**The Master of Science (M.S) Program in Civil Engineering**
**Tennessee Technological University**

## Executive Summary

The Master of Science (M.S) program in the Department of Civil and Environmental Engineering (CEE) at Tennessee Technological University (TTU) started in the late 1960s with the first degree conferred in 1969. The program has always achieved favorable performance assessments in the Tennessee Board of Regents (TBR) external program reviews, with the last self-study report reviewed in 2008. In 2010, CEE faculty were informed that TBR would start a new and more self-reflective concept of review for continuous improvement called the "Academic Quality Work-AQW" (the process) and "Academic Audit-AA" (the review) beginning from 2013. Thus, from the middle of 2010, a journey of self-reflection, honest brokering and creation of a faculty-wide 'mental model' for improvement began. The Graduate Program Coordinator, who had attended the initial Academic Audit workshop organized by TBR in August 2010, initiated the conversation for this journey with the following: *What exactly do we hope to accomplish with the MS program in Civil Engineering? What do we want our students to learn and master when they graduate with an MS degree? Are we learning from best practice? Do we have quantifiable evidence to support what we say is being done right in our MS program? Is "Good Enough" satisfactory, or can we do even better?* These were some of the many questions that faculty began to reflect on and seek answers to through many rounds of dialogue. This Academic Audit report presents a faculty-driven view of the program's strength and weaknesses based on an honest desire for continual improvement. The report has been compiled in the manner suggested by the proponents of Academic Audit (e.g. "*Academic Quality Work*" book written by Massey, Graham and Short, 2007). There are also additional sections on Research and Scholarship given that student-driven inquiry is a critical component of the MS program for achieving the program objectives. A webpage dedicated to the academic audit has been created at http://www.tntech.edu/cee/academic-audit/ to facilitate the review of this report and various supporting documentation. As a first-time effort with only a few years of 'conversation' on the AQW process, the cycle of self-assessment for continual improvement is not entirely complete. When feedback from the audit team is received and integrated into the fledgling AQW process, the MS program will be expected to continue on this new path of continual improvement and complete one full audit cycle for the next review.

## 1.0 INTRODUCTION

The Department of Civil and Environmental Engineering (CEE) has offered a Master of Science and Master of Engineering degree since the late 1960's with the first degrees conferred in 1969. During the past 42 years, more than 320 Master's degrees have been awarded in the areas of structural mechanics, environmental, transportation, geotechnical and structural engineering. The degrees granted include 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. Figure 1 below illustrates the distribution of degrees conferred each academic year since the program was initiated. For detailed information on recent theses titles, names of students, major advisors, and year of graduation, the reader is referred to http://www.tntech.edu/cee/dissertations2005topresent/.

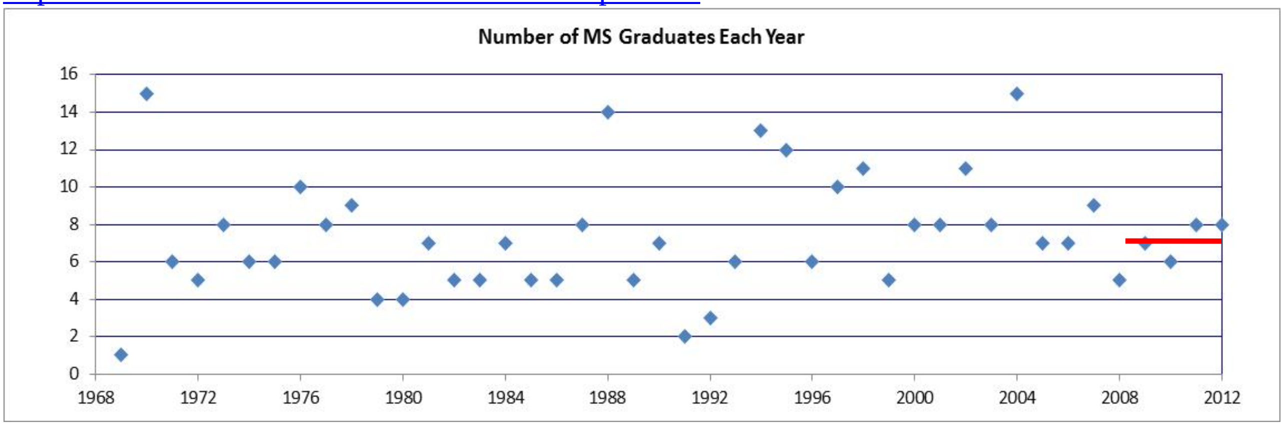


**Figure 1 - Distribution of MS degrees conferred each academic year since inception.**

Since the last program review in 2008, the number of students graduating has remained steady. The most recent 5-year (2008-2012) average annual graduation rate is about 7 graduates per year (Figure 1- see red line). This recent 'equilibrium' state can be explained by the campus-wide strategic repositioning towards a more aggressive PhD program since 2002. Many CEE faculty engaged in sponsored research shifted focus on supporting PhD students in lieu of MS students to build a more self-supporting program. However, a consistent feature of the CEE MS program is that the 5-year running average graduation rate has never been below 5 per year, which is the Tennessee Higher Education Commission (THEC) specified limit below which a graduate program is classified as "low-producing".

The goal of the MS program in CEE is to provide the strong academic training needed for students to both join and make significant contributions to the civil engineering profession in the 21st century and also become well informed productive members of society. By virtue of the diverse nature of the profession, an MS student is required to select and then build emphasis in one of the major focal areas (also referred to as 'area of concentration') recognized by the Tennessee Board of Regents (TBR). These focal areas are: environmental engineering, structural engineering and transportation engineering. A significant number of MS graduates have also specialized in the areas of engineering mechanics, materials, and water resources (see http://www.tntech.edu/cee/dissertations2005topresent/). Since 2008, the total annual graduate enrollment has been steady in the range of 25-30 (of which PhD enrollment is 5-7), which is a significant increase from the annual enrollment of 10-15 (with very few PhD candidates) during the years 2002-2008. A lot of this growth can be attributed to success of the fast-Track BS/MS Program, initiated in 2007, that provides an opportunity for promising undergraduate students to accelerate the completion of the MS degree.

Over the 2008-2012 period, a total of 175 student applications to the CEE MS program were received. One hundred and twenty applications (68%) were granted either provisional or unconditional admission. A total of 50 applicants actually enrolled during this time. Thirty-five (70%) of those enrolled have already successfully completed their MS degree in an average time of 16 months (1 year and 4 months; see Table 2 of Appendix One or http://www.tntech.edu/files/cee/Appendix_One.pdf). The remaining 15 (admitted between 2011-2012), at the time of writing this report, were either continuing their program or were expected to graduate in 2013. The average time to completion of the MS degree represents a considerable improvement over what pertained during the previous round of assessment, where 2 years and 4 months was the average for the 2002-2008 period. This reduction can be attributed to the launch of the BS/M.S fast-track program where most students were able to graduate within 8-12 months. One particular student required 70 months to complete the program because of his part-time status, which underscores the flexibility of the program to accommodate the special needs of certain students.

Demographic data indicate that the graduate student body is made up of both US citizens and international students. More recently, the CEE graduate program has attracted considerably greater solicitations from prospective applicants from reputed institutions such as the Ohio State University, University of Wisconsin, Georgia Institute of Technology Indian Institutes of Technology, Tsinghua University etc. Applications or email inquiries by potential applicants from countries like India, China, Lebanon, Malaysia, Egypt, Iran, Saudi Arabia, Turkey, Russia, Austria, Vietnam, Bangladesh and Philippines are also now more frequent. As a result, the current CEE graduate student body is internationally more diverse than we have had in previous years. This is a testimony to the increasing visibility of the graduate program and its outreach into the international arena. A summary of the demographic characteristics of applicants to the program, their academic performance, job placement, and their major accomplishments are presented in Appendix One (provided online at: http://www.tntech.edu/files/cee/Appendix_One.pdf).

During the completion of the last program review in 2008, the CEE Advisory Board provided input on setting evidence-based quantifiable targets as goals for 2015. Some of the key targets were: 1) Increase global visibility of the graduate program through strategic partnerships with National/Foreign Institutions, and thereby provide MS students with opportunities to become globally more engaged; 2) Increase annual scholarly research journal publications by 100% by 2015; and 3) Establish nationally-recognized niche areas of student-driven research through an externally-funded and sustainable research program. The last self-study report is available for perusal at http://www.tntech.edu/files/cee/MSReviewReport2008.pdf. Although progress towards some of the strategic goals have been satisfactory, the aim of the current report is to present a more introspective view of the MS program with regards to teaching, learning, research and scholarship for the enrolled student according to the AQW’s five focal areas which are described next

## 2.0 OVERALL PERFORMANCE ACCORDING TO AQW CONCEPT

As will be evident in the ensuing discussion of the AQW process, CEE faculty have begun (since late 2010) the process of working together to build a faculty-driven 'mental model' for the MS program. One of the first programmatic evaluation products that resulted from this effort was to conduct surveys of recent and senior MS graduates as well as their employers. Faculty worked collectively to draft commonly agreed upon questionnaires for graduates and employers (detailed description is available under Section 8 "Quality Assurance"). Unlike an exit interview of graduating students, MS alumni have no vested interest in promoting or championing our MS program, particularly if their expectations had not been fulfilled in becoming a useful member of the profession. Thus such surveys were deemed by faculty as a more honest reflection of 'overall performance' and a good starting point to initiate the AQW dialogue. More than 60 alumni (going as far back as the class of 1998) and employers were surveyed on their overall perception of the quality of the MS program (see http://www.tntech.edu/files/cee/Alumni_Survey_Results.pdf for details). Among the many aspects surveyed, alumni were asked if they would recommend the MS program to anyone else. Employers were also asked if they would hire an MS graduate again from TTU in Civil Engineering. Ninety-six (96) percent of alumni and 100 percent of employers responded in the affirmative, respectively. Although this verifies in principle the faculty-held assessment of satisfactory overall performance, there is certainly a lot of room for improvement in various areas of the MS program that will be elaborated later in this report.

Table 1 below shows the makeup of CEE faculty expertise in core areas of civil engineering research. Several CEE faculty have cross disciplinary expertise that allow them to play a more synergistic mentoring role during a student's MS candidature. Detailed qualifications of each faculty are available on the CEE website at http://www.tntech.edu/cee/facultystaff. The cross-disciplinary expertise of CEE faculty is very important for the MS program. By design, the MS program is student-centric and cannot function without the close collaboration of multiple faculty throughout the student's candidature. This is because of the multiple tasks and milestones that each student must accomplish in close consultation with at least 3 or more faculty relevant to the area of concentration to fulfill the minimum requirements for graduation. These key tasks and milestones are: 1) The student must file a Program of Study (POS) with the Graduate School; 2) student must form an advisory committee comprising at least 3 faculty members relevant to the study objectives; 3) The student must prepare a proposal and successfully defend the proposal in a manner that is acceptable to the student's advisory committee; 4) The student must prepare and successfully defend, to the satisfaction of the advisory committee, a research thesis (for thesis option) or a project report (for non-thesis option). Naturally, multiple faculty serving on the advisory committee, are required to work collaboratively in advising an MS student during a typical 24 month candidature. The cross-disciplinary expertise of each faculty only fosters greater collaboration for the student's benefit.

On matters, such as curriculum and co-curriculum development, student teaching and learning, the recent initiation of the AQW process has also fostered a new sense of faculty collaboration for programmatic improvement in each area of concentration. For example, with some exceptions, most faculty seldom considered the concept of curriculum sequencing and topic selection within a course to ensure a more positive and seamless impact on learning as a student progresses from one course to another. While curriculum sequencing needs further development, faculty in the transportation and water resources area have already worked closely together to discuss ways to reorganize their respective course topics to allow a smoother and more holistic learning experience on a discipline for the student. Faculty in other areas are also catching up to this concept of curriculum sequencing (discussed more under section "Curriculum and co-curriculum").

**Table 1**: Summary of faculty expertise in the CEE Department

| Sl | Name | PhD Degree | Area of Specialization | | | | |
|---|---|---|---|---|---|---|---|
| | | | Geotechnical/ Materials | Transport-ation | Structural Mechanics | Structural Engineering | Water/ Environ. |
| 1 | Daniel Badoe | U Toronto | X | X | | | |
| 2 | Kevin Young | . | | | | | X |
| 3 | Steven Click | NCSU | | X | | | |
| 4 | Lenly Weathers | U. Iowa | | | | | X |
| 5 | Alfred Kalyanapu | U Utah | | | | | X |
| 6 | Faisal Hossain | U. Conn | | | | | X |
| 7 | Dennis George | Clemson | | | | | X |
| 8 | Jane Liu | U. Hawaii | | | X | X | |
| 9 | Sharon Huo | U. Nebraska | | | X | X | |
| 10 | Craig Henderson | U Tenn. | | | X | X | |
| 11 | Ed Ryan | U. New Mexico | X | | | X | |
| 12 | David Huddleston | U Tenn. | | | X | | X |
| 13 | Ben Mohr | GA Tech | X | | | | |
| 14 | L. K. Crouch | Missouri | X | X | | | |
| 15 | Guillermo Ramirez | Colorado State U. | | | X | X | |

Regarding program objectives for each area of concentration (structural, transportation and environmental engineering), following the AQW process has prompted CEE faculty to collectively seek answers to questions such as: '*what do we want our students to learn in the MS program?'* and '*what are the minimum skills that we want our MS graduates to have at the time they enter the workforce?"* Seeking answer to such questions led to the collective articulation of program objectives and outcomes for each emphasis area (see http://www.tntech.edu/files/cee/Program_Objectives_and_Graduate_Student_Plan.pdf) that did not exist in writing until the AQW process started. Since the articulation of program objectives, a self-assessment of the program to continuously identify weaknesses and correct them has begun. This assessment (described later in detail) focuses on content (syllabi) restructuring, effectiveness of instructional delivery, perception of peers and survey of alumni and employers. Recently (in 2010), faculty also unanimously agreed to make attending a newly formulated 1-hour graduate course (CEE6910 CEE Graduate Seminar) mandatory for all graduate students. In this course, all enrolled students receive 3 weeks of intense training on conducting research, plagiarism detection and thesis/proposal writing and attend seminars on diverse CEE topics during the semester. In the same year, a graduate club and blog was initiated (see http://ttuceegraduateclub.blogspot.com/) to foster a greater sense of camaraderie among graduate students and faculty. This graduate club also organizes a once-a-year social event for faculty-student interaction. Overall, there are now a considerably larger number of schemes in place for continuous assessment of the MS program since 2008.

