

SELF-STUDY DOCUMENT

January 2008

**REVIEW OF
MASTER OF SCIENCE
PROGRAM**

**Department of Civil and
Environmental
Engineering**



**Tennessee Technological
University**

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January, 2008
Department of Civil and Environmental Engineering**

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I. INTRODUCTION

A. Program Overview

Historical Background

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 38 years, 291 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) is the only degree currently available to CEE students. Figure 1 below illustrates the distribution of degrees conferred each academic year since the program was initiated in 1969.

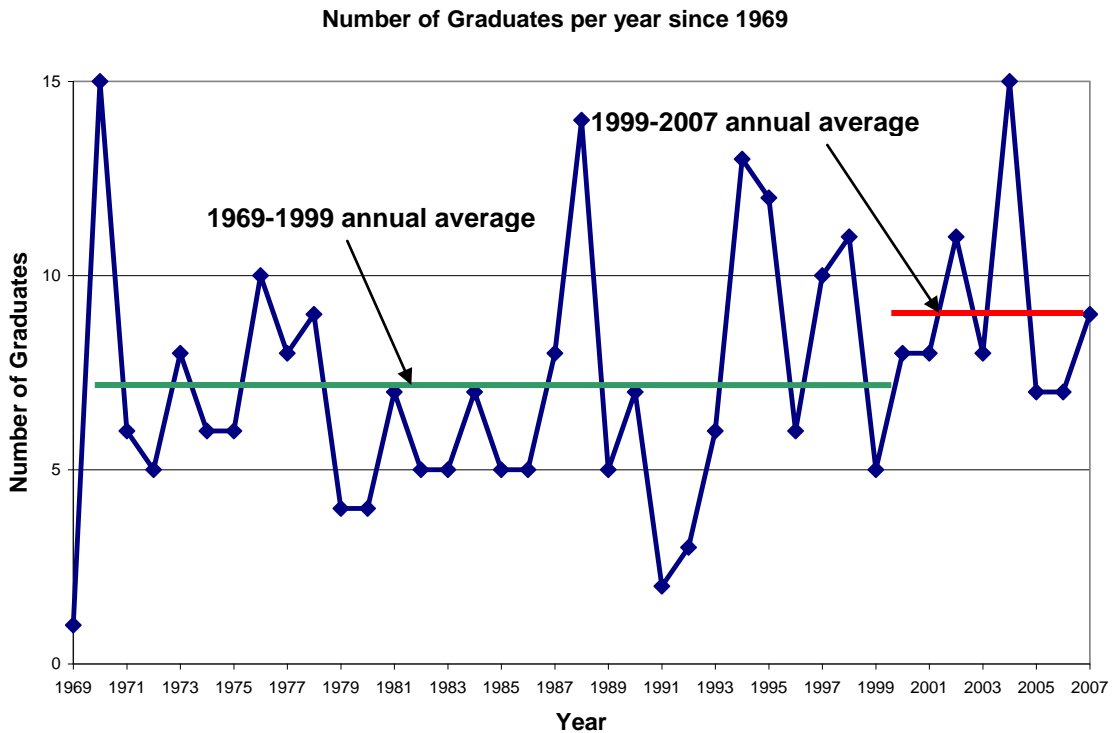


Figure 1 - Distribution of degrees conferred each academic year since the program was initiated.

Since the last review in 1999, a modest rise in graduate student enrollment has been noted in CEE MS program. The most recent 8 year (1999-2007) annual average enrollment is 9.125 per year, which is about 29% higher than the previous 30 year (1969-1999) average annual enrollment of 7.03 per year (Figure 1). A consistent feature of the CEE enrollment is that it has never been below 5, which is the Tennessee Higher Education Council (THEC) specified limit below which a graduate program is classified as “low-producing”.

The goal of the graduate program in CEE is to provide the strong academic training needed for students to become educated members of society who can both join and make significant contributions to the civil engineering profession. Because of this goal for graduates to make significant contributions, a research project and thesis document is a necessary component of the degree. A research project and a thesis document are thus necessary components of the degree. Concentration areas approved by the Tennessee Board of Regents (TBR) are in environmental, structural and transportation engineering. The CEE department has plans to establish official concentrations in some or all of these areas in the future. This should facilitate improved publicity and marketing of the program leading to higher growth in enrollment. A significant number of students have also specialized in the areas of engineering mechanics, materials, and water resources (Table 1).

Table 1 – Distribution of graduates as a function of area of specialization during 2002-2007.

