TTU's CEE MS graduate program, including any strengths and weaknesses you may have observed.
14	The curriculum of the CEE Master's program has prepared me well for the tasks expected of me in the workplace. It is important to be able to express myself both orally and in writing, two skill sets that were developed well during the Masters program at Tennessee Tech.
15	An interview would be more appropriate. The CEE MS graduate program prepared me, but I feel I have been successful mostly because my CEE BS was also from TTU. A building design structural engineer should probably have more pertinent 6000 level classes than what are currently offered. I do understand, however, that the faculty only has so much ability. I would suggest leaving the BS program exactly the way it is, and consider no longer having the structural engineering option for an advanced degree, but instead offer guidance on where a student wishing to pursue an advanced degree in structural engineering should apply. Regarding Question 17, I would recommend the TTU CEE MS degree program to student in materials and environmental/water resources.
16	The program has limited classes for the materials concentration but are very structural mechanics heavy.
20	Not enough focus on making work worthy of going into a journal especially for people who asked. Strong theoretical background. Experimental background good, but need to update accessibility for students to do this type of work. Would like to see a lab manager where people can access the Mechanics of Materials lab. Have suggestions if people would like to follow up.
22	Strength in courses and tutors, weakness in lack of funding for the laboratory equipment
23	I significantly increased my technical knowledge and critical thinking skills during graduate school. I feel that the TTU CEE MS program more adequately prepared me for the work force than my colleagues with similar degrees from other universities. The faculty is very knowledgeable and willing to assist in any way possible. I do wish, however, that I could have had the opportunity for more full-scale research and experimentation.
24	I felt the program was well balanced. We did a lot of report writing and presentations on independent research but also did a lot of in class discussion and problem solving.
26	In the non-thesis CEE MS, I kind of ran out of courses that were in my area of specialization before I completed the necessary hours.
30	Many of the CEE MS classes prepared me well for the industry. I did take a few classes that had no benefit. I also regret that I did not learn how to publish work in scholarly journals while pursuing a MS. I would highly recommend this to be a part of the CEE MS program.
32	Overall, my experience within this program was great. I feel that the education I received was top-notch quality from incredible professors who truly care about the futures of their students. A strength of this program is the close ties formed between the students and faculty/staff. Personally, these strong relationships helped me to not only pursue my dream of higher education but to enjoy the experience along the way. The support and encouragement I received from the faculty/staff when I was in the program and even now after completing the program is such a blessing. The only minor weakness I experienced was the number of design classes for structural engineering. Structural engineering students often complete mechanics classes to meet requirements for the degree. Although mechanics classes provide valuable knowledge, I feel design courses might be more beneficial for students wanting to pursue consulting or design careers.
33	I enjoyed the CEE MS Program greatly. I feel like it prepared me very well for design work. I highly recommend it to anyone and everyone I can, both graduate and undergraduate programs.
34	Faculty members were very knowledgeable and helpful. The courses I took back then still have strong impact on my current career development.
35	In regards to the lack of degree specific classes at other schools (a co-worker is currently dealing with this), I am thankful that there were a variety of structures related courses offered in TTU's graduate program. Being able to take a course on structural dynamics in particular has been very helpful for me in my current position.
36	TTU made it simple to transition from an undergraduate student to a graduate student. The professors are extremely helpful on all levels, and the course work is not so over bearing that you wish you would have never started, but hard enough to push your knowledge limitations. I started at my current company right out school (a week after graduation), and I was performing at the same level and had the same amount of knowledge as other employees who went to Ohio State.