In summary, quantifiable evidence so far indicates that the overall performance, according to AQW standards, is satisfactory and aligned towards self-improvement during the next full-cycle Academic Audit.

**3.0 LEARNING OBJECTIVES**

As part of the AQW process, CEE faculty participated in a discussion in late 2011 to finalize a draft for learning objectives of the MS program. In addition, representative faculty from each area of concentration, who also make up the CEE graduate affairs committee, were tasked with formulating area-specific learning objectives and outcomes through discussion with colleagues in their respective area. A series of meetings were held among faculty to reach a commonly agreed upon set of objectives. To learn from best practices, a number of peer institutions were also reviewed. The complete documents on learning objectives and outcomes are posted at http://www.tntech.edu/files/cee/Program_Objectives_and_Graduate_Student_Plan.pdf.

**Program Objectives of the M.S. in Civil Engineering are:**

1. *Graduates of the M.S. program will have the technical competence to be successful in the chosen area of study in civil engineering professional practice or research.*
2. *Graduates of the M.S. program will have the skills to undertake technically sound analysis independently and present their work at professional meetings or publish their work in scholarly journals.*
3. *Graduates of the M.S. program 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.*

**Student Learning Outcomes are:**

Students of the MS program in Civil Engineering will be able to:

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

CEE faculty agreed that there already existed mechanisms in place to achieve and verify the above program objectives as follows:

**Program Objective#1:** through technical work in courses, attendance of CEE6910 (seminar), examination role by students' graduate committee and survey of alumni and employers.

**Program Objective #2:** through completion of core course requirements in civil engineering (curriculum) and completion of other graduate level course work (co-curriculum); comprehensive examination, oral defense of thesis or project report and scholarly publications.
**Program Objective#3:** through advisor-guided studies, comprehensive exam, seminar series and acceptance to Doctoral program at peer institutions.

Similarly for student learning outcomes, the mechanisms or tools in place for verification are as follows:

**Learning Outcome#1:** through aptitude in graduate level coursework and a thesis or independent project that is acceptable to the committee.
**Learning Outcome#2:** through project work and graduate level courses.
**Learning Outcome#3:** through a thesis or project report, and its acceptable presentation to the advisory committee.

**Essential Student Learning Objectives per Area of Concentration**

Water Resources/Environmental – *Students will have advanced level knowledge on environmental chemistry, transport and quantitative methods.*
Transportation/Materials – *Students will have advanced level knowledge of cement-based materials or traffic control and transportation demand analysis.*
Structural Mechanics/Engineering- *Students will have advanced level knowledge in the areas of structural analysis, behavior of structures, and design of structures with concrete, steel or masonry.*
Structural Mechanics- *Students will have advanced level knowledge in the area of theoretical and computational mechanics, statics and dynamics behavior of continuum media.*

Section Eight, titled “Quality Assurance,” provides independent evidence on how well the objectives and outcomes are currently being met via surveys of MS graduate alumni and employers. In the next section, titled ‘Curriculum and Co-curriculum”, the design and recent revisions by faculty of the MS curriculum for better alignment with the AQW process are discussed.

## 4.0 CURRICULUM AND CO-CURRICULUM

Curriculum design and co-curriculum selection for the MS program go through periodic updates in response to the continual changes in focus and requirements for research, scholarship, and advanced training expected of Civil Engineers in this fast changing world. Consistent with this, periodic updating of existing courses and/or introduction of new courses is a necessity to provide an educational experience to students that is relevant. The complete listing of graduate courses in Civil Engineering and the syllabi are made available at http://www.tntech.edu/cee/graduate-course-syllabi-academic-audit/. The frequency with which courses have been offered over the last 5 years and the list of new courses introduced in each area of emphasis, are provided in Tables 1 and 2 of Appendix Two (http://www.tntech.edu/files/cee/Appendix_Two.pdf)

One of the major initiatives in curriculum 'realignment' along the AQW principles was reformatting all syllabi for graduate courses according to a standard one page template focusing on goals and measurable outcomes. Appendix Two provides a sample of the typical one-page format for the graduate course CEE6440 Hydrometeorology along with frequency of course delivery. This reformatting enforced consistency across all syllabi by articulating explicitly the learning objectives, outcomes and providing a detailed breakdown of topics aligned to those objectives and outcomes. Such a realignment of curriculum was a major faculty-wide effort that began during Fall semester of 2010 and ended in early 2012. This effort prompted each individual faculty to reflect, in consultation with his/her colleagues, on *what exactly he/she intended to accomplish through instruction regarding student learning and how well did the course objectives align to overall program objectives?*

Faculty agreed that the standard one-page template should provide the following key information in a bullet format: a) course goals b) learning objectives, c) major topics covered and c) measureable outcomes. During this process of syllabi reformatting, it was realized that there would be many advantages to such a standard and uniform template for reformatting the graduate curriculum. First and foremost, the syllabi reformatting prompted individual faculty engaged in instruction of graduate courses to reflect more deeply on learning objectives and measurable outcomes in the spirit of the AQW process and the MS program's overall goals. Second, such a format, being very similar to the format used for syllabi of undergraduate courses for periodic B.S. program accreditation by ABET (Accreditation Board for Engineering and Technology) Inc., builds natural synergy in curriculum sequencing and topic realignment for the BS/MS fast-track program in which qualified undergraduate seniors have the opportunity to complete their MS degree in a shorter than normal period. Lastly, the breakdown of syllabi into measureable outcomes and topics, allows faculty to systematically tweak with content and delivery mechanisms until the course learning objectives are achieved. All graduate course syllabi reformatted according to the new one-page AQW format are available for perusal at http://www.tntech.edu/cee/graduate-course-syllabi-academic-audit/). To compare the improvements in course restructuring, the previous format employing a hap-hazard approach (such as for the previous MS Program review) is also provided at http://www.tntech.edu/files/cee/pdfs/Course_Syllabi_in_Old_Format.pdf

As the curriculum reformatting has only recently been completed (spring 2012), one full cycle of delivery and iteration to improve content delivery and assess student learning according to the AQW concept was not available at the time of writing this report. However, assessment of the effectiveness of the instruction of graduate curriculum is expected to be available for select graduate courses taught during the Fall semester of 2012 in anticipation of the Spring 2013 AA auditor team visit. Nevertheless, there is already considerable evidence available from the delivery according to the less-structured and self-styled (non-AQW) format created by individual faculty and archived in their course folders. Assessments of student learning in the form of homework, class projects and exams are available for each CEE graduate course upon request. Current documentation reported in the previous self-study report and accumulated since 2002 appears to indicate that achievement of student learning outcomes have been in the 'ball park' because of the many student-authored class project reports, assignments, journal publications, presentations, theses produced in the pertinent area (see Tables 3a and 3b of Appendix One for a summary of this evidence). In addition, the survey of alumni and employers (see section on "Quality Assurance" for more details) indicates that faculty is able to meet most of the course objectives. Faculty recognize that the AQW process should now allow a more thorough assessment of objectives, outcomes and student learning of individual topics by conducting mid or end-of-the-semester surveys of students according to the AQW-formatted syllabi.

**Relevance of Curriculum to Program Objectives**

There is no general core curriculum for the MS in Civil Engineering but instead, students must take a core of courses according to the area of concentration. Students must work with their graduate advisory committee to establish the program of study and research thesis or project. Each area of concentration is next presented with the core of courses recommended for every student. These core requirements reflect the essential learning objective and outcomes outlined for each area in the previous section on "Learning Objectives."

**Core Courses for the Water Resources and Environmental Engineering Concentration:**

(1) CEE 6610 – Applied Environmental Chemistry
(2) CEE 6520 – Open Channel Hydraulics
(3) Statistics Course (Specific Course is dependent on research area)

Students select a Statistics course in consultation with their major advisor.

**Core Courses for the Structural Engineering Concentration:**

(1) CEE 6930 – Theory of Elasticity
(2) CEE 7610 – Finite Element Analysis I

**Core Courses for the Transportation Engineering Concentration:**

(1) CEE 6470 – Transportation Demand Analysis
(2) CEE 6410 – Traffic Control Systems
(3) CEE 6300 – Composition and Properties of Concrete (or Multi-Scale Analysis of Concrete)
(4) Statistics or Materials Course – Statistical Inference for Engineers (CEE 6200, formerly ISE 6200) or Advanced Mechanics of Material (CEE5190).

Students pursuing a Program of Study with emphasis on transportation materials are required to take a course in Composition and Properties of Concrete (CEE 6300) and either Statistical Inference for Engineers (CEE6200, formerly ISE6200) or Advanced Mechanics of Material (CEE5190). Students pursuing a Program of Study with emphasis on transportation planning and operations are required to take Transportation Demand Analysis (CEE6470), Traffic Control Systems (CEE 6410), and one of the courses in statistics, which is determined in consultation with the major advisor.

**Core Courses for the Structural Mechanics Concentration:**

(1) CEE 6930 – Theory of Elasticity
(2) CEE 7610 – Finite Element Analysis I
(3) MATH 5510 – Advanced Math for Engineers

The CEE curriculum committee regularly reviews the relevance of the curriculum, and faculty, when warranted, propose changes (additions, deletions, or consolidation) to keep coursework relevant and on the cutting edge. During 2002-2012, twenty-two new and timely graduate courses were designed and taught by faculty in the various areas. Nine of these courses were introduced in the 2008-2012 period alone. These courses bring newer insights to the changing field as well as an inter-disciplinary depth and breadth that have now become a necessary feature of the Civil Engineering profession today. Table 2 in Appendix Two provides a listing of the new courses that have been added as part of curriculum enhancement along with a brief justification (http://www.tntech.edu/files/cee/Appendix_Two.pdf).

**Co-Curriculum (Inter-disciplinary Coursework)**

Graduate students have many options available to them with regards to co-curriculum (i.e. course work taken outside of the CEE department). For example, the structural mechanics specialization is highly interdisciplinary by nature with strong collaboration between faculty from CEE and Mechanical Engineering (ME). Similarly, students who choose the environmental option have substantial opportunities for collaboration with students and faculty from the broad environmental science community (such as Biology and Geology). Recently, the materials area has focused resources and energy on participation in collaborative research with Chemical Engineering (ChE) faculty and students in the study of cement properties and performance. The interdisciplinary emphasis is balanced by requiring that the majority of the course-hours in the students' program of study must be earned from courses taken in the CEE department. Appendix Two (Table 3) summarizes the number of non-CEE courses and hours taken by CEE graduate students by department and emphasis area (http://www.tntech.edu/files/cee/Appendix_Two.pdf). In addition, the programs of study of students who graduated during 2008-2012 are provided online at http://www.tntech.edu/files/cee/POS_of_MS_Students.pdf. These programs of study exemplify the nature of specialization pursued by each candidate through co-curriculum beyond the minimum that is required as core to meet the program objectives in each area.

**Curriculum Sequencing**

Sequencing of curriculum is defined herein as the realignment and selection of topics within a course that allow a seamless transition for the student to learn the next course on the basis of content learned in the preceding courses. In general, the concept of prerequisite or co-requisite courses is supposed to address this need somewhat. However, many courses are not pre or co-requisites at the graduate level. If the topics within a course are not carefully examined holistically vis-a-vis other courses, then there can be substantial redundancy or learning difficulty for the student. When the AQW process started, CEE faculty generally recognized the importance of this effort in their respective areas of concentration. However, verification of sequencing and the necessary modification of content is currently a work in progress. At the time of writing the report, four faculty in the water resources area (Huddleston, Kalyanapu, Hossain and Young) have discussed sequencing of topics to maximize the positive impact on students. In addition, transportation and materials faculty have traditionally performed informal course sequencing of graduate courses in a collaborative environment. A quick overview of the reformatted syllabi (see http://www.tntech.edu/cee/graduate-course-syllabi-academic-audit/) along with the frequency of course offering (Table 1 of Appendix Two) indicates that there is no major overlap of course topics and that courses in general are designed to achieve the desired seamless transition in learning for the student.

Faculty have also outlined a recommended plan for students in a given area of concentration as a 'flowchart' of actions to complete each semester. The recommended plan is essentially the sequence of courses, tasks and milestones that each student are expected (or have in the past) to complete each semester within a stipulated time period. This recommended plan emerged from a mental model by faculty from each area and prompted by the AQW process. It acts as a 'guide' to ensure that students are not drifting aimlessly in their program. The plans for each area are provided at http://www.tntech.edu/files/cee/Graduate_Student_Plan.pdf.

## 5.0 TEACHING AND LEARNING METHODS

By design, the MS program (thesis or non-thesis option) has a fundamentally strong self-inquiry driven component that ties with the instructional component (of courses). The goal of self-inquiry is to make MS graduates 'independent thinkers, researchers or problem solvers' for the Civil Engineering profession. Thus 'research and scholarship' is a core vehicle for achieving the objectives of the program. The assessment of the AQW focal area of "teaching and learning methods" is better served if cast within the context of "research and scholarship" (section 7.4). Please refer to section 7 (and 7.4) for discussion of the AQW focal area of 'Teaching and Learning Methods').

## 6.0 STUDENT LEARNING ASSESSMENT

In line with the argument outlined above in section 5.0, the next section on "Research and Scholarship" addresses the AQW focal area of "student learning assessment" for the MS program (see section 7.4).

## 7.0 QUALITY ASSURANCE

### 7.1 IN-HOUSE QUALITY ASSURANCE PROTOCOLS

The primary responsibility to monitor student progress resides with the major advisor. For students who have not yet formed a graduate advisory committee, the responsibility resides with the CEE Chairperson or the Chair's designee. Typically, a new student admitted to the MS program is first advised to confer with the chairperson or his/her designee to determine specific chronological requirements. Generally, the following checkpoints are verified in sequence to ensure steady progress toward degree objectives and a minimum quality of graduate education.