	02-03	03-04	04-05	05-06	06-07
Environmental	5	1	3	1	3
Water Resources	1	1	1	2	3
Structural Engineering	3	2	3	1	1
Engineering Mechanics			2	1	4
Transportation	1	2	1	2	5
Materials	3	3	3		2
Total	13	9	13	7	18

Recent Development: B.S/M.S Fast Track Program

In the fall of 2007, a Fast-track BS/MS Program in Civil Engineering was initiated to provide an opportunity for promising undergraduate students to accelerate the completion of the MS degree. CEE undergraduate students are eligible to apply to the CEE Fast-Track MS program by the end of their second junior term, provided they maintain at least an overall GPA of 3.25 and have at least a 3.5 GPA in CEE courses. Students admitted to the Fast-Track program must take the GRE during their second senior term (one semester prior to their anticipated BS graduation). The general admission criteria to the graduate program are the same as the regular MS program. In anticipation of the additional 30 credit hour requirement for professional licensure by the National Council of Examiners for Engineering and Surveying (NCEES) in 2015, the B.S/M.S Fast-track program is considered a timely addition for our CEE graduate program.

B. Faculty

Currently there are 16 full-time faculty members engaged in the continued growth of the CEE graduate program. Faculty expertise covers the breadth, depth and the level of sophistication required for today's highly inter-disciplinary Civil Engineering profession. All graduate faculty hold terminal degrees in a major area of Civil Engineering. Table 2a below shows the make up 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 research experience. Detailed qualifications of each faculty are provided as 2-page resumes in Appendix 1.

Table 2a- Distribution of Faculty Expertise.

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

Performance Metrics of Faculty Activity

During 2002-2007, faculty remained very 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) etc. More than 14 national/international conference sessions were organized or chaired during this time at regional or international venues. Nine external PhD theses were sent to CEE faculty for review from Universities as far and prestigious as the Indian Institutes of Technology. More than 500 research proposals were reviewed for federal grant agencies. One assistant professor holds an associate editorial position with the Journal of American Water Resources Association. Collectively, faculty reviewed more than 180 manuscripts for the editorial boards of scholarly journals in the CEE discipline. Sixty-nine invited seminars were delivered nationwide by faculty during this time. Total external funding for research secured by CEE faculty during this 5-year period was \$2.47 million (see Table 1a in Appendix 2). The average annual research funding over the last five years has been approximately \$494,000/year. CEE faculty were particularly successful in securing research funding from federal agencies such as National Science Foundation (NSF), National Aeronautics and Space Administration (NASA), United States Department of Agriculture (USDA), Federal Highway Administration (FHWA), United States Geological Survey (USGS) and US Wildlife and Fisheries (USWF). These projects have supported more than 50% of our graduate students. Several faculty have also been actively engaged in engineering education societies such as the American Society of Engineering Education (ASEE).

In terms of productivity of scholarly work, more than 90 journal papers and 70 conference proceedings were published by faculty during 2002-2007. The average rate of scholarly journal publications by CEE faculty has remained consistently above 15 per year. Aggressive startup activity by newly recruited faculty over recent years has contributed to a trend of increased productivity. Faculty publication has increased to 20 per year during the last two years. Table 2b below provides a summary of research and scholarly activity by faculty during 2002-2007. In Appendix 2 (Tables 1a and 1b) more detailed activity on scholarship and research funding are provided.

Table 2b – Summary of research and scholarly activity by CEE faculty during 2002-2007.

	02-03	03-04	04-05	05-06	06-07	07-08*
External Research Funding	\$467,320	\$539,606	\$503,627	\$429,761	\$275,102	\$530,779
Journal publications	14	13	21	20	21	7
Conference Publications	12	12	14	12	22	8
Chaired Sessions/Editorship of Journals	2	3	2	0	4	1
Review of project proposals and research manuscripts	90	132	125	154	148	10
Invited seminars	12	10	7	13	17	2

* In progress

C. Students

General Overview

On average, there have been more than ten graduate students in the MS program at any given time. Over the 2002-2007 period, a total of 227 student applications to the CEE MS program were received. One hundred and thirty-six applications (60%) were granted admission (including provisional standing). A total of 102 actually enrolled during this time. Fifty-five (54%) of those enrolled have already successfully completed their MS degree in an average time of 2.21 years. A remaining 20% (admitted between 2005-2007), at the time of documentation, were either continuing their program or were expected to complete by 2008. The 5-year average graduation rate is 75%, which is a reflection of the high standards enforced in retention and quality control of MS graduates. Those enrolled in the program are not automatically guaranteed a degree without satisfying the requirements of satisfactory progress in coursework and research. Table 3 below provides a summary of the minimum and average qualifications of students enrolled in the program. An aspect that is not apparent in the data reported herein is the participation by CEE faculty in advising a large number of graduate students from other departments. In particular, faculty from the mechanics area have regularly served as major advisor of several Mechanical Engineering (ME) students due to the inter-disciplinary nature of research work. Water resources faculty have also served as major advisor to students from the ME and Biology Departments.