Table D-5. Survey responses to Question 19

Survey Entry #	19) Were there to be one technical and/or workplace skill you wished had been a part of the CEE MS program curriculum, what would it be?
2	I think that oftentimes engineering curriculum focuses so much on technical expertise that other 'soft' skills get left behind. In the workplace, so much of one's technical job responsibilities are learned on the job, but I feel like having some sort of project/team management class or maybe even just a project could have been helpful. Although it wasn't the case for my particular experience in graduate school, I know many MS students who could have benefited from a technical writing course.
6	I would have liked to learn more regarding safety, such as using the MUTCD and the Highway Safety Manual (HSM) for class projects (i.e., crash modification factors, crash rates, etc.). This is the only material I use on the job that I didn't learn in TTU's CEE MS (or BS) program.
7	Exposure to practical experience.
12	I wish I had obtained a better understanding of civil plans at school. I think it would be helpful to have a plan reading/design course available to the students.
13	Sustainability Studies
15	Obviously only so much is possible, but consider the following list of courses for building design engineers only. - ASCE 7 (Loads) - CAD/Revit Modeling (Primary and Advanced Courses) - Light -frame Design (Timber/CFS) - Foundation Design (beyond what is covered in the geotechnical course for BS) - Steel Building Design (Complete) - Concrete Building Design (Complete) I'm not sure you can find these courses in any program, but looking back, these all would have been very beneficial to my career. You could take my MS degree for example using the non-thesis track and replace all but my fast-track courses (Adv. Steel and Adv. Concrete) and Structural Dynamics, and this would be a degree. If the courses offered as dual BS/MS had already been take prior to MS, there are still other great classes to choose from including forensic engineering and theory of elasticity that could help a structural engineering student, just to name a few.
16	ACI certifications
19	It would have been nice to be able to observe my field of study in the real world environment; such as, what do engineers do Day-to-day for the different disciplines of structures, materials, or traffic engineering. That could have helped my choice as to where I wanted to apply for internships and jobs.
20	Technical writing course or English department available for this type of help.
22	Bring attention to decentralized wastewater treatment technologies and areas Emphasize on process controls and latest software used in the industry
23	Wind load provisions of ASCE 7; Code requirements for analysis and design/detailing of lateral force resisting systems (ordinary, intermediate, and special braced and moment frames and shear walls)
26	More communication skills building for the non-thesis CEE MS (presentations, etc)
30	I wish I would have learned how to publish work in scholarly journals.
31	A class involving use of a load code particularly ASCE 7.
32	I think it could be possible to teach an entire course on structural design loads. Many loads are seen regularly throughout the curriculum such as dead and live loads. However, many others (wind, rain, blast, etc.) slip between classes and are rarely mentioned. I think it would be beneficial to have a basic understanding of these loads and how to design for them in multiple scenarios according to governing design codes.
33	I could say an advanced diaphragm class for structural engineering. That was one area I was not very familiar with out of the program, but it prepared me well enough that I was able to learn it quickly.
35	I would encourage the continuation of teaching future engineers the skills they need to use modeling and analysis software, even if it is only done as a small portion of another class. The program in particular is not as important, as I personally use more than 5 consistently. A good foundation in basic modeling skills and proper interpretation of output are as vital to structural engineers as a knowledge of our codes.
36	More actual design courses. Most of the courses available were theory based.

Employer Survey

The employers of MS graduates from the self-study period were also contacted and asked to fill out an electronic survey. The employers were asked to respond to the following questions or statements:

1. First and last name
2. Name of Institution/Company where employee with a MS degree in Civil and Environmental Engineering (CEE) from Tennessee Tech University (TTU) is employed or enrolled
3. How many years has the employee been in your institution/company
4. What is the job description of the employee?
5. The employee has successfully demonstrated technical competence in the planning and/or design/operation of civil engineering infrastructure and environmental processes (or relevant protocols).
6. The employee presents technical material well at meetings with other staff and with clients.
7. The employee periodically presents work at professional meetings or periodically publishes work in scholarly journals.
8. The employee is trusted with undertaking civil and environmental engineering analysis independently.
9. The employee works well within a team setting to develop civil and environmental engineering solutions.
10. The employee (CEE MS graduate) has successfully undertaken further advanced study at the doctoral level in civil engineering or a related area.
11. The employee has demonstrated a sustained level of productivity since graduation with an MS degree.
12. Based on your experience with the employee with a MS degree in CEE from TTU, would you employ another graduate of the program in future?
13. Please state technical and workplace skills that your Institution/Company desires to see in TTU MS degree graduates in CEE right after their graduation that could be incorporated into the curriculum.

Six employers responded within the survey period. Their responses are summarized in the following tables.