1. **Standardized Examinations.** Admission to graduate study is conditional on an applicant having attained satisfactory test scores on the Graduate Record Examination (GRE).
2. **Appointment of an Advisory Committee**. The graduate student's advisory committee is appointed during the student's first term but no later than the term in which 15 credit hours of course work are to be completed. The mission of this committee is to be 'available' for guidance of the student as needed and also ensure that the student embarks on a journey of self-inquiry that is relevant to the Civil Engineering profession.
3. **Program of Study**. The student's program of study (also referred to as "plan of study" previously) is developed by the student as soon as an advisory committee is selected. In this plan of study (see http://www.tntech.edu/files/cee/POS_of_MS_Students.pdf) the student outlines a thoughtful plan on which courses to take, the order in which these courses should be taken, and the amount of effort to be devoted to research/project each semester.

4. **Proposal**. Either formally or informally, the student has to identify a research problem of interest, and then present a plan for self-inquiry that demonstrates an ability to independently address the research objectives to the satisfaction of the advisory committee. During this stage, a student receives constructive input from the Advisory Committee on improving the plan to make a successful study more likely.

5. **Comprehensive (Oral) Examination**. The student must complete a comprehensive examination, a part of which is open to the public, conducted by the Advisory Committee at least three weeks prior to graduation. During this stage, the quality of the student's work and development as an independent thinker is assessed by the advisory committee to determine if he/she is indeed ready to be classified as a "Master of Science" in Civil Engineering. Prior to and after the comprehensive oral examination, the thesis document goes through rounds of editing and revision in close consultation with the major advisor and the advisory committee until it is of acceptable quality and meets graduate school requirements.

6. **Thesis Submission to Graduate School Office**. The student has to submit the final version of his/her thesis (for thesis option) or project report (for non-thesis option) to the Graduate School at least two weeks prior to graduation.

For initial advisement, all new MS students meet with the CEE chairperson or the Chair's designee to discuss the graduate program and determine the student's interest, potential funding sources, and other personal needs. They agree on the first semester program of study, and then students are advised to meet individually with each faculty member in the chosen area of concentration to discuss coursework, research and funding. The student is responsible for forming a graduate committee and determining a research project which is satisfactory to all concerned.

After the formation of the committee, each member of a graduate student's advisory committee is expected to review the student's proposal and to approve it or make recommendations toward improvement. This step is completed before the student registers for credits on research or project work. Unless an exception has been granted by the departmental chairperson, the dean of the college, and the Associate Vice President of Research and Graduate Studies, a graduate student who has earned at least 15 semester hours of course credit that does not have an appropriate advisory committee is not be permitted to register. This is a key step for quality assurance of the graduate program. After 15 semester hours have been earned, failure to form or to maintain an appropriate committee is cause for transfer of the student to non-degree status.

### 7.2 PEER TO PEER STUDENT INTERACTION FOR QUALITY ENHANCEMENT

The steady graduate enrollment has allowed students to be immersed within a group of peers and enrich their graduate experience both on the individual and collective level. For example, collective participation in student orientation and graduate seminars became a regular event from 2005 and has been mandatory since 2010 (see http://www.tntech.edu/cee/currentseminarschedule/ and http://www.tntech.edu/cee/archivedgraduateseminars/). This is a key weekly forum where students regularly and collectively exercise their curiosity to understand and learn more about emerging issues in Civil Engineering that are otherwise not easily apparent from regular coursework or traditional research. Graduate students also receive a 3-week intense training on conducting research, plagiarism detection and thesis writing while attending the seminars on diverse CEE topics during the semester. Students also present their own research prior to their comprehensive examination for critique by their fellow peers. The Student Research Day organized each year in April by the University's Office of Research has also regularly seen multiple submissions of graduate student work often in the same area of specialization. Several CEE students have won the best poster/paper award at this event. Most students are also members of their respective scientific/professional bodies, such as ASCE, AGU, ITE, ACI, PCI, and Sigma Xi etc. graduate club and blog (see http://ttuceegraduateclub.blogspot.com/) to foster a greater sense of camaraderie among TTU-CEE graduate students. This graduate club also organizes a once-a-year social event for faculty-student interaction. Such interaction allows an outside-classroom forum for graduate students to get to know the greater CEE faculty and candidly express their concerns about the program or department.

Students also utilize a wide range of enrichment opportunities to ensure a healthy scholarly environment. The graduate seminar series, graduate club and blog, already described earlier, are the most notable examples as they are sustained by student participation and presentations. The Stonecipher Symposium is another event organized each year by the University where a nationally recognized authority is hosted for a seminar on a timely topic. Students also regularly attend regional and national conferences where they present their research in public (see Appendix Three at http://www.tntech.edu/files/cee/Appendix_Three.pdf).

Lastly, as one specific measure of quality assurance, a Civil Engineering Graduate Handbook to guide new and senior graduate students effectively through the MS degree, was compiled in 2007 and is periodically updated. This handbook is currently provided to all entering CEE graduate students during an orientation that is held the first class of the CEE6910 CEE Graduate seminar series. The handbook is also made available on the CEE website (http://www.tntech.edu/cee/graduate). The collective impact of the various quality assurance protocols described earlier in sections 8.1, 8.2 and also in previous sections, was recently gauged through an online survey of alumni and employers (described next).

### 7.3 SURVEY RESULTS: IMPACT OF QA/QC PROTOCOLS

One way of evaluating the effectiveness of the graduate program and identifying remedial measures to correct existing weaknesses is to track student performance after graduation. Historically, qualitative reports in terms of awards, placement, attendance of seminars, workshops and industry feedback have been collected. These usually indicated that graduate students are well prepared for a professional career in civil engineering. Also, informal efforts to collect data from alumni would indicate that graduates had secured placement in industry or academia, while several pursued a PhD at prestigious institutions.

As part of the AQW process, formalized surveys of recent and senior MS graduates as well as their employers were conducted. Faculty worked collectively to draft questionnaires for graduates and employers. The questionnaires were aligned closely to the program objectives and outcomes. The survey was conducted online via surveymonkey.com. The sample questionnaire for alumni and employers are available at http://www.tntech.edu/files/cee/Alumni_Survey_Results.pdf and http://www.tntech.edu/files/cee/Employer_Survey_Results.pdf, respectively. The key statements of accomplishments and questions that faculty through collaborative discussion drafted are:

**For Alumni (graduated with a MS degree):**

1. *The CEE MS degree has provided me with skills to be successful in civil engineering professional practice.*
2. *The CEE MS degree has made me aware of the present day professional practice in my area of study in civil engineering.*
3. *The CEE MS degree has provided me with the necessary skills to present work at professional meetings or publish work in scholarly journals.*
4. *The CEE MS degree has provided me with skills to independently undertake technically sound analysis*
5. *The CEE MS degree has provided me with the technical competence needed to successfully undertake further advanced study at the doctoral level in civil engineering or a related area.*
6. *The CEE MS degree has provided me with the technical competence to pursue lifelong learning through professional education.*
7. *Would you recommend the TTU CEE MS degree program to other potential candidates in future?*

The first six questions were framed as multiple choice (no opinion, strongly disagree, disagree, agree and strongly agree). The seventh question required selecting one of two possible answers (yes or no).

**For Employers:**

1. *The employee has successfully demonstrated technical competence in the planning and/or design of civil engineering infrastructure*
2. *The employee is aware of the present day professional practice in his/her area in civil engineering.*
3. *The employee has successfully presented work at professional meetings or published work in scholarly journals.*
4. *The employee has demonstrated skills to undertake technically sound analysis independently*
5. *If applicable: the graduate has successfully undertaken further advanced study at the doctoral level in civil engineering or a related area.*
6. *The employee is pursuing lifelong learning through professional education.*
7. *The employee has developed civil engineering solutions within a team setting.*
8. *The employee has demonstrated a sustained level of productivity since graduation.*
9. *If other vacancies exist within your organization, would you hire more TTU CEE MS degree graduates with the same educational background?*

The first eight questions were framed as multiple choice (no opinion, strongly disagree, disagree, agree and strongly agree). The ninth question required selecting one of two possible answers (yes or no).

It is reassuring to observe that 96% of alumni would recommend the MS program to someone else, and 100% of employers would hire another graduate from TTU's MS program in Civil Engineering. A careful look at the breakdown of the survey results indicate that the following areas may be potential weaknesses of the program and hence require faculty collaboration for long-term improvement:

1) Alumni are not entirely convinced on aspect #2 - *The CEE MS degree has made me aware of the present day professional practice in my area of study in civil engineering*

2) Alumni are somewhat skeptical about aspect#4 - *The CEE MS degree has provided me with skills to independently undertake technically sound analysis*. Part of the less-than-convincing response can be explained from the fact that a small percentage of the alumni surveyed actually pursued a PhD degree elsewhere. Hence, most were probably unclear about this aspect. Nevertheless, this aspect requires a further breakdown by tracking specifically those who are or have pursued a PhD degree and soliciting their feedback.

3) One particular alumnus (recent) was strongly against recommending the MS program to anyone else. While this is clearly a statistical outlier (representing less than 3.5% of the overall response rate), it still deserved careful scrutiny. Further investigation revealed that there had been a divergence in expectations between the advisor and the student according to the complaints lodged by the student with the erstwhile chairperson. For future remedial effort, it may be worthwhile to have provisions in the Graduate Handbook that clearly state the minimum expectations of behavior from student and advisor to avoid such misunderstandings. The advisory committee should also strive to inform all students early regarding the nature of the committee-student relationship and the privileges/rights that come with it.

4) For the employer survey, the response rate was 40%; however, the number of respondents is statistically small (4). Therefore more effort needs to be put in casting the employer net wide and soliciting their feedback. More data will be obtained as tracking improves.

## 8.0 RESEARCH OUTCOMES

Both the thesis and non-thesis option of the MS program require a significant component of self-inquiry driven investigation to impart graduates with independent thinking and problem solving skills. For the thesis option, this is achieved by requiring a thesis that entails at least 6 credit hours of research, that is well documented, that is to be defended successfully, and demonstrated to be of relevance through scholarly publications and presentations. 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 force students to think independently. The essential research objective outcome for the MS program (both thesis and non-thesis options) are the objective#3 and outcome#3 of the overall MS program, respectively, already outlined in section 3. To repeat, these are:

**Research Objective:** *Graduates of the M.S. program 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.*

**Research Outcome:** *Make professional presentations or write scholarly manuscripts worthy of publication in peer reviewed journals.*

A critical element of the process for facilitating a students' development in independent thinking is the requirement that each student work on a research project of real-world significance to the Civil Engineering discipline and to present their work at a peer-reviewed conference and/or publish it in a peer-reviewed journal Titles of conference and journal publications authored by MS students are summarized in Tables 1 and 2 of Appendix Three (see http://www.tntech.edu/files/cee/Appendix_Three.pdf) and the thesis titles are listed in http://www.tntech.edu/cee/dissertations2005topresent/. These titles indicate the real-world nature of the research projects undertaken by MS students. The research projects, being directly relevant to the graduate course curriculum, allow students to apply the learning acquired in the class room on a real-world problem pertinent to society. As an example, a student in the water resources area, after taking *Engineering Hydrology* (CEE5420) and *Water Resources Engineering* (CEE 5440), should be able to tackle a hydrologic modeling problem for a real watershed where research is an on-going effort.

Most graduate courses taught by CEE faculty have a 'class project and/or critical review paper' component to develop/reinforce the independent thinking ability of the students. These class projects and review papers, when well integrated into the instructional pedagogy, make students become better learners while faculty become better teachers. Currently there is no hard quantitative evidence to show the extent to which a faculty's research program is integrated into the instructional methodology of his/her graduate courses and the impact it has on student learning. A continuation of the AQW process should shed light on this aspect.

## 9.0 RESEARCH ENVIRONMENT AND SUPPORT

Space is available for instruction of graduate courses and for conducting student-driven research in physical laboratories. All classrooms are equipped with state of the art multi-media presentation facilities that can be used for instruction, presentations by students, and which allows the presentation of quality seminars. Graduate students often use these rooms for their comprehensive exams, dissertation defense, and class project/seminar presentations. Each area of concentration has specific rooms or floor space designated for research and development. The rooms are adequately stocked with supplies, and have the necessary equipment for research as well. Currently there are a total of seven types of laboratories for performing graduate level research. These are: 1) The Cement-based Materials Laboratory; 2) The Construction and Materials Laboratory; 3) The Surveying Laboratory; 4) The Structures Laboratory; 5) The Environmental Research Laboratory; 6) The Mechanics and Experimental Stress Laboratory; and 7) The Transportation Laboratory. There also exists a Machine Shop where CEE students can have their experimental apparatus built and customized. The condition of these laboratories ranges from good to excellent. The total laboratory floor space is 17,297 sq. ft (see Table 3, Appendix Three http://www.tntech.edu/files/cee/Appendix_Three.pdf).

MS students on a graduate assistantship are generally provided with office space and a personal computer. There are also an additional 14 state-of-the-art networked computers available in the student computer laboratory in Prescott Hall, which houses the Civil Engineering Department. This laboratory is open 24 hours a day and provides valuable auxiliary support to graduate students during intense research periods. Faculty and graduate students also make use of the Computer Aided Engineering (CAE) laboratory maintained by TTU to solve real-world engineering problems in civil engineering. The CAE network maintains eight groups of parallel computing resources, with a total of 69 systems, 196 processors, 200 GB of memory, and 8,759

GB of temporary disk space. All systems run Debian GNU/Linux 4.0. Systems in each group may work on independent problems simultaneously, or solve portions of a larger problem as part of a parallel solution. These high performance computing facilities can be remotely accessed by faculty and student from their desktops both on and off campus.