Table 3 – Demographic pattern and qualification of students enrolled in the CEE MS program

Year	Number of women/minority candidates	Minimum GRE/GPA score	Average GRE/GPA score
02-03	5	1190*/3.118	1577*/3.237
03-04	8	1190*/3.000	1384*/3.459
04-05	7	1015/2.760	1098/3.212
05-06	9	735/2.640	1115/3.473
06-07	6	1050/3.029	1176/3.482

- Older system of GRE score out of 2400(Q800+V800+A800)

Student Participation in B.S/M.S Fast-Track Program

As mentioned earlier, the Department has also been working on developing a new BS/MS Fast-Track graduate program since spring 2005. 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 quality as well as the University's goals of focusing on upper division undergraduate education and preparing students for graduate studies. At the initiation of the program in fall 2007, four candidates met the stringent requirements and were admitted to the Fast Track program. Of the four Fast-Track students, three of them have received the highly honored University Academic Service Scholarships.

The students' overall GPAs range from 3.72 to 3.98 and their major GPAs range from 3.85 to 4.0. A particularly unique feature of the Fast-Track program is that the Fast-Track students have the opportunity to participate in challenging undergraduate research that can transition into MS thesis research. Each of the four students participates in research work, to various degrees, in their senior year under the guidance of his/her mentor. It is anticipated that the program will have a positive impact on graduate student enrollment. The description of the CEE BS/MS Fast-Track program is enclosed in Appendix 3.

Student Make-up

Demographic data indicate that the graduate student body is made up of both national and international students. Very recently, CEE has attracted considerably greater interest from high caliber students from world renowned institutions such as Indian Institutes of Technology, Tsinghua University, Bangladesh University of Engineering and Technology, and Ohio State University. Applicants from countries like India, China, Lebanon, Malaysia, Egypt, Vietnam, Bangladesh and Phillipines have become a regular feature. This is a testimony to the increasing visibility of the graduate program and its quality in the international arena. About 34% of those enrolled are women or minority as noted in Table 3.

Student Recruitment

Typically, faculty would recruit qualified students through dissemination of their research project during seminars on campus and elsewhere. The CEE graduate seminar series, held regularly since fall 2006, has served as an information gateway for undergraduate seniors to consider the CEE graduate program. Open graduate assistantship positions on funded research projects are also announced in magazines published by professional societies such as ASCE and AGU. Many graduate students also receive an opportunity to broaden their research experience through internships at research centers (such as Oak Ridge National Research Laboratory - ORNL), Co-ops in industry and international summer camps. Between 2005 and 2007, three students participated in international summer camps in China and India. Another undergraduate student, expected to join the Fast-Track program next year, has participated in a 5-week long NSF field trip to Ethiopia in summer of 2007.

Financial Support for Students

There are primarily two sources of financial support available to graduate students, namely – research assistantships and teaching assistantships. Teaching assistantships are administered through the CEE department. Research assistantships are usually administered by one of the three Centers of Excellence at TTU, which are discussed in the next section. Table 4 below provides a summary of support provided to graduate students.

Table 4 – Distribution of graduate students supported and research funding secured by CEE faculty through the Centers of Excellence

(Note: CMR supported 4 students during this time)

Year	Water Research Center		Center for Energy Systems Research		CEE Department
	Students Supported	CEE Research Funding (\$)	Students Supported	CEE Research Funding (\$)	Students Supported
2002-2003	12	180,417	9	343,498	14
2003-2004	9	252,772	9	353,834	15
2004-2005	4	316,990	N/A	N/A	10
2005-2006	6	235,273	1	\$234,719	8
2006-2007	6	263,539	4	\$24,000	9

D. Centers of Excellence

TTU has three state-funded centers of excellence for research. These are: 1) Center for the Management, Utilization and Protection of Water Resources (CMUPWR or Water Center), 2) Center for Energy Systems Research (CESR) and 3) Center for Manufacturing Research (CMR). These centers have played a supporting role in sustaining the quality of the CEE graduate program and its continued growth. A brief overview is provided on each center followed by the supporting role played in the CEE graduate program.