- Details about the employer respondent firms and employees – Table D.6
- Responses to Questions 5 to 12 – Table D.7
- Responses to Questions 13 – Table D.8

Table D-6. Employer Survey Responses to Questions 2 to 4

Survey Entry #	Institution / Company Name	Number of years the employee has been in your institution company	Job description of employee
1	Strand Associates	5	Project Engineer
2	TDOT	0.5	To assist in Preliminary Engineering design and cost estimates. To assist in traffic analysis, Road Safety Audits, and technical report writing.
3	Structural Design Group	1.5	Structural Engineer
4	KCI Technologies, Inc.	4	Professional Engineer – Possesses knowledge, skills, and expertise in providing traffic engineering and transportation planning services to a variety of clients (both public and private).
5	TDOT	0.5	Transportation Project Specialist
6	TDOT	4	TPS - Supervisor

Table D-7. Employer Survey Responses to Questions 5 to 12

Survey Entry #	The employee has						Based on your experience with the employee with a MS degree in CEE from TTU, would you employ another graduate of the program in future?
	Technical competence in planning and/or design/operation of civil engineering	Presents technical material well at meetings.	Periodically presents at professional meetings or publishes	Trusted with undertaking engineering analysis independently	Successfully undertaken doctoral study	Demonstrated a sustained level of productivity	
1	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	(no response)	Strongly Agree
2	Strongly Agree	Strongly Agree	Agree	Agree	Strongly Agree	No	Strongly Agree
3	Agree	Agree	Disagree	Disagree	Agree	No	Agree
4	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	No	Strongly Agree
5	Strongly Agree	Strongly Agree	No opinion	Agree	Strongly Agree	No	Strongly Agree
6	Strongly Agree	Strongly Agree	No opinion	Strongly Agree	Agree	No	Strongly Agree

Table D-8. Employer Survey Responses to Question 13

Survey Entry #	Please state technical and workplace skills that your Institution/Company desires to see in TTU MS degree graduates in CEE right after their graduation that could be incorporated into the curriculum.
2	The employee is highly skilled in traffic analysis and roadway design. The employee needs oversight when applying MUTCD and Safety analysis and design. TTU needs a class that dives into the details of the Highway Safety Manual and MUTCD as well as how to calculate crash rates and improve safety design concepts through crash history patterns.
4	I believe it is extremely important that an engineering program (specifically transportation or civil) expose students to the social, cultural, and political environment for which they will be working. It is no longer simply building something that is technically sound. Questions of who are we building it for? What are the needs or desires for the improvement? How will it be used? What is the current and future context for which we are building/designing the improvement? Who will it serve? What are the negative or unintended impacts to others (and how do we mitigate them)? I am not sure there is a single work or phase for this thought but it is more in the avenue of holistic or broad spectrum thinking (context sensitive solutions). Additionally, I think some aspect of critical thinking. They need to ask why and understand the reason for doing what they are doing rather than just doing it because they were asked to design something. These comments are based on what I see for the profession as a whole. Additionally, students need to be thinking about future implications (autonomous or driverless vehicles, greater use of technologies, etc.) and an aging and diverse future population. These will be the future users of the designs they are solving for (ex – larger lettered street signs for older drivers, etc.).

APPENDIX E

Master of Science in Civil and Environmental Engineering
Oral Defense and Thesis Assessment Form

Appendix E

Master of Science in Civil and Environmental Engineering
Oral Defense and Thesis Assessment Form

Candidate Name: _____ Sub-discipline: _____

Committee Member _____ Faculty _____ Student _____ (Please check one)

Date: _____

Evaluation of Oral Presentation

Oral Presentation Type (circle): Proposal Thesis Defense

Graduates of the M.S. program in Civil and Environmental Engineering will be able to communicate their ideas effectively with their technical peers and with others outside their discipline. Please assess this candidate's oral presentation and written work using the following scale:

Not Acceptable	Below Expectations	Meets Expectations	Above Expectations
1	2	3	4

1 2 3 4	**Content:** appropriate, complete, concise, and logically organized; problem, approach and results clear; appropriate use of time.
1 2 3 4	**Visual aids:** readable & clear, concise wording, effective use of graphics, appropriate amount of information
1 2 3 4	**Presenter:** appears well-prepared, vocabulary technically correct and audience-appropriate
1 2 3 4	**Presentation mechanics:** good voice volume, enunciation, speed; free of hesitations, distracting mannerisms; good poise, eye contact
1 2 3 4	**Responses to questions and comments**: appropriate, direct, and complete

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Evaluation of Thesis Document

1 2 3 4	**Quality of English**: good grammatical form, voice, tense, punctuation. Concise presentation
1 2 3 4	**Technical content**: clear description of problem, state-of-the-art, technical approach, and results; relevant and timely references
1 2 3 4	**Technical writing**: good organization; clear description of problem; clear figures and tables