Adequate library facilities are available through the TTU main library which currently houses approximately 353,000 volumes, 27,000 electronic books, over 1.5 million microforms, and subscribes to over 3,050 magazines, journals, and newspapers (in print and electronic). Electronic resources of the library consist of 45 research databases, 23 reference e-books, 196 discipline-specific e-books and 25,871 general academic e-books. As a member of the Southeastern Library Network (SOLINET), CEE faculty and students can leverage the vast library resources of other institutions in the region. A memorandum of understanding exists to utilize the library resources of University of Tennessee-Knoxville (UT), Vanderbilt University (VU) and most research libraries in the nation. CEE graduate students and faculty may use and borrow materials from any UT, VU or TBR library. The TTU library currently subscribes to 62 journals (electronic/hard copy) and 12 electronic databases that are relevant to the Civil Engineering discipline. A list of these CEE relevant journals available is provided in Table 4 of Appendix 3 (http://www.tntech.edu/files/cee/Appendix_Three.pdf). At the beginning of every fall term, a workshop is organized by the TTU library as part of a graduate seminar series (CEE6910) to introduce new graduate students to the library's facilities.

Graduate students are also encouraged to pursue co-op or summer internship opportunities in an area relevant to their research. For example, the Oak Ridge National Laboratory, which is only 70 miles from campus, has hosted graduate students pursuing advanced learning/workshops in cutting-edge areas of research. Students have also taken part in international field camps. In such camps, students get a chance to apply the theory learned in classes in the field. The CEE Department strives to provide the opportunity to students to attend conferences and workshops. The College of Engineering also sometimes provides financial support to graduate students to cover travel expenses for attending conferences (see Tables 1 and 2 of Appendix Three). The University also organizes a Student Research Day during the first week of April where student research poster submissions are solicited. Awards are given out to the best presenter. Student Research Day often acts as 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. Since 2009, student participation in University Research Day has dramatically increased from the usual 5-10 participants to 15-20 participants, explained in a large part by the participation of students in the BS/MS fast-track program and an expansion of the PhD program.

For the MS program, CEE faculty teaching graduate courses are also expected to be successful in pursuing their research program and be able to integrate it closely with education agenda. In addition, faculty need to serve as effective mentors of graduate students. Thus, teaching load is often made compatible with the needs of the graduate program. The CEE Department now tries to accommodate a reduced teaching load for newly recruited faculty during their first few years. This is supplemented with close mentorship provided by senior and research-active faculty, with formal briefings and assessment carried out at least once a year. Such an arrangement allows new faculty to be successful in obtaining research grants and developing their own research program and education plan. This reduced teaching load is complemented with support from TTU in the form of start-up packages such as graduate student, travel funds or seed money for initiating proof of concept research. The Centers of Excellence on campus also provide extensive secretarial support to CEE faculty to secure and successfully manage externally funded projects. Each center has dedicated staff for grant proposal submission, contract compliance, fiscal management and publications/editorial activities. Center staff work closely with CEE faculty to prepare project proposals, manage project-budgets and provide project reports according to the requirements of funding agencies. Newly recruited CEE faculty have leveraged this support from Centers and become very successful in starting a research program in their area of expertise.

During 2008-2012, faculty remained active in providing leadership to their professional societies, such as the American Society of Civil Engineers (ASCE), Institute of Transportation Engineers (ITE), American Concrete Institute (ACI), American Geophysical Union (AGU), American Water Resources Association (AWRA), American Meteorological Society etc. Four (33%) CEE faculty hold editorial positions in scholarly journals of the CEE profession. More than thirty invited presentations were delivered nationwide by CEE faculty during this time. Further evidence of the impact of the overall research environment may be seen in the sponsored projects (discussed next), publications/presentations activity (Appendix Three), survey of alumni and employers, and job placement of graduates in industry and research firms (see Appendix One and http://www.tntech.edu/cee/academic-audit/).

## 10.0 SYNERGY WITH EDUCATION

By design, there exists strong synergy between research and education within the MS program for both thesis and non-thesis options. This is because of the minimum amount of coursework that needs to be pursued by the student along with his/her self-inquiry driven effort (research thesis or a project report). In addition, this coursework needs to be relevant to the student’s area of concentration, satisfy all core requirements, and approved by the advisory committee as being pertinent to the training needed for self-inquiry and research. For the thesis option, at least 24 semester credit hours of graduate coursework must be completed in addition to the mandatory 1 hour CEE6910 CEE Graduate Seminar and 6 credit hours of research and thesis work. Undergraduate courses are not counted towards a graduate degree although they may be taken for background or remedial requirements. For the non-thesis option, students must take a larger number of courses relevant to the area of study to fulfill the requirements. At least 30 hours of graduate coursework, in addition to the 1 hour mandatory CEE6910 CEE Graduate Seminar and 3 credit hour of a self-inquiry driven project work.

As mentioned earlier, the Department has recently implemented (since 2007) a new BS/MS Fast-Track graduate program. The program is designed to enable qualified CEE undergraduates to accumulate up to six credit hours of graduate coursework while still pursuing their undergraduate degree and to transition to the graduate program with accelerated completion. The new program is well aligned with the Department’s goals to develop a graduate program of high research quality as well as integrating research into the upper division undergraduate education and preparing students for graduate studies. Since Fall 2008, more than thirty candidates have enrolled in the program after meeting the stringent requirements. More than twenty BS students have graduated with an MS degree in this manner since 2008. The students’ overall MS GPAs ranged from 3.50 to 4.00. A particularly unique feature of the Fast-Track program is that the students have the opportunity to participate in challenging research that can transition into MS thesis research early during their junior or even sophomore years of the undergraduate curriculum.

It is also very common for faculty working on sponsored projects to frequently integrate their research into graduate courses. Graduate students address a key research problem as part of a course through team work and a class project. Such class projects have periodically resulted in scholarly publications (see Table 2, Appendix Three and faculty publication profile by browsing http://www.tntech.edu/cee/facultystaff/)

**11.0 SPONSORED PROGRAMS**

As discussed briefly in section one, the CEE faculty has had a good record of research productivity during the past five years (2008-2012). Table 6 of Appendix 3 shows external funds generated by CEE faculty for research, testing projects, service projects, faculty research grants, etc. It does not include College, Center or Department matching funds that were often available for research activities. For example, Centers and Departments frequently provide full graduate assistantships for graduate students working on externally funded projects. In Table 5 of Appendix Three, more details of each funded project (project title, sponsor) are provided.

Total external funding awarded for research to CEE faculty during this 4-year period was more than US$ 2,000,000 (see Table 1a in Appendix 2). The annual research funding over the last four years has ranged between approximately $350,000 to 450,000 /year. CEE faculty were particularly successful in securing research funding from federal agencies such as the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA), the United States Department of Agriculture (USDA), the Federal Highway Administration (FHWA), the United States Geological Survey (USGS) and the Tennessee Department of Transportation (TDOT). These projects have supported more than half of the graduate students. Several faculty have also been actively engaged in engineering education societies such as the American Society of Engineering Education (ASEE). For example, CEE faculty Dr. Steven Click is leading the hosting of the ASEE-Southeast Conference during Spring 2013 on campus. This meeting will bring the bright minds on engineering education and provide CEE graduate students and faculty an opportunity to learn from best practice on teaching and learning methods.

In terms of productivity of scholarly work, more than 70 journal papers and 50 conference proceedings were published by the graduate faculty during 2008-2012. The average rate of scholarly journal publications by the collective CEE faculty has remained consistently above 10 per year with a significant percentage of them lead authored by MS students (see Appendix 3, Table 2 at http://www.tntech.edu/files/cee/Appendix_Three.pdf). Support for newly recruited faculty over recent years has also contributed to a trend of increased scholarly productivity. In Appendix Three, more detailed activity on scholarship and research funding are provided**.**

Sponsored projects facilitate research and scholarship, which consequentially build intellectual capital for the graduate program through student-driven research activity. One key byproduct of sponsored projects is therefore scholarly publications that are peer-reviewed in the most critical manner by peers from other institutions. Comparison of scholarly publication between TTU-CEE and other institutions can therefore be a good way to identify where exactly the CEE MS program 'stacks up' amongst the nation's CEE graduate programs. As part of the AQW process, an informal survey of this aspect was conducted by gleaning information made available on the websites of CEE graduate programs at various institutions. With about approximately 70 scholarly publications over the last 5 years, the graduate program of CEE ranks somewhere in the 50% percentile of other institutions with a similar or larger-sized graduate program in Civil Engineering. Details of the survey, evaluation and the performance metrics used in the survey are provided on the Academic Audit page link http://www.tntech.edu/files/cee/Survey_of_Peers.pdf titled "Peer Program Survey (Academic Audit)"

## 12.0 QUALITY AND PRODUCTIVITY INDICATORS

Faculty quality and productivity are measured on an annual basis per TTU and TBR guidelines in conjunction with a faculty's Agreement of Responsibilities. The CEE Chairperson performs an Annual Evaluation of each faculty with subsequent review by the College of Engineering Dean. The annual faculty evaluations measure faculty quality and productivity in four main areas – teaching, research and scholarship, advising, and service/outreach. Research and scholarship are measured by a variety of factors such as number of proposals submitted, proposals funded, presentations, publications, and graduate and undergraduate research students supervised. The College of Engineering is in the process of revising the Annual Evaluations while maintaining the framework as required by the university. Information regarding the expertise of the CEE faculty can be found in Sections 2.0, 11.0 and Table 1. Faculty vitas can be found in Appendix Four (http://www.tntech.edu/files/cee/Appendix_Four.pdf). Student demonstration of advanced knowledge is presented in Sections 7.0, 8.0, and 10.0.

## 13.0 CONTRIBUTIONS TO PROGRAM, DEPARTMENTAL AND UNIVERSITY GOALS

The Educational Objectives of the Department directly support and are consistent with the mission of the institution. Tennessee Technological University's mission statement begins with the concept that its "mission is to broaden and enhance its unique role as the state's only technological university through strong emphasis on and support of its academic programs in engineering and basic science and through expansion of its research activities in these and related areas."

The mission statement continues, "The University is engaged in scholarly activity, especially basic and applied research." One of the Department's Educational Objectives is to "maintain an environment to carry out fundamental and applied research and advance engineering knowledge through research." The mission statement also refers to the Centers of Excellence as strengthening the research role of the University, and the Department works closely with all three Centers of Excellence in various research and education activities.

Recently, the College of Engineering developed at Strategic Plan"2020 Destination → Eminence". Part of this plan focuses on increasing and improving the research from both a student and faculty perspective, which are consistent with the mission of the department and university. More information about the Strategic Plan can be found here: http://www.tntech.edu/engineering/strategicplan/

## 14.0 RECOMMENDATION AND POTENTIAL INITIATIVES

The adoption of the AQW process by CEE faculty as described above during the last two years helped reach the following faculty-wide recommendations for improvement:

**Recommendation ONE:** Effectiveness of instruction of each graduate course needs to be assessed by faculty (during the semester) on the measurable outcomes that are now articulated in the new one-page AQW formatted syllabi. This assessment of effectiveness should translate to a faculty-driven plan for continued improvement in delivery of the graduate course if significant weaknesses in learning are identified.

**Recommendation TWO:** Curricular topics (within core courses) should be reviewed for seamless sequencing to prevent gaps and overlaps in course material.

**Recommendation THREE:** Non-binding input from Alumni, Employer and the CEE Advisory Board should be sought in the phasing out of outdated graduate courses, addition of new courses and updating the syllabi of existing courses.

**Recommendation FOUR:** CEE Advisory Board should have at least one member who is an alumnus of the MS program.

**Recommendation FIVE:** Formal tracking of academic performance of MS alumni who pursue doctoral studies at other institutions needs to be implemented.

## 15.0 MATRIX OF IMPROVEMENT INITIATIVES

| No. | Initiative | Responsibility | Participation | Begins | Frequency |
|---|---|---|---|---|---|
| One | Communicate MS program learning objectives to all incoming students | Graduate Program Coordinator | All incoming MS students, Graduate Program Coordinator, CEE Graduate Affairs and CEE Chair | Fall 2013 | On-going |
| Two | Assess student learning of course topics through survey of measurable outcomes | Faculty | Faculty | Fall 2013 | Every 2 years |
| Three | Curricular topic sequencing to prevent gaps and overlaps for the core curriculum | Faculty | Faculty and Graduate Affairs Committee | Fall 2013 | Every Audit Cycle |
| Four | Solicit input on curriculum modernization from alumni and Advisory Board | Graduate Program Coordinator and Chairperson | CEE Advisory Board and Faculty | Spring 2013 | Every Audit Cycle |
| Five | Tracking of performance of MS alumni in Doctoral programs | Graduate Program Coordinator and Major Advisor (MS) of the student | Faculty | Spring 2013 | Ongoing |