Center for the Management, Utilization and Protection of Water Resources

The Center for the Management, Utilization and Protection of Water Resources (Water Center) is dedicated to the vision of enhancing environmental education through research by focusing the expertise of its team of interdisciplinary professionals in the areas of environmental hazards, environmental informatics, and environmental resource management and protection. Within those categories, Center faculty concentrate on aquatic toxicology, ecological assessment, environmental social issues and education, fisheries assessment, water and wastewater treatment, waterborne pathogens, and watershed analysis. Their work has received international attention as they publish and present their findings, but nowhere has the Center's research been more valuable than in its own state of Tennessee. Since its inception, the Center has attracted more than \$31.7 million (2006 equivalent dollars) in externally funded research, approximately \$31.1 million (2006 equivalent dollars) of which has remained in the state.

Center for Energy Systems Research

The Center for Energy Systems Research (CESR) was established to advance and apply scientific and engineering knowledge associated with energy systems and in particular with electric power while supporting the instructional program of TTU in academic areas associated with energy systems. Research efforts, both theoretical and experimental, are focused on solving current and anticipated problems associated with energy systems. Special emphasis is given to the needs of the electric power industry.

Center for Manufacturing Research

The Center for Manufacturing Research (CMR) was created to draw together resources of the State of Tennessee, TTU, industries from Tennessee and abroad, and government funding agencies into a cooperative effort to be on the leading edge of the latest technological advances in manufacturing. The Center utilizes expertise from throughout the College of Engineering and various other colleges, departments and the University, as appropriate, as well as resources outside the University. The Center also employs dedicated faculty and staff that are responsible for enhancing and supporting our strategic research program. Staffing includes four faculty, one Post Doctoral Assistant, three R&D engineers, eight supporting office and laboratory staff, and numerous graduate research assistants.

Supporting Role of Centers in Graduate Program

Centers provide financial support to CEE graduate students in the form of research assistantship from research projects directed by CEE faculty. Centers also host internationally recognized experts for the graduate seminar series. Students are provided access to the laboratories of the Centers for conducting research. The chemistry analytical laboratory and the Geographic Information Systems (GIS) laboratory of the Water Center have been regularly accessed by CEE students to perform graduate level research in the field of water resources and environmental engineering. CMR's Computer Aided Engineering Laboratory has been frequently used by CEE graduate students engaged in high performance computational research in the engineering mechanics and water resources area. Between 2002-2007, the Water Center provided financial support (including logistic and laboratory facilities) to nineteen (3 PhD and 16 MS) CEE graduate students in the Environmental/Water area. In the same period, CESR supported nine (1 PhD and 8 MS) students in various sub-disciplines such as mechanics, structural engineering and transportation engineering. CMR supported four students (4 MS) in the area of mechanics and transportation engineering. Table 4 provides a summary of graduate student support and research project funding secured by CEE faculty through the Centers of Excellence.

Centers 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. The staff work closely with CEE faculty to prepare project proposals, manage project budget and provide project reports according to the requirements of funding agencies. Newly recruited CEE faculty have utilized this support from Centers and become very successful in starting a research program in their area of expertise.

As part of enhancing research collaboration beyond TTU, the Water Center has recently established a 5-year Memorandum of Understanding (MOU) with three institutions – i) Institute of Water Modeling, Bangladesh; ii) Faculty of Sciences, Tunisia; and iii) Tennessee State University (TSU). The intent of these MOUs is to facilitate an exchange of faculty, students, research data, and educational and developmental programs between the cooperating parties. As such, these collaborative agreements provide an opportunity for graduate students to enrich their research experience beyond the classroom.

E. Research and Laboratory facilities

Overview

The Department of Civil and Environmental Engineering has adequate space for classes and laboratories. All classrooms are equipped with state of the art multi-media presentation facility that can be used for instructions, presentations by students, and which allows the hosting of quality seminars. Graduate students often use these rooms for their comprehensive exams, dissertation defense or 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 necessary equipment for research as well. Currently there are a total of eight types of laboratory for performing graduate level research. These are: 1) Cement-based Materials Laboratory; 2) Construction and Materials Laboratory; 3) Surveying Laboratory; 4) Structures Laboratory; 5) Environmental Research Laboratory; 6) Mechanics and Experimental Stress Laboratory; 7) Transportation Laboratory, and, 8) Machine Shop. Condition of these laboratories range from good to excellent. Total floor space for laboratory is 17,856 sq. ft (see Table 2, Appendix 2).

Student Facilities

All graduate assistants 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 the main Civil Engineering building. This is open 24 hours and provide valuable

auxillary support to graduate students during intense research periods. Faculty and graduate students also make use of the Computer Aided Engineering (CAE) laboratory hosted by CMR to solve real-world engineering problems in civil engineering. The CAE laboratory is the University's High Performance Computer center with a total data storage volume of nine terabytes, 85 GB of memory and several dual processor machines. These high performance computing facilities can be remotely accessed by faculty and student from their desktops both on and off campus.