# APPENDIX ONE

**Table 1-Summary of Applicant Data since 2008 (see next 5 pages)**

| Term | Major | GRE-Q | GRE-V | Total GRE | TOEFL | GPA | Admission Status | Admission Standing (P-Provisional; F-Full Standing) | Nationality |
|---|---|---|---|---|---|---|---|---|---|
| 200850 | CE | 710 | 460 | 1170 | | 2.915 | Incomplete Application | P | USA |
| 200850 | CE | 800 | 480 | 1280 | | 3.948 | Admitted | F | USA |
| 200850 | CE | 740 | 470 | 1210 | | 3.018 | Admitted | F | USA |
| 200850 | CE | 780 | 410 | 1190 | | 3.765 | Admitted | F | USA |
| 200850 | CE | | | 0 | | | Admitted | F | USA |
| 200850 | CE | 530 | 310 | 840 | | | Incomplete Application | | Ethiopia |
| 200850 | ENGR-DCE | 640 | 370 | 1010 | | | Admitted | F | USA |
| 200880 | ENGR-DCE | 730 | 290 | 1020 | 490 | 3.35(BS);3.86(MS) | Admitted | F | Ethiopia |
| 200880 | ENGR-DCE | 660 | 360 | 1020 | 550 | 3.562(BT);3.041(MT) | Admitted | F | India |
| 200880 | ENGR-DCE | 700 | 410 | 1110 | 597 | 3.089(BS)3.72(MS) | Denied | | India |
| 200880 | ENGR-DCE | 740 | 380 | 1120 | 553 | 2.559(BE);3.517(ME) | Admitted | F | China |
| 200880 | ENGR-DCE | 700 | 360 | 1060 | 587 | 2.326(BS);3.091(MS) | Admitted | F | Nigeria |
| 200880 | CE | 720 | 620 | 1340 | 533 | 3.404 | Admitted | F | Nigeria |
| 200880 | CE | | | 0 | | | Denied | | Saudi Arabia |
| 200880 | CE | 560 | 420 | 980 | | 3.426 | Admitted | P | USA |
| 200880 | CE | 750 | 400 | 1150 | 627 | 3.08 | Admitted | | India |
| 200880 | CE | | | 0 | | | Admitted | | USA |
| 200880 | CE | 650 | 580 | 1230 | | 3.68 | Admitted | F | USA |
| 200880 | CE | 630 | 360 | 990 | 577 | 3.517(BE);3.65(ME) | Admitted | F | India |
| 200880 | CE | 750 | 270 | 1020 | 560 | 3.733 | Admitted | F | India |
| 200880 | CE | 700 | 350 | 1050 | 593 | | Admitted | | India |
| 200880 | CE | 690 | 480 | 1170 | | 3.00 | Admitted | F | USA |
| 200880 | CE | 750 | 330 | 1080 | 577 | 3.683 | Admitted | | India |
| 200880 | CE | 660 | 300 | 960 | 583 | 3.957 | Admitted | | India |
| 200880 | CE | 560 | 380 | 940 | | | Admitted | | Ghana |
| 200880 | CE | 580 | 320 | 900 | 547 | 3.769 | Incomplete Application | | India |
| 200880 | CE | 780 | 520 | 1300 | | | Admitted | | USA |
| 200880 | CE | 620 | 380 | 1000 | | 3.393 | Admitted | F | USA |
| 200880 | CE | 720 | 320 | 1040 | 577 | 3.897 | Admitted | | India |
| 200880 | CE | | | 0 | | | Admitted | | Ethiopia |
| 200880 | CE | 770 | 280 | 1050 | 550 | 3.717 | Admitted | | India |
| 200910 | CE | | | 0 | | | Admitted | | USA |
| 200910 | CE | 680 | 530 | 1210 | | 2.44 | Admitted | | USA |
| 200910 | CE | 630 | 610 | 1240 | | 3.55 | Admitted | | USA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 200910 | CE | 650 | 310 | 960 | N/A | 2.98(BS);3.52(MS) | Denied-Admitted Fall '12 | | Bangladesh |
| 200910 | CE | | | 0 | | | Admitted | | USA |
| 200910 | CE | | | 0 | | | Incomplete Application | | Ethiopia |
| 200910 | CE | | | 0 | | | Admitted | | India |
| 200910 | CE | | | 0 | | | Admitted | | USA |
| 200910 | ENGR-DCE | 760 | 300 | 1060 | None | 3.829(BS);3.167(MS) | Incomplete Application | | Ethiopia |
| 200910 | ENGR-DCE | 730 | 290 | 1020 | 490 | 3.35(BS);3.86(MS) | Admitted | P | Ethiopia |
| 200950 | CE | 660 | 520 | 1180 | | 3.62 | Admitted | F | USA |
| 200950 | CE | | | 0 | | | Admitted | | USA |
| 200950 | CE | | | 0 | | | Admitted | | USA |
| 200980 | CE | 680 | 450 | 1130 | 583 | 3.33 | Admitted | F | Bangladesh |
| 200980 | CE | | | 0 | | | Admitted | | USA |
| 200980 | CE | 730 | 450 | 1180 | 590 | 3.10 | Admitted | | Bangladesh |
| 200980 | CE | 770 | 350 | 1120 | | 3.26 | Admitted | | China |
| 200980 | CE | 770 | 340 | 1110 | 610 | 3.905(BS);3.63(MS) | Admitted | | India |
| 200980 | CE | 780 | 320 | 1100 | 537 | 3.10 | Admitted | | India |
| 200980 | CE | 660 | 430 | 1090 | | 3.06 | Incomplete Application | F | USA |
| 200980 | CE | 740 | 450 | 1190 | | 3.31 | Admitted | F | USA |
| 200980 | CE | no paperwork | | 0 | | 2.67 | Admitted | P | USA |
| 200980 | CE | 740 | 480 | 1220 | | 3.64 | Admitted | | USA |
| 200980 | CE | | | 0 | | | Admitted | | USA |
| 200980 | CE | no paperwork | | 0 | | 2.66 | Incomplete Application | | USA |
| 200980 | CE | no paperwork | | 0 | | | Admitted | | USA |
| 200980 | CE | 670 | 440 | 1110 | | 2.66 | Incomplete Application | P | USA |
| 200980 | CE | no paperwork | | 0 | | | Admitted | | USA |
| 200980 | CE | 650 | 310 | 960 | | 2.98(BS);3.52(MS) | Admitted | P | Bangladesh |
| 200980 | CE | 610 | 340 | 950 | | 3.06 | Admitted | P | USA |
| 200980 | CE | 680 | 540 | 1220 | 567 | 2.84 | Incomplete Application | | Ethiopia |
| 200980 | CE | | | 0 | | | Incomplete Application | | Spain |
| 200980 | ENGR-DCE | | | 0 | | | Incomplete Application | | Iran |
| 200980 | ENGR-DCE | | | 0 | | | Incomplete Application | | Iran |
| 200980 | ENGR-DCE | | | 0 | | | Admitted | | Bangladesh |
| 200980 | ENGR-DCE | 710 | 330 | 1040 | 577 | 3.857 | Admitted | | India |
| 200980 | ENGR-DCE | 720 | 510 | 1230 | 603 | 3.11(BS);3.747(MT) | Admitted | | Ethiopia |
| 200980 | ENGR-DCE | 540 | 320 | 860 | | 2.974(BS);3.5(MS) | Denied | | USA |
| 200980 | ENGR-DCE | | | 0 | | | Incomplete Application | | Nigeria |
| 200980 | ENGR-DCE | | | 0 | | | Incomplete Application | | USA |
| 200980 | ENGR-DCE | 580 | 390 | 970 | 627 | 2.91(BS);3.205(MS) | Admitted | | Ethiopia |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 201010 | CE | | | 0 | | | Denied | | Saudi Arabia |
| 201010 | CE | | | 0 | | | Admitted | | USA |
| 201010 | CE | 670 | 560 | 1230 | | 2.70 | Admitted | | USA |
| 201010 | CE | | | 0 | | | Admitted | | USA |
| 201010 | CE | 640 | 420 | 1060 | | 3.50 | Admitted | | USA |
| 201010 | CE | | | 0 | | | Admitted | | USA |
| 201010 | CE | | | 0 | | | Denied | | USA |
| 201010 | CE | | | 0 | | | Admitted | | Bangladesh |
| 201010 | CE | 740 | 260 | 1000 | 553 | 4.00 | Admitted | | India |
| 201010 | CE | 660 | 360 | 1020 | 580 | 3.664 | Admitted | | India |
| 201010 | ENGR-DCE | 650 | 390 | 1040 | | 2.888(BS);3.857(MS) | Admitted | | Ethiopia |
| 201010 | ENGR-DCE | | | 0 | | | Incomplete Application | | Ethiopia |
| 201010 | ENGR-DCE | | | 0 | | | Incomplete Application | | Ethiopia |
| 201050 | CE | 710 | 410 | 1120 | | 3.50 | Admitted | | USA |
| 201050 | CE | | | 0 | | | Incomplete Application | | India |
| 201050 | CE | 510 | 390 | 900 | | 2.24 | Incomplete Application | | USA |
| 201050 | CE | | | 0 | | | Incomplete Application | | Iran |
| 201050 | CE | | | 0 | | | Admitted | | USA |
| 201050 | CE | | | 0 | | | Admitted | | USA |
| 201050 | ENGR-DCE | | | 0 | | | Incomplete Application | | Iran |
| 201080 | CE | 640 | 500 | 1140 | 547 | 3.255 | Admitted | | Nigeria |
| 201080 | CE | 800 | 450 | 1250 | | 2.307 | Denied | | Iran |
| 201080 | CE | 720 | 300 | 1020 | 550 | 3.698 | Admitted | | India |
| 201080 | CE | 680 | 310 | 990 | | 2.29 | Denied | | India |
| 201080 | CE | | | 0 | | | Incomplete Application | | India |
| 201080 | CE | | | 0 | | | Admitted | | USA |
| 201080 | CE | N/A | N/A | 0 | N/A | 2.775 | Denied | | Iran |
| 201080 | CE | | | 0 | | | Admitted | | USA |
| 201080 | CE | 740 | 480 | 1220 | 563 | 3.702 | Admitted | | Bangladesh |
| 201080 | CE | | | 0 | | | Admitted | | India |
| 201080 | CE | | | 0 | | | Admitted | | USA |
| 201080 | CE | 790 | 500 | 1290 | | 3.30 | Admitted | | USA |
| 201080 | CE | | | 0 | | | Denied | | USA |
| 201080 | CE | 710 | 330 | 1040 | 547 | 3.022 | Admitted | | China |
| 201080 | CE | 750 | 420 | 1170 | 570 | 3.845 | Admitted | | Iran |
| 201080 | CE | | | 0 | | | Denied | | Iran |
| 201080 | CE | | | 0 | | | Incomplete Application | | Iran |
| 201080 | CE | | | 0 | | | Admitted | | India |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 201080 | CE | | | 0 | | | Admitted | | USA |
| 201080 | CE | | | 0 | | | Incomplete Application | | India |
| 201080 | CE | 760 | 320 | 1080 | | 3.405 | Admitted | | USA |
| 201080 | CE | 730 | 460 | 1190 | | 3.70 | Admitted | | USA |
| 201080 | CE | 790 | 520 | 1310 | 587 | 3.03 | Admitted | | China |
| 201080 | CE | | | 0 | | | Incomplete Application | | China |
| 201080 | CE | | | 0 | | | Admitted | | China |
| 201080 | ENGR-DCE | | | 0 | | | Incomplete Application | | Iran |
| 201080 | ENGR-DCE | 730 | 300 | 1030 | | 2.66(BT);2.49(MS) | Denied | | India |
| 201080 | ENGR-DCE | 750 | 420 | 1170 | 553 | 3.234 | Admitted | | China |
| 201080 | ENGR-DCE | | | 0 | | | Admitted | | India |
| 201080 | ENGR-DCE | | | 0 | | | Incomplete Application | | Nigeria |
| 201080 | ENGR-DCE | | | 0 | | | Incomplete Application | | Iran |
| 201080 | ENGR-DCE | 680 | 360 | 1040 | 633 | 2.49(BS);3.381(MS) | Admitted | | Ethiopia |
| 201080 | ENGR-DCE | | | 0 | | | Admitted | | Ethiopia |
| 201080 | ENGR-DCE | | | 0 | | | Incomplete Application | | India |
| 201110 | CE | | | 0 | | | Admitted | | Nigeria |
| 201110 | CE | | | 0 | | | Incomplete Application | | Egypt |
| 201110 | CE | | | 0 | | | Admitted | | USA |
| 201110 | CE | 630 | 370 | 1000 | | 2.55 | Admitted | | Ghana |
| 201110 | CE | | | 0 | | | Denied | | USA |
| 201110 | CE | 620 | 390 | 1010 | | 2.98 | Admitted | | USA |
| 201110 | CE | No scores on file | | 0 | | 3.10 | Admitted | | USA |
| 201110 | CE | 650 | 230 | 880 | | 2.49 | Denied | | Egypt |
| 201110 | CE | 580 | 490 | 1070 | | 3.54 | Admitted | | USA |
| 201110 | CE | 730 | 420 | 1150 | | 3.11 | Admitted | | USA |
| 201110 | CE | | | 0 | | | Incomplete Application | | USA |
| 201110 | ENGR-DCE | 720 | 270 | 990 | | 3.50(BT);3.5(ME) | Admitted | | India |
| 201110 | ENGR-DCE | | | 0 | | | Incomplete Application | | Ethiopia |
| 201110 | ENGR-DCE | 750 | 290 | 1040 | 607 | 3.67(BS);3.065(MS) | Admitted | | Ethiopia |
| 201150 | CE | 670 | 430 | 1100 | | 3.17 | Admitted | | USA |
| 201150 | CE | 750 | 590 | 1340 | | 3.66 | Admitted | | USA |
| 201180 | CE | 700 | 420 | 1120 | | 3.89 | Admitted | | USA |
| 201180 | CE | 750 | 420 | 1170 | | 3.95 | Admitted | | USA |
| 201180 | CE | 770 | 500 | 1270 | | 3.87 | Admitted | | USA |
| 201180 | CE | 570 | 300 | 870 | | 3.04 | Admitted | | Iran |
| 201180 | CE | 690 | 350 | 1040 | | 3.52 | Admitted | | USA |
| 201180 | CE | 730 | 390 | 1120 | | 3.61 | Admitted | | USA |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 201180 | CE | | | 0 | | | Admitted | | USA |
| 201180 | CE | 710 | 490 | 1200 | | 3.96 | Admitted | | USA |
| 201180 | CE | | | 0 | | | Incomplete Application | | Ethiopia |
| 201180 | CE | | | 0 | | | Incomplete Application | | Iran |
| 201180 | CE | | | 0 | | | Incomplete Application | | Rwanda |
| 201180 | CE | | | 0 | | | Incomplete Application | | Sierra Leon |
| 201180 | CE | 740 | 640 | 1380 | | 3.95 | Admitted | | USA |
| 201180 | CE | 780 | 620 | 1400 | | 3.035 | Admitted | | Ghana |
| 201180 | CE | | | 0 | | | Incomplete Application | | Iran |
| 201180 | CE | 670 | 270 | 940 | 627 | 3.24 | Admitted | | India |
| 201180 | CE | | | 0 | | | Denied | | Iran |
| 201180 | CE | 740 | 590 | 1330 | 673 | 3.012 | Admitted | | India |
| 201180 | CE | 730 | 320 | 1050 | 573 | 3.035 | Admitted | | Russia |
| 201180 | ENGR-DCE | 710 | 310 | 1020 | 497 | 3.688(BT);3.25(MT) | Admitted | | India |
| 201180 | ENGR-DCE | | | 0 | | | Incomplete Application | | Ethiopia |
| 201180 | ENGR-DCE | 800 | 410 | 1210 | 603 | 3.188(BS);3.815(MS) | Admitted | | Iran |
| 201180 | ENGR-DCE | | | 0 | | | Incomplete Application | | Iran |
| 201210 | CE | | | 0 | | | Incomplete Application | | USA |
| 201210 | CE | | | 0 | | | Incomplete Application | | USA |
| 201210 | CE | | | 0 | | | Incomplete Application | | Algeria |
| 201210 | CE | | | 0 | | | Incomplete Application | | China |
| 201210 | CE | 154 | 149 | 303 | | 3.29 | Admitted | | USA |
| 201210 | CE | 780 | 410 | 1190 | | 3.24 | Admitted | | India |
| 201210 | CE | 160 | 159 | 319 | | 3.55 | Admitted | | USA |
| 201210 | CE | 153 | 146 | 299 | | 3.15 | Admitted | | USA |
| 201210 | ENGR-DCE | 650 | 300 | 950 | N/A | 2.38(BCE);3.50(MS) | Admitted | | Iran |
| 201210 | ENGR-DCE | 790 | 560 | 1350 | | 3.71(BS);4.00(MS) | Admitted | | USA |
| | | | | 0 | | | | | |

**Table 2- Academic Data and Overall Performance of MS Graduates during 2008- 2012**

| **Student Name (Initials)** | **Duration** (months) | **Total Credit Hours** | | | **GPA** |
|---|---|---|---|---|---|
| | | Thesis/ Research or Project | Curriculum (CEE Courses) | Co-Curriculum (Non-CEE Courses) | |
| K H | 12 months | 6 | 21 | 3 | 3.88 |
| J S | 16 months | 6 | 21 | 3 | 4.00 |
| A V | 24 months | 6 | 21 | 3 | 3.60 |
| J Y | 12 months | 6 | 24 | 0 | 4.00 |
| K C | 16 months | 6 | 24 | 0 | 3.25 |
| R v D | 28 months | 6 | 24 | 0 | 3.88 |
| J P | 20 months | 6 | 24 | 0 | 4.00 |
| A M | 20 months | 6 | 18 | 6 | 3.50 |
| J H | 28 months | 6 | 15 | 9 | 4.00 |
| C B | 12 months | 6 | 21 | 3 | 4.00 |
| M B | 8 months | 6 | 12 | 12 | 3.88 |
| J T | 12 months | 6 | 21 | 3 | 4.00 |
| B S | 16 months | 6 | 18 | 6 | 4.00 |
| C B M | 8 months | 6 | 21 | 3 | 3.83 |
| E B | 16 months | 6 | 24 | 0 | 4.00 |
| S M | 20 months | 6 | 24 | 0 | 3.88 |
| M M | 16 months | 6 | 21 | 3 | 3.76 |
| M. A | 16 months | 6 | 18 | 6 | 3.52 |
| C S | 20 months | 6 | 15 | 9 | 3.89 |
| S M S | 20 months | 6 | 18 | 6 | 3.44 |
| J H | 16 months | 6 | 21 | 3 | 3.89 |
| R H | 16 months | 6 | 18 | 6 | 4.00 |
| G B | 16 months | 6 | 15 | 9 | 3.88 |
| J V D | 16 months | 6 | 15 | 9 | 3.84 |
| T L | 12 months | 6 | 21 | 3 | 3.50 |
| L B S | 20 months | 6 | 21 | 3 | 4.00 |
| M A | 16 months | 6 | 18 | 6 | 3.25 |
| A C | 16 months | 6 | 21 | 3 | 3.89 |
| S D | 16 months | 6 | 21 | 3 | 4.00 |
| A P* | 70 months | 11 | 21 | 3 | 3.88 |
| S Z | 20 months | 9 | 24 | 0 | 4.00 |
| B F | 12 months | 7 | 18 | 6 | 3.84 |

* Part-time student

**Table 3a- Summary of Program Quality (success of CEE MS graduates) – Student Publications and Awards/Accolades.***

| Year | Minimum Number of Student-authored Publications | | Minimum Number of Student Oral Presentations | | Minimum Number of Student Awards at regional/national Level |
|---|---|---|---|---|---|
| | Journals | Conferences | MS Defense | Conference | |
| 2008-09 | 10 | 6 | 10 | 10 | 4 |
| 2009-10 | 5 | 3 | 5 | 22 | 3 |
| 2010-11 | 10 | 3 | 8 | 15 | 3 |
| 2011-12 | 3 | 3 | 5 | 3 | 2 |

- Derived from Annual Report published by CEE.

**Table 3b-Summary of student placement after graduation.**

| Year | Number of Graduates | Continued to a PhD program | Job Placement | |
|---|---|---|---|---|
| | | | Total Number | Sample of Companies/Institutions Hiring MS graduates |
| 2008-09 | 10 | 0 | 10 | P2S, AMEC |
| 2009-10 | 5 | 1 (Auburn U) | 5 | Ross Bryan Associates, Shaw Areva, USACE |
| 2010-11 | 8 | 2 (Vanderbilt U; Virginia Tech) | 8 | Chattanooga State, TVA, Smith Seckman Reid, Inc. USACE, Boeing, Foundation Systems Engineering |
| 2011-12 | 8 | 3 (TTU) | 8 | AECOM, United Launch Alliance, Daniel Consultants Inc. (DC) |

# APPENDIX TWO

## (Sample One page Syllabus for Academic Quality Work)

Tennessee Technological University
Department of Civil & Environmental Engineering
CEE 6440 – Hydrometeorology

2010 Catalog Data: CEE 6440: Hydrometeorology. Credit 3. Theory and observations of hydrological processes in landsurface and atmosphere. Precipitation processes, radiation and clouds, atmospheric boundary layer dynamics, coupled balance of moisture and energy, soil moisture and climate feedbacks, hydroclimatology, monsoonal flow and thunderstorms. Emphasis on recent research and modern methods for data analysis and modeling.

Suggested Textbook: Physical Hydrology (Lawrence Dingman) ISBN – 0-13-099695-5.
Reference: Atmospheric Science: An introductory Survey by J. Wallace and P. Hobbs, Academic Press.
The Atmosphere, Lutgens, Tarbuck and Tasa, 10th Edition. Prentice Hall

Faculty Coordinator: Faisal Hossain, Associate Professor of Civil Engineering
Participating Faculty: David Huddleston, Alfred Kalyanapu, Lenly Weathers and Dennis George

Prerequisites: CEE 4420(5420) Engineering Hydrology or consent of instructor

Goal: The goal of CEE 6440 "Hydrometeorology" is to introduce students to land atmosphere interaction that dictate the dynamics of the water cycle.

Course learning objectives:

1) To provide a detailed background of meteorological processes involving precipitation, lifting, atmospheric stability, radiation and teleconnections and to help students achieve a more holistic view of hydrology that incorporates meteorology.
2) To gain factual knowledge on mathematical modeling of surface hydrologic processes comprising runoff, evapo-transpiration, stream flow, infiltration and ground water flow.

Major Topics Covered:

1. The water cycle
2. Earth's Radiation budget
3. Atmospheric processes – stability, lifting, adiabatic/pseudo adiabatic cooling, pressure-temperature-humidity relationships
4. Reynolds Transport Theorem
5. Precipitable water and T-storm model
6. Precipitation process – general concepts
7. Teleconnections, climate and weather
8. Mesoscale convective rainfall systems
9. Surface hydrology – Evapo-transpiration, infiltration, overland flow and channel flow
10. Mathematical modeling of the rainfall-runoff process
11. Case studies on hydrometeorologic controls on weather and climate

Measurable outcomes:

Students will be expected to:

1. estimate radiation budget at a given location and time of the year
2. be able to identify stability (conditional, unconditionally stable, unstable) of an air parcel
3. understand the major lifting mechanisms in precipitation formation
4. be able to track the temperature and humidity of an air parcel during orographic lifting
5. understand basic concepts of precipitation formation in mid-latitude and subtropical climates
6. understand the practical importance of teleconnected phenomena such as ENSO.
7. be able to physically model ET, infiltration, overland flow and channel flow for a catchment
8. understand the art and science of rainfall-runoff modeling and identify the iterative modeling process to develop the right hydrologic model
9. be able to apply Reynolds Transport Theorem for calculating precipitable water.

**Table 1 - Frequency of offering for CEE graduate courses during 2008-2012 (*Core courses)**

| | Course Name | F08 | S09 | F09 | S10 | F10 | S11 | F11 | S12 |
|---|---|---|---|---|---|---|---|---|---|
| STRUCTURAL ENGINEERING | CEE 7610* Finite Element Analysis I | | X | | X | | X | | X |
| | CEE 5130 Matrix and Finite Element Methods | | | X | | X | | X | |
| | CEE5190 Advanced Mechanics of Materials | X | | X | | X | | X | |
| | CEE 5350 Advanced Structural Design | | | X | | X | | X | |
| | CEE 5360 Advanced Topics in Structural Concrete Design | X | | X | | X | X | | X |
| | CEE 5380 Bridge Design | | X | | X | | X | | X |
| | CEE 5700 Masonry Design | | | | X | | X | | X |
| | CEE 7720 Fiber-Reinforced Composite Materials | | | | X | | X | | |
| | CEE 7810 Structural Dynamics | X | | | | X | | X | |
| ENVIRONMENTAL/WATER RESOURCES | CEE 6520* Open-Channel Hydraulics | X | | | X | | | X | |
| | CEE 6610-20* Applied Environmental Chemistry | X | | X | | X | | X | |
| | CEE 5410 Solid & Hazardous Waste Management | | | | | X | | X | |
| | CEE 5500 Construction Management | | X | | X | | X | | X |
| | CEE 5450 Water Quality Modeling | X | | X | | | | | |
| | CEE 5420 Engineering Hydrology | X | | X | | X | | X | |
| | CEE 5430 Environmental Engineering | | | | X | | | | |
| | CEE 5440 Water Resources Engineering | | X | | X | | X | | X |
| | CEE 6040 Intermediate Fluid Mechanics | | | X | | | | | |
| | CEE 6420 Fluvial Hydraulics | | X | | | | | | |
| | CEE 6430 Probabilistic Methods in Hydroscience | X | | | | | | X | |
| | CEE 6440 Hydrometeorology | | | | | X | | | |
| | CEE 6710 Environmental Engineering Unit Operations and Processes - 1 | X | | X | | X | | X | |
| | CEE 6720 Environmental Engineering Unit Operations and Processes - 2 | | X | | X | | X | | X |
| | CEE 6770 Environmental Engineering Laboratory | | X | X | | X | | | |
| | CEE6840 Environmental Applications of Remote Sensing | | | X | | | | | X |

| | Course Name | F08 | S09 | F09 | S10 | F10 | S11 | F11 | S12 |
|---|---|---|---|---|---|---|---|---|---|
| TRANSPORTATION/MATERIALS | CEE 6300* Composition and Properties of Concrete | X | | X | | X | | X | |
| | CEE 6470* Transportation Demand Analysis | X | X | X | | X | | X | X |
| | CEE 6410* Traffic Control Systems | | | | X | | | | X |
| | CEE 5600 Civil Engineering Materials | | X | | X | | X | | |
| | CEE 5610 Pavement Design | X | | X | | X | | X | |
| | CEE 5630 Traffic Engineering | | | X | | | | X | |
| | CEE 5640 Highway Engineering | | X | | X | | X | | X |
| | CEE 7420 Public Transportation | | | | | | X | | |
| | CEE 5660 Transportation Planning | X | | X | | X | | X | |
| | CEE 7410 Advanced Travel Demand Modeling | X | | | | | | | |
| | CEE 5930 Noise Control | | | | | | X | | |
| | CEE 7450 Topics in Concrete Durability | | | | | | X | | X |
| STRUCTURAL MECHANICS | CEE 7610* Finite Element Analysis I | | X | | X | | | | X |
| | CEE 6930* Theory of Elasticity | X | | X | | X | | X | |
| | CEE 7100 Advanced Computational Methods in Engineering | | X | | | X | | | X |
| | CEE 7510 Theory of Plates and Shells | | | | | | | X | |
| | CEE 7620 Finite Element Analysis II | | | X | | X | | X | |
| | CEE 7720 Fiber Reinforced Composite Materials | | | | X | | | | X |