Library Facilities

Adequate library facilities are available through the TTU main library which currently houses approximately 347,146 volumes. 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 library currently subscribes to more than 50 journals (electronic/hard copy) and 16 electronic databases that are relevant to the Civil Engineering discipline. A list of these CEE relevant journals available is provided in Table 3 of Appendix 2. At the beginning of every fall term, a workshop is organized by TTU library as part of the graduate seminar series to introduce new graduate students to the library's facilities.

F. Curriculum

The CEE Department supports several coursework at the 5000, 6000, and 7000 levels to accommodate students' Program of Study requirements and desired field of specialization. Additionally, courses are available in supporting departments and colleges that can be used to satisfy degree requirements. The CEE Department has compiled folders, each containing a synopsis of a recent offering of each CEE course. These folders are available from the Departmental Chairperson.

Courses approved for graduate studies in the CEE Department are listed in Appendix 4. The instructor syllabi for a sample of courses offered during the 2005-07 period is included in Appendix 5 (detailed course syllabi is available upon request). Courses are offered frequently enough to enable students make reasonable progress towards degree completion. Table 4 in Appendix 2 provides a summary of CEE graduate courses and the chronology of their offering during the 2002-2007 period.

G. Program Quality Assessment

CEE graduate program quality is assessed through a process of continual review of the performance of students before and beyond graduation. Performance is measured in terms of student research publications, job placement, graduates opting for a PhD program, achievement of student awards, honors and participation in international camps. Recently initiated data collection efforts from alumni indicate that at least six of our graduates have continued to a PhD program in prestigious universities like Vanderbilt University, University of Texas (Arlington) and University of Southern California during 2002-2007. This is a testament to the confidence peer institutions have in our MS program. More than 60% of graduates received placement in reputed firms in the industry or state/national organizations (such as DOT, USACE, FHWA, USGS). Recently, a graduate has also set an example by taking up faculty positions in the academia at McNeese State University while continuing his PhD at TTU. Between 2002-2007, there have been a total of 18 journal publications and 31 conference proceedings with primary authorship by a student. Three students have received national or international awards while another three have participated in international camps. Table 5a in Appendix 2 provides a statistical summary of student achievements.

Elements of Quality Enhancement

In a bid to formalize the review of the student research experience and continually enhance the overall program quality, the Graduate Affairs committee was set up in fall of 2005. A handbook was compiled to guide new graduate students effectively through the MS candidature. This handbook is currently provided to all entering graduate students during an orientation that is held the first day of the seminar series. The handbook is also made available publicly on the CEE website. The graduate affairs committee has also been regularly hosting seminar speakers from the industry and academia. Speakers are experts in their field and are brought to campus to promote student interaction. A particular feature of the seminar series is the introduction to students of potential federal research funding opportunities for research, training on thesis/manuscript writing, usage of online scientific database and library facilities for research. Although the implementation of these recent quality enhancement procedures are relatively new, qualitative feedback from recent graduates and employers alike indicate that these measures have been effective. Appendix 6 provides the schedule of seminar speakers and some sample seminar abstracts since the seminar program began in the fall of 2006.

II. OBJECTIVE STANDARDS

A. Admission of Students

General Admission Standards

The student who completes the MS degree is the product of the CEE Department and the reason for State funding of the program. This MS student must therefore receive the training that meets the needs of employers and graduate schools. The graduating students must be personally satisfied with their accomplishments, and be able to contribute to society during their career. The CEE graduate program must therefore maintain appropriate academic rigor.

The requirements for admission to the MS program are the same as the general requirements for graduate admission to the College of Engineering. The minimum requirements for regular admission are: i) a Bachelor of Science in Civil Engineering (BSCE) degree; ii) a GPA of at least 3.0 on a 4.0 scale; iii) a total of at least 1000 on the verbal and quantitative portions of the General Test of the Graduate Record Examination (GRE) along with a 3.5 score on the analytical writing portion of the test; iv) and three letters of recommendation from persons familiar with the applicant's academic abilities. Admission standards are documented in the TTU Graduate Catalog and the CEE Graduate Student Guide. In addition, a prospective student can access all relevant information remotely from the website of the graduate school at <http://www.tntech.edu/graduatestudies/>. All admission and funding decisions are based upon the application submitted by the student.