**Table 2 - List of new graduate courses designed and offered during 2002-2012 by CEE faculty**

| Course Name | Area of Specialization | Year First Offered | Justification/Purpose |
|---|---|---|---|
| CEE6520-Open Channel Hydraulics | Water Resources | 2011 (reintroduced by new faculty) | Core course in water/environmental specialization. Course reincarnated by new hire faculty (Kalyanapu in Fall 2011) to provide greater emphasis on high resolution computational modeling. |
| CEE 6420-Fluvial Hydraulics | Water Resources | 1999 | Provides a modern perspective to river management through a multi-disciplinary approach involving hydraulics and river morphology |
| CEE 6430-Probabilistic Methods in Hydrosciences | Water Resources | 2004 | Provides an introduction of stochastic theory application to water resources engineering. Helps students understand the meaning of a random process. |
| CEE6440 Hydrometeorology | Water Resources | 2005 | Provide a more in-depth and holistic understanding of the global water cycle. Introduce students to emerging water measurement technologies like remote sensing and satellites |
| CEE7420 Urban Public Transportation | Transportation | 2005 | Provides for advanced study into urban public transportation issues and planning. At the time, none of the listed courses addressed this. |
| CEE 7910 Study of Current Literature in Engineering Mechanics. | Structural Mechanics | 2007 | Creates a formal atmosphere for faculty and students to study new and emerging topics that have been reported in the literature e |
| CEE 7360 Advanced topics in Prestressed Concrete Design | Structural Engineering | 2004 | New course -- Graduate students majoring in structures need to learn advanced topics in structural design. This addition meets the needs of graduate students for advanced study in structural engineering. |
| CEE 5350 Advanced Structural Design | Structural Engineering | 2002 | The Advanced Structural Design course has been partially redesigned based on the new American Institute of Steel Construction (AISC) Manual of Steel Construction, Thirteenth Edition. |
| CEE 5380 Bridge Design | Structural Engineering | 2002 | The bridge design course has been fully redesigned to follow the new American Association of State Highway and Transportation Officials Load and Resistance Design Specifications |

| | | | |
|---|---|---|---|
| | | | (AASHTO LRFD). The revision of the course content is necessary because Federal Highway Administration mandates that all state DOTs have to use the AASHTO LRFD in 2007. |
| CEE 6900 Durability of Cement-Based Materials | Materials | 2007 | Students acquire knowledge of durability issues regarding the US deteriorating infrastructure and means to mitigate such damage. State-of-the-art topics were introduced through case studies. |
| CEE 6410 – Advanced Traffic Control | Transportation | 2007 | Entire course re-developed to match state of the practice. |
| CEE 6300 Multi-Scale Analysis of Concrete | Materials | 2007 | Changed from Composition and Properties of Concrete. The name change reflects the course content as taught by the current faculty. There is an emphasis on the nano-, micro-, and macro-scale behavior of Portland cement concrete and its related components. |
| CEE 5600 Civil Engineering Materials II. | Materials | 2008 | Change is course description changed to reflect change is topics to benefit students. The course description will now read: Design and testing of High-strength PCC, self-consolidating PCC, hgh volume fly ash PCC and pervious PCC. Controlled low-strength materials. Concrete formwork design. Masonry materials evaluation. Aggregate production and improvement. |
| CEE6480 (6900)-Environmental Applications of Remote Sensing | Water Resources | 2009 | This course was added because of increasing importance of remote sensing in the field of environmental and water resources management. Students acquire knowledge on the state of the art of remote sensing for estimating water variables from ground and space platforms. Applications are stressed. |
| CEE 6300 Multi-Scale Analysis of Concrete | Materials | 2009 | The current laboratory sessions are primarily computer based, which does not require a separate lab component. The lags will be retained as part of the course and will be incorporated into the lectures for the course. Students will still be required to perform the exercises, which will now be considered outside assignments. |

| | | | |
|---|---|---|---|
| CEE 5410 Solid and Hazardous Waste Management | Water Resources | 2010 | The prerequisite changed from CEE 3420 to CEE 3413 or consent of instructor in order to give the student more flexibility to enroll as soon as they had the knowledge to successfully continue the work in CEE 4410. |
| CEE 6950-60 Graduate Seminar | All disciplines | 2010 | This was an inactive course and the faculty voted to delete it. |
| CEE 6910 CEE Graduate Seminar | All disciplines | 2010 | CEE6910 was introduced for a more meaningful experience for CEE graduate students. In this course, experts in various fields of Civil Engineering are invited to deliver seminars and expose CEE graduate students to the state of the art. However, the most unique and key feature of this course, unlike typical graduate seminar courses, is a 3 week long orientation for new graduate students. In this orientation, students are exposed to plagiarism avoidance, research proposal/grant writing, literature review, rules/regulations set by graduate school and various tips to be successful. |
| CEE 7450 Advanced Topics in Concrete Durability | Materials | 2011 | This is for advanced graduate level work requiring strong background knowledge of cement-based materials. There are currently no transportation materials courses offered at the 7000-level; therefore this course will strengthen the course offerings for CEE doctoral students. |
| CEE 6480 – Environmental Applications of Remote Sensing | Water Resources | 2011 | This was a Special Topics during Fall 2009. The course is changed to remote sensing because there is no graduate level remote sensing course on campus tailored to environmental and water resources applications. |
| CEE 6200 Statistical Methods for Engineers | All disciplines | 2012 | This was formerly ISE 6200. Due to the integration of the ISE department and faculty into other engineering units, ISE courses must also be integrated. The faculty who teach ISE 6200 are now in the CEE department. |

**Table 3. Summary of non-CEE courses (co-curriculum) taken by CEE students by Department and emphasis area.**

| Department and Course Name | Emphasis Area | | | |
|---|---|---|---|---|
| | **Environment/ Water** | **Structural Engineering** | **Transportation /Materials** | **Structural Mechanics** |
| **Earth Sciences** | | | | |
| GEOG5210- Cartography | | | X | |
| GEOG5510-Theory of GIS-I | X | | X | |
| GEOG-GIS-II | X | | | |
| GEOG5650- Environmental Applications of GIS | X | | | |
| GEOL5711- Hydrogeology | X | | | |
| GEOG5850 – Advanced GIS | | | X | |
| **Industrial Systems Engineering** | | | | |
| ISE6200- Probability and Statistics | | | X | |
| **Statistics** | | | | |
| STAT5410- Statistical Methods-II | | | X | |
| **Mechanical Engineering** | | | | |
| ME5510- Aerodynamics | | X | | X |
| ME6010 – Conduction Heat Transfer | | | | X |
| ME6360 – Introduction to Continuum Mechanics | | X | | X |
| ME5060 – Machine Vibrations | | X | | |
| ME6050 – Convection Heat Transfer | X | | | |
| ME7090 - Computational Fluid Dynamics | X | | | |
| ME7100 – Turbulence | X | | | |
| **Mathematics** | | | | |
| MATH5510 – Advanced Math for Engineers | | X | | X |
| MATH5470–Probability and Statistics-I | X | | X | |
| MATH6170–Experimental Design | X | X | | |
| MATH6510-Finite Difference Solution | | | | X |
| MATH6070-Applied Statistical Methods-I | | | X | X |
| MATH6080–Applied Statistical MethodsII | X | | X | |
| **Biology** | | | | |
| BIOL5130 – Environmental Microbiology | X | | | |
| BIOL5840-Limnology | X | | | |

## APPENDIX THREE

**Table 1-Summary of participation in conferences and oral presentations for a sample of students.**

| **Student Name** | **Title of Conference Presentation (Oral)** |
|---|---|
| **2008-2009** | |
| J Philips | "A Rapid Green Base Repair CLSM," *Transportation Research Board 88th Annual Meeting Compendium of Papers DVD, January 2009.* |
| B. Byard | "Making Precast Concrete Mixtures More Sustainable with Byproduct Fine Aggregate," *The National Bridge Conference, PCI Annual Convention, Orlando, FL, October 7, 2008.* |
| Kristen Hood | "Lean, Green and Mean (LGM) PCC: A First Look," *TDOT – TCA Liaison Committee Meeting, Nashville, September 3, 2008.* |
| J Philips | Lean, Green and Mean (LGM) PCC: A First Look," *TDOT – TCA Liaison Committee Meeting*, Nashville, September 3, 2008 |
| J D Self | "Making Precast Concrete Mixtures More Sustainable with Byproduct Fine Aggregate," *The National Bridge Conference, PCI Annual Convention, Orlando, FL, October 7, 2008.* |
| Lindsay Smith | "Expansion and Cracking of Concrete Structures Due to Delayed Ettringite Formation," (Poster presentation). *4th Annual Undergraduate Research Posters at the Capital, Nashville, TN, February 11, 2009.* |
| Lindsay Smith | Expansion of Cementitious Mortars Due to Delayed Ettringite Formation," *19th Annual Argonne Symposium for Undergraduates in Science, Engineering, and Mathematics, Argonne National Laboratory, Argonne, IL, November 7, 2008.* |
| **2009-2010** | |
| Elizabeth Boden | "Real Time Traffic Signal Delay Estimation Using State-of-the-Practice Detection Technology: a Simulation Proof-of-Concept". *TTU Research Day, 2010* |
| Caitlin B. Moffit | "Validation of the Global NASA Satellite-based Flood Detection System in Bangladesh". *TTU Research Day, 2010.* |
| Elizabeth Boden | "Real Time Traffic Signal Delay Estimation Using State-of-the-Practice Detection Technology: a Simulation Proof-of-Concept", *89th Annual Transportation Research Board Meeting January 2010*. |
| **2010-2011** | |
| Chris Berry | New Interchange Design: FRE Interchange: Releasing Control and Enhancing Performance" *89th Annual Meeting of the Transportation Research Board, 2010*. |
| Gregory Browning | "Optimum Air Content Range (Plastic and Hardened) for TDOT Class D PCC RES 2010-07 Update", *TDOT – TCA Liaison Committee Meeting, Nashville, February 17, 2011* |
| Suhai Zhang | Simplification of Live Load Distribution Factor Equations, *TTU Research Day, 2011.* |

| 2011-2012 | |
|---|---|
| Benjamin Fennell | Water Reuse and Conservation Considerations in Drought Planning Using Oasis Modeling, *TN Water Resources Symposium, April 12, 2012*. |
| D. G. Keaton | 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.* |
| D.G. Keaton | Nano-scale Pore Analysis of Cementitious Mortars Due to Delayed Ettringite Formation” (Poster presentation). *Tennessee Technological University Student Research Day*, Cookeville, TN, April 11, 2012. |

**Table 2-List of sample journal publications ensuing from the thesis work for a sample of MS students.**

| Student Name | Full citation in the journal ensuing from thesis work |
|---|---|
| Amanda Harris | Optimal configuration of conceptual hydrologic models for satellite rainfall-based flood prediction for a small watershed," *IEEE Geosciences and Remote Sensing Letters*, vol. 5(3), July, 2008 |
| Jason Philips | Five Part Series on the New TDOT 204.06 CLSM Specification Part 5: The Future of CLSM in Tennessee", *Tennessee Concrete*, Vol. 23, No. 1, Spring 2009. |
| Matthew Boynton | Improving Engineering Education Outreach in Rural Counties through Engineering Risk Analysis, *ASCE Journal of Professional Issues in Engineering Education and Practice*, (DOI: 10.1061/(ASCE) EI.1943-5541.0000026. 2010 |
| A.H.M. Siddique-E-Akbor | Inter-comparison Study of Water Level Estimates Derived from Hydrodynamic-Hydrologic Model and Satellite Altimetry for a Complex Deltaic Environment. *Remote Sensing of Environment*, vol. 115, pp. 1522-1531 (doi:10.1016/j.rse.2011.02.011). 2011 |
| Caitlin B. Moffit | Validation of TRMM Flood Detection System over Bangladesh, *International Journal of Applied Earth Observation and Geoinformatics*, (doi:10.1016/j.jag.2010.11.003). 2011 |
| Caitlin B. Moffit | "A Review of State of the Art on Treaties in relation to Management of Transboundary Flooding in International River Basins and the Global Precipitation Measurement Mission" *Water Policy* (DOI:10.2166/wp.2009.117. 2010 |
| Caitlin B. Moffit | Forensic Analysis of two contrasting satellite rainfall products for detection of the July 2002 flooding in South-central Texas, *Environmental Forensics*, vol. 12, pp. 19–225,(doi:10.1080/15275922.2011.595045). 2011 |
| Kirsten Hood | "Influence of Bleed Water Reabsorption on Cement Past Autogenous Deformation", *Cement and Concrete Research*, 2010; 40(2):220-225. |
| Kirsten Hood | "Factors Influencing Mitigation Strategies for Autogenous Shrinkage." *Cement and Concrete Research* (In review) |
| A.H.M. Siddique-E-Akbor | Role of Land-water Classification and Manning's Roughness parameter in Space-borne estimation of Discharge for Braided Rivers: A Case Study of the Brahmaputra River in Bangladesh, *IEEE Special Topics in Applied Remote Sensing and Earth Sciences*, (doi:10.1109/JSTARS.2010.2050579). 2010. |
| Chris Berry | Evaluation of Traditional and Non-Traditional Interchange Treatments to Preserve the Service Life of Narrow Over- and Underpass Roadways, *J. Transportation Research Board*, 10-2676, 2010. |
| Elizabeth Boden | Using Dynamic Maximum Greens to Reduce Traffic Signal Timing Maintenance Needs. *ITE Journal*, Volume 80, Issue 4, 2010 |
| Elizabeth Boden | "Evaluation of Traditional and Non-Traditional Interchange Treatments to Preserve the Service Life of Narrow Over- and Underpass Roadways" *Transportation Research Record: Journal of the Transportation Research Board*, Issue 2171, 2010. |

**Table 3-List of research facilities/laboratories in CEE Department**

| Physical Facility Building and Room Number | Purpose of Laboratory | Condition of the Laboratory | Adequacy for Graduate Studies | Number of Student Stations | Area (sq.ft) |
|---|---|---|---|---|---|
| PH 132 | Construction Materials | Excellent | Adequate | 5 | 943 |
| PH 134 | Construction Materials | Very good | Adequate | 5 | 697 |
| PH 127 | Surveying Laboratory | Good | Adequate | 4 | 624 |
| PH 131 | Materials Laboratory | Excellent | Adequate | 5 | 1003 |
| PH 345 and 310 | Geotechnical Instruction | Very good | Adequate | 4 | 1296 |
| PH 314 | Structures Research and Instruction | Good | Adequate | 2 | 755 |
| PH 341 | Structures Research and Instruction | Good | Adequate | 2 | 740 |
| PH 315 | Strength of Materials and Concrete Research Laboratory | Excellent | Adequate | 2 | 360 |
| PH 317 | Materials | Very good | Adequate | 1 | 384 |
| PH 328 | Environmental Preparation and Instruction | Good | Adequate | 2 | 265 |
| PH 329 | Environmental Research and Instruction | Very good | Adequate | 5 | 902 |
| PH 326 | Environmental Research and Instruction | Very good | Adequate | 5 | 1626 |
| PH 338 | Environmental Instruction | Very good | Adequate | 5 | 740 |
| PH 320 | Environmental Research and Instruction | Fair | Adequate | 2 | 172 |
| PH 321 | Environmental Research and Instruction | Good | Adequate | | 172 |
| PH 335 | Environmental Preparation | Good | Adequate | | 172 |
| PH 336 | Environmental Preparation and Research | Good | Adequate | 1 | 172 |
| Stadium, ESTA 122 | CEE Shop – support services | Good | Adequate | | 1035 |
| Stadium, | Structures Lab, Shop – | Good | Adequate | 1 | 2988 |

| | | | | | |
|---|---|---|---|---|---|
| ESTA 121 | support services | | | | |
| CH 104 | Mechanics Instruction | Excellent | Adequate | 5 | 1210 |
| CH 122 | New Materials and Mechanics Laboratory | Excellent | Adequate | 4 | 1041 |
| PH 122C | Transportation Laboratory | Good | Adequate | 3 | - |
| **TOTAL** | | | | | **17,297 sq.ft.** |

**Table 4- List of scholarly journals relevant to Civil Engineering that are subscribed by the TTU library**

| | Journal Name | Area of Specialization | Type | Coverage |
|---|---|---|---|---|
| 1 | ACI Materials Journal | Materials/ Transportation | Journal | Print: 1988-present |
| 2 | Advanced Materials and Processes | Engineering Mechanics | Journal | Print: 1986-present<br>Online: 1994-present |
| 3 | Applied Mechanics Review | Engineering Mechanics | Journal | Microfilm: 1948-1963<br>Print: 1964-1999<br>Online: 2000-present |
| 4 | Architectural Record | Structural Engineering | Journal | Microcard: 1891-1902<br>Print: 1948-2003<br>Online: 1992-present |
| 5 | Building and Environment | Inter-disciplinary | Journal (Discontinued) | Print: 1976-2008 |
| 6 | Civil Engineering | Inter-disciplinary | Journal | Print: 1930-present |
| 7 | Civil Engineering Practice (Journal of Boston Society of Civil Engineers/ASCE) | Inter-disciplinary | Journal | Print: 1987-2008 |
| 8 | Computer Applications in Engineering Education | Inter-disciplinary | Journal | Print: 1992-1996<br>Online: 1996-present |
| 9 | Computers and Fluids | Water/Inter-disciplinary | Journal | Print: 1973-2008<br>Online: - present |
| 10 | Computers in Education Journal | Inter-disciplinary | Journal | Print: 1991-present |
| 11 | Concrete | Structural Engineering/ Materials | Journal | Print: 1968-2008 |
| 12 | Concrete International (Design and Construction) | Structural Engineering/ Materials | Journal | Print: 2000-present |
| 13 | Engineering and Technology | Environment/Water | Journal | Print: 2006-present |
| 14 | Environmental Engineering Science | Environment/Water | Journal | Online: 1984-present |
| 15 | Environmental Progress | Environment/Water | Journal | Print: 1982-1998<br>Online: 2009-present |

| | | | | |
|---|---|---|---|---|
| 16 | Hydraulics and Pneumatics | Water | Journal | Print: 1969-1983 + last 2 years<br>Online: 1983-present, less 2 years |
| 17 | IMA Journal of Numerical Analysis | Inter-disciplinary | Journal | Print: 1982-2008<br>Online: 1999-2006 |
| 18 | International Journal of Numerical Methods in Engineering | Inter-disciplinary | Journal | Online: 1996-present |
| 19 | International Journal of Engineering Education | Inter-disciplinary | Journal | Print: 1992-1996<br>Online: 1994-present |
| 20 | International Journal of Engineering Science | Inter-disciplinary | Journal | Print: 1963-2001<br>Online: 2002-present |
| 21 | Journal of the American Water Works Association | Water/Environment | Journal | Print: 1914-1947<br>Online: 1997-present |
| 22 | Journal of Applied Mathematics and Mechanics | Engineering Mechanics | Journal | Print: 1958-2001<br>Online: 1998-present |
| 23 | Journal of Applied Mechanics | Engineering Mechanics | Journal | Print: 1935-1949; 1959-1999<br>Microfilm: 1951-1960<br>Online 1970-present |
| 24 | Journal of Computational and Non-linear Dynamics | Inter-disciplinary | Journal | Online: 2006-present |
| 25 | Journal of Environmental Systems | Environment/Water | Journal | Print: 1972-present<br>Online: 2002-2006 |
| 26 | Journal of Irrigation and Drainage (ASCE) | Water/Environment | Journal | Online: 1983-present |
| 27 | Journal of Materials in Civil Engineering | Materials/ Transportation/ Structural Engineering | Journal | Online: 1989-present |
| 28 | Journal of Materials Education | Materials/ Transportation | Journal | Print: 1984-present |
| 29 | Journal of Sound and Vibration | Engineering Mechanics | Journal | Print: 1964-1997<br>Online: 2002-present |
| 30 | Journal of Air and Waste Management Association | Environment/ Water | Journal (Discontinued) | Print: 1955-1989 |
| 31 | Journal of the American Water Resources Association | Water/ Environment | Journal | Online: 1997-present |
| 32 | Journal of the IEST | Inter-disciplinary | Journal | ? |

| | | | | |
|---|---|---|---|---|
| 33 | Magazine of Concrete Research | Structural Engineering /Materials | Journal | Print: 1966-2009<br>Online: 1976-present |
| 34 | Materials Characterization | Engineering Mechanics/ Materials | Journal | Print: 1990-2001<br>Online: 2002-present |
| 35 | Materials Evaluation | Materials/ Transportation | Journal | Print: 1964-present |
| 36 | Metallurgical and Materials Transactions | Materials | Journal | Print: 1964-1996<br>Online: 1997-present |
| 37 | Modern Steel Construction | Structural Engineering | Journal | Print: 1988-2002 + last 2 years<br>Online: 2003-present, less 2 years |
| 38 | Natural Hazards Review | Environment/Water | Journal | Online: 2000-present |
| 39 | PCI Journal (Prestressed Concrete Institute) | Structural Engineering/ Materials | Journal | Print: 1964-present |
| 40 | Public Works (New York) | Environment | Journal | Microfilm: 1896-1968<br>Print: 1968-1991<br>Online: 1992-present |
| 41 | Soils and Foundation | Materials/ Geotechnical | Journal | Print: 1969-present |
| 42 | Structural Engineer | Structural Engineering | Journal | Print: 1965-present |
| 43 | Tennessee Environmental Law Letter | Environment | Journal (Discontinued) | Print: 1992-2009 |
| 44 | Transportation Journal | Transportation | Journal | Print: 1968-1992<br>Online: 1992-present |
| 45 | Transportation Science | Transportation | Journal | Print: 1984-1997<br>Online: 1998-present |
| 46 | Water and Environment Journal | Water/ Environment | Journal | Print: 2001-2002<br>Online: 1997-present |
| 47 | Water Environment Research | Environment/ Water | Journal | Print: 1992-1996 + last 2 years<br>CD-ROM: 2000-2009 |
| 48 | Water Resources Research (AGU) | Water/Environment | Journal | Print: 1965-present<br>Online: 2010-present, less 1 year |

| | | | | |
|---|---|---|---|---|
| 49 | ASCE Journal of Hydrologic Engineering | Water | Journal | Online: 1996-present |
| 50 | ASCE Journal of Bridge Engineering | Structural Engineering | Journal | Online: 1996-present |
| 51 | ASCE Journal of Composites for Construction | Engineering Mechanics/ Materials | Journal | Online: 1997-present |
| 52 | ASCE Journal of Geotechnical & Geoenvironmental Engineering | Geotechnical/ Materials | Journal | Online: 1997-present |
| 53 | ASCE Journal of Materials in Civil Engineering | Materials | Journal | Online: 1989-present |
| 54 | ASCE Journal of Performance of Constructed Facilities | | | Online: 1987-present |
| 55 | ASCE Journal of Computing in Civil Engineering | Inter-disciplinary | Journal | Online: 1987-present |
| 56 | ASCE Journal of Structural Engineering | Structural Engineering/ Mechanics | Journal | Online: 1983-present |
| 57 | ASCE Journal of Surveying Engineering | Surveying | Journal | Online: 1983-present |
| 58 | ASCE Journal of Waterway, Port and Coastal Engineering | Water/ Environmental | Journal | Online: 1983-present |
| 59 | ASCE Journal of Engineering Mechanics | Engineering Mechanics | Journal | Online: 1983-present |
| 60 | ASCE Journal of Environmental Engineering | Environmental/ Water | Journal | Online: 1983-present |
| 61 | ASCE Journal of Water Resources Planning and Management | Water/ Environment | Journal | Online: 1983-present |
| 62 | Journal of Transportation Engineering | Transportation/ Traffic | Journal | Online: 1983-present |
| 63 | ASCE Journal of Urban Planning and Development | Transportation | Journal | Online: 1983-present |
| 64 | Academic OneFile | Inter-disciplinary | Electronic Database | |
| 65 | ASCE Online | Inter-disciplinary | Electronic Database | |
| 66 | Blackwell Synergy | Inter-disciplinary | Electronic Database | |
| 67 | Computer Database | Inter-disciplinary | Electronic Database | |
| 68 | EBSCOhost Electronic Journals | Inter-disciplinary | Electronic | |

| | | | | |
|---|---|---|---|---|
| | | | Database | |
| 69 | Energy Citations Database | Inter-disciplinary | Electronic Database | |
| | Engineering Village Cempendex | Inter-disciplinary | Electronic Database | |
| 70 | Environment Index | Inter-disciplinary | Electronic Database | |
| 71 | Expanded Academic | Inter-disciplinary | Electronic Database | |
| | Information Bridge: DOE Scientific & Technical Information | Inter-disciplinary | Electronic Database | |
| 72 | J-Stage | Inter-disciplinary | Electronic Database | |
| 73 | Sage Publications | Inter-disciplinary | Electronic Database | |
| 74 | Scitation | Inter-disciplinary | Electronic Database | |
| 75 | SpringerLink | Inter-disciplinary | Electronic Database | |
| 76 | TRID (Transportation Research Board) | Inter-disciplinary | Electronic Database | |
| 77 | Wiley Online Library | Inter-disciplinary | Electronic Database | |

**Table 5 - List of some major externally funded projects during 2008-2012**

| Faculty Name | Project Title | Sponsor |
|---|---|---|
| Sharon Huo | "Simplified Live Load Distribution Factor Equations for Tennessee Bridge Design"; Amount: USD $65,000; June 2009; PI | TDOT |
| L K Crouch | "Optimum Air Content Range (Plastic and Hardened) for TDOT Class D Portland Cement Concrete (PCC)", Amount: USD $130,000; June 2009; PI | TDOT |
| | "Higher Volume Fly Ash PCC for Sustainability and Performance"; Amount: USD$ 130,000; June 2010; PI | TDOT |
| | | |
| Faisal Hossain | "Modeling the hydrologically-relevant features of uncertainty of NASA's high resolution precipitation products for advancing global applications over ungauged regions"; Amount: USD$82,800; May, 2008, PI. | NASA |
| | "Advancing the Hydrologic potential of NASA's TRMM-based Satellite Rainfall Estimation System for Global Flood Monitoring in Anticipation of GPM"; Amount: USD$ 310,000; April, 2008, PI. | NASA |
| | "A Satellite-based Early Warning, Mapping and Post-Disaster Visualization System for Water Resources of Low-lying Deltas of the Hindu Kush-Himalayan Region"; Amount: USD $840,000, April 2012; PI | NASA |
| | "Understanding Atmospheric Rivers, Terrain and Anthropogenic Land Cover Changes on Storm Modification around Large Dams using Multi-sensor Satellite Data, Cloud Tracking and Numerical Modeling"; Amount: USD$82,800, May 2012; PI | NASA |
| | "Satellite Rainfall Uncertainty Estimation Across the Globe for Diverse Hydrologic Applications Using Readily Accessible Geophysical Features"; Amount: USD$ 82,800; May 2012; PI | NASA |
| Daniel Badoe | "Development of a Tennessee Travel Demand Model Users' Group"; Amount: USD $7,000, June, 2009 PI | TDOT |
| | Development of a Tennessee Travel Demand Model Users' Group"; Amount: USD $27,750, August, 2010. | TDOT |
| Vince Neary | Development of Morphology Relationships and the Establishment of Geomorphic Reference Reaches for the Nashville Basin Physiographic Province"; Amount: USD$ 98,808; January, 2009; PI | TDEC |
| | "Hydrodynamic and Water Quality Modeling Review II, Northern Everglades, ARM Loxahatchee NWR," Amount: USD$75,000; PI | US Fish and Wildlife |
| Benjamin Mohr | "Transport Kinetics of Internal Curing Water in High Performance Concretes," Amount: USD $220,767; PI | NSF |
| | "MRI: Acquisition of XRD Attachments for Extending X-Ray | NSF |

| | | |
|---|---|---|
| | Laboratory Capabilities"; Amount: USD $171,083; September 2009; PI | |
| | "Nanoscale Characterization of Expansion Due to Delayed Ettringite Formation"; Amount: USD$ 300,000; September 2011; PI | NSF |
| Steven Click | "Application of Non-Traditional Interchange Treatments to Improve Interchange Quality of Service and Preserve the Service Life of Narrow Over- and Underpass Roadways" Amount: USD$100,000; PI | TDOT |
| | Field Evaluation of Traffic Signal Based Interchange Treatments"; Amount: USD $200,000; June 2009, PI | TDOT |
| Jane Liu | "Modeling of Face Sheet Wrinkling of Cylindrical Sandwich Shells," Amount: $24,000, April 30, 2008; PI | United Launch Alliance |
| | "Biaxial Stress Testing of Rohacell"; Amount: USD$ 15,000; April, 2009; PI | United Launch Alliance |

**Table 6-** Individual CEE faculty project funding (approximate and rounded off to the nearest thousand) awarded (as PI and Co-PI) since 2008-09. (Only external funding is reported). For multiple CEE Co-PIs, only the PI's name is reported). Note: the budget figures on the rightmost column are not necessarily always activations on campus for the specific year in question.

| YEAR | FACULTY | RESEARCH FUNDING |
|---|---|---|
| **2008-09** | Badoe | 7,000 |
| Total Activations: $449,061 | Click | 100,000 |
| | Crouch | 37,000 |
| | Mohr | 75,000 |
| | Huo | 65,000 |
| | Hossain | 210,000 |
| | Liu | 24,000 |
| | Neary | 120,000 |
| **2009-10** | Badoe | 7,000 |
| Total Activations: $431,985 | Click | 70,000 |
| | Crouch | 130,000 |
| | Mohr | 220,000 |
| | Huo | 35,000 |
| | Hossain | 210,000 |
| | Liu | 45,000 |
| **2010-11** | Badoe | 27,750 |
| Total Activations: $376,166 | Click | 200,000 |
| | Crouch | 255,000 |
| | Mohr | 110,000 |
| | Huo | 65,000 |
| | Hossain | 27,000 |
| **2011-12** | Badoe | 9,500 |
| $484,207 | Click | 66,000 |
| | Crouch | 210,000 |
| | Mohr | 110,700 |
| | Huo | 70,000 |