International Applicants

International students must score at least 550 (213 computer-based) on the Test of English as a Foreign Language (TOEFL). An applicant who is granted provisional admission due to a low TOEFL score is required to take ESL 1010 and/or ESL 1020 as remedial study. Applicants must also provide proof of access to sufficient funds to cover all of their expenses including travel home at the completion of their studies. The CEE graduate program is designed for graduates of approved undergraduate programs. Thus a baccalaureate degree in civil engineering is required for full standing. Applicants that have an undergraduate degree in a closely related field are evaluated on a case-by-case basis and may be admitted to full standing upon completion of identified background courses.

Enforcement of Admission Standards

Although the basic standards for admission are clearly defined by the College, these standards comprise only the minimum requirement to make a preliminary assessment of the applicant. To judge an applicant more rigorously, the CEE Chairperson, in consultation with a faculty familiar with

applicant's institution, assesses applications by paying particular attention to prior coursework performance and the quality of undergraduate instruction at the applicant's institution. This qualitative procedure has helped CEE to maintain standards of admission and the average quality of enrolled students.

Admission with Provisional Standing is granted to some applicants who do not satisfy all of the requirements previously stated or if the graduate affairs committee deem the candidate to be deficient in preparation. This category indicates that in the opinion of the CEE Department and the Dean of Graduate Studies, the student does not qualify for Full Standing and that before Full Standing can be granted, certain deficiencies must be addressed. The defined remedial work must be completed prior to the completion of 15 graduate hours. Deficiencies may be either (1) low undergraduate grade average, (2) insufficient background preparation for the specific field, indicating the necessity for certain prerequisite courses as preparation for pursuing the proposed graduate program, or (3) lack of satisfactory scores on admission tests. The student must apply for reclassification after deficiencies are addressed and special conditions or requirements are met. Applicants who have earned their BS in a field closely related to civil engineering can be granted provisional admission. Such applicants will usually be required to complete appropriate remedial coursework. The student's status from Provisional to Full Standing is changed via a memo from the CEE chairperson to the graduate student. The student and chairperson initiate the change after all specified criteria have been met.

Evidence of Enforcement of Admission Standards

As mentioned earlier, between 2002-2007, a total of 227 applications were received for the graduate program. One hundred and thirty-six were granted admission. A general summary of the qualifications of those enrolled was provided in Table 3 of the previous section. In Table 6 of Appendix 2, examples of the enforcement of admission criteria are provided on a case by case basis. Although the qualification of applicants in the 2002-2007 period has varied widely, the minimum qualifications for those granted admission with full standing has always been above the minimum required by the College. Furthermore, the large number of applicants who were denied admission despite meeting the quantitative standards of admission is evidence of the additional rigor that has been followed by CEE in granting admissions. The average GRE and GPA score of those granted admission has typically hovered above 1100 and 3.24/4.00, respectively.

Student Orientation

In the previous review period (1994-2000) there was no formal student orientation. In the fall 2005 semester, the CEE Graduate Affairs Committee was established as a standing committee and a formal graduate student orientation program was implemented. Beginning of fall 2006 semester, regular

orientation began at the start of each semester for new incoming students. This initial orientation is made a part of the graduate seminar series where each student is provided with the CEE Graduate handbook and supplementary information packet (see Appendix 6). The handbook was compiled by the committee to provide students with knowledge of pertinent rules and procedures for maintaining candidacy during the graduate program. In addition, guidelines are provided to assist students with research, thesis writing, presentations, and avoidance of plagiarism. Presentations are also made by selected CEE faculty, the CEE Chairperson, and the College of Engineering Associate Dean for Graduate Studies and Research relative to research and academic policies and procedures.

Mechanism of Student Orientation

Typically, a new CEE graduate student would undergo three rounds of orientation during the first year of his/her study period. While the first is the general orientation held en masse during the beginning of the graduate seminar in fall/spring, the second one usually occurs when the student forms his/her advisory committee upon consultation with the chairperson of the department during the early stages of the second semester. Subsequent to the formation of the advisory committee, the student then undergoes the third round of orientation where a preliminary research proposal is presented by the student in front of the committee to ensure quality and relevance of the student's thesis and coursework. In addition to this, all students under assistantship are also required to pass an online training course on sexual harassment prevention. This is a university wide policy. Details of the general student orientation can be found listed on the CEE web link for the seminar at <http://www.tntech.edu/cee/Graduate%20Seminar%20Schedule.htm>. As seen from the seminar schedules posted in Appendix 6, new students experience several opportunities to orient themselves with the art of thesis writing, preparing research proposals, practicing oral presentations and learning to search library databases for scientific literature research.

B. Supervision and Retention of Students

Retention Standards

Retention standards are clearly mentioned in the graduate handbook that is distributed to all new students during student orientation. These standards can also be remotely accessed by any student from the website of the graduate school at <http://www.tntech.edu/graduatestudies>. The minimum program requirements for the MSCE degree include 24 semester hours of graduate-level coursework specified on the program of study approved by the student's graduate advisory committee, and a minimum of six hours of research and thesis completed under the supervision of the graduate advisor and committee. The thesis requirement includes development of a research problem statement, successful execution of a research program, and documentation of the research findings written to the satisfaction of the Graduate School Office regulations and the student's graduate advisory committee.

Additionally, the research findings and thesis must be successfully defended before the graduate advisory committee.

Minimum GPA requirement in coursework: A graduate student is required to maintain a cumulative GPA of at least a *B* (3.0) on all courses taken for degree purposes. Credit toward the MS degree objective will be granted for any graduate course in which a grade of *A*, *B*, *C*, or *S* (Satisfactory) or *SP* (Satisfactory Progress) for thesis is assigned; however, not more than six hours of *C* credit will be accepted. If a grade of *D*, *U*, *F*, *WF*, or *NF* is assigned in a degree-related course, the course must be repeated, and both the original grade and grade for the repetition will be counted in the cumulative average. The grade point distribution for MSCE students between 2002-2007 is presented in Table 7 of Appendix 2.

Background Courses: A graduate student must achieve a grade of at least a *C* for each course taken for non-degree purposes, that is, courses taken for background preparation, certification, or personal enrichment. A student will be required to repeat each non-degree course in which a grade of *D*, *U*, *F*, *WF*, or *NF* is assigned. With the approval of the student's advisory committee, it may be possible that repetition of a course will not be required if a student's cumulative grade average on all courses (degree and non-degree) is at least *B* (3.0).

Probation: If a student's cumulative average on courses applied toward the graduate degree falls below *B*, he/she will be permitted one semester of probationary standing in which to sufficiently raise the average. If the term average on all courses taken during any one semester falls below *C*, the student's case will be reviewed by the Dean of Graduate Studies and CEE representatives (usually the chair of the department and the student's committee) and, without extenuating circumstances, the student will be dismissed from the graduate program. During this reporting period, 3 students were dismissed from the program for poor academic performance, as indicated in Table 7 of Appendix 2.

Graduate Assistant Requirements: A graduate assistant is required to maintain a minimum GPA of 3.0 each semester. On the recommendation of the CEE department chairperson and Dean of Engineering, the student may be permitted to retain the assistantship on probation for one semester should the average fall below the minimum requirement. Additionally, a student is only allowed to remain on assistantship during his/her first two calendar years in the degree program. Exceptions can be requested. This performance is monitored by the CEE department as part of the graduate student data base.

Criteria Enforcement Procedures: The major advisor would often meet informally at the end of each semester to discuss the progress of his/her graduate student during the previous semester. Much emphasis is placed on the 3.0 GPA and the *C* grade. Generally, the student is advised to leave

the program if academic problems are present. Occasionally, students are granted another semester to improve their performance or are allowed to change the area of concentration and essentially begin a new program of study. Reasons for exceptions to the retention criteria have included personal problems which have been mostly solved (work schedules, illness or death in the immediate family, divorce, etc.), research works in progress which are of great importance to the student and a faculty member, or some indication that the student initially pursued the wrong option.

Monitoring of Student Progress

The primary responsibility to monitor student progress resides with the Major Professor (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. Students are expected to make steady progress towards their degree requirements.

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 need to be verified by the student in sequence to ensure steady progress toward degree objectives.

1. **Standardized Examinations.** Admission to graduate study is conditioned by a requirement to take a standard examination (GRE) before or during the first term of enrollment. CEE graduate students are to check the certificate of admission and confer with personnel in the Graduate School Office to ensure compliance.
2. **Appointment of an Advisory Committee.** The graduate student's advisory committee may be appointed during the student's first term but no later than the term in which 15 credits of course work are to be completed.
3. **Reclassification.** This step is necessary for any CEE student who was admitted in Provisional Standing. Students must apply for reclassification by the completion of 15 graduate hours.
4. **Program of Study.** Should be developed by the CEE student as soon as an advisory committee is selected. There will be a hold placed on a student's registration if the program of study has not been filed by the time 15 semester hours have been earned.
5. **Candidacy.** Students should apply for candidacy no later than the term in which 15 hours of graduate credit have been completed.

6. **Application for Graduation.** Initiated by the candidate at the beginning of the semester in which conferral of the degree is expected. All of the above steps, plus course substitution, should be completed prior to application.

7. **Comprehensive (Oral) Examination.** Must be completed by the CEE student and the Advisory Committee at least three weeks prior to graduation.

8. **Thesis Submission to Graduate School Office.** Must be submitted by the student in final form at least two weeks prior to graduation, or sooner if stipulated in the official Schedule of Classes.

9. **Graduation.** A student is required to be present for the conferral of the degree unless a written exception is made by the Dean of Graduate Studies. Students graduating in absentia may have their diploma mailed but must assume the inherent risks.

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, funding sources, and other personal needs such as housing, transportation, etc. They agree on a first semester program of study and the student is 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 research proposal and to approve it or make recommendations to improve it. This step should be completed before the student registers for research and thesis credits. Each member of the committee is expected to review the student's thesis prior to the comprehensive examination; and to assist in conducting an examination to ensure that the student has at least a satisfactory knowledge of the subject matter covered in the program of study and that the thesis (when required) is of suitable caliber and presents a valid investigation properly completed. 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 will not be permitted to register. 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.

Each student must make certain that all requirements of the CEE department, the area of concentration, the College of Engineering, and the Graduate School are satisfied. Their advisory committee will help them pursue and accomplish a course of study so that all requirements will be met; however, final responsibility rests with the student.

Time Limits for Completion of the MS Degree

Per TTU policy (see: http://www.tntech.edu/gcat/asp/degree_general_time.asp), a graduate student in a master's program needs to complete all degree requirements within a period of six consecutive years. Time limits are computed from and including the first term in which credit applied to the degree is earned. If the student has not graduated by the end of 21 semesters after entering the graduate program and has not been granted special approval to continue to take graduate courses and satisfy requirements within the most recent 21 semesters, the student's status changes to non-degree graduate student and all regulations pertaining to non-degree graduate students will apply. This university-wide policy ensures that the time limits are appropriate for the MS degree. A summary of the time taken for each student to graduate is provided in Table 7 of Appendix 2. The average time taken during the 2002-2007 period was 2.2 years with no student exceeding 4.5 years for degree completion.

C. Availability and Sophistication of Coursework

Course Rigor and Graduate Quality

Courses approved for graduate studies in the Civil and Environmental Engineering Department are listed in Appendix 4. Detailed course syllabi for a sample of courses offered in the 2005-07 period are included in Appendix 5. Courses are offered frequently enough to enable students to make reasonable progress towards degree completion. Table 4 (Appendix 2) lists all graduate courses offered during 2002-2007. In any two year cycle, a graduate student is typically able to avail all necessary CEE graduate courses in his/her area of specialization.

The rich and diverse set of courses evident from Appendix 4 illustrates the level of academic rigor in advanced courses. As can be noted from the course descriptions and syllabi, doctoral courses generally include at least one graduate level prerequisite course. This is one indication of a distinction in level of academic rigor. Per TTU policy documented in the graduate catalog, no more than 30% of a student's program of study can be comprised of dual-listed courses (5000 level).

Core Curriculum

The Department of Civil and Environmental Engineering maintains four areas of concentration for the MS degree. These are 1) transportation engineering, 2) structural engineering, 3) environmental engineering, and 4) structural mechanics. Therefore there is no core curriculum for the MS in Civil Engineering but instead a core of courses for each concentration. Students must work with their graduate advisory committee to establish the plan of study and research project. Each area of concentration is next presented with the core of courses recommended for every student.

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 register for the Statistics course upon 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 Methods for Engineers (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 Methods for Engineers (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

Interdisciplinary Course Work

Graduate students have many options available to them as regards course work outside of the CEE department. Our engineering 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, Geology). Recently, our materials group has focused resources and energy to participate in collaborative research with

Chemical Engineering (ChE) faculty and students in the study of cement properties and performance. This interdisciplinary emphasis is balanced by requiring that the majority of the course hours utilized in the students' program of study must be taken in the CEE department. Table 8 in Appendix 2 summarizes the number of courses and hours taken by our graduate students by department and emphasis area. In addition, the plans of study of students who graduated between 2002-2007 are also provided in Appendix 7. These plans of study exemplify the nature of specialization pursued by each candidate beyond the minimum that is required as core.

Dual-listed Course Work (undergraduate-graduate)

A part of the graduate course curriculum comprises courses that are also offered to senior level undergraduate students. These courses are dual-listed (as 4000/5000) and a higher level of rigor is enforced for graduate students that enroll in the course. In general, at least 21 semester credits including the thesis shall be required at the 6000 level (pure graduate level) in a thesis program for the master's degree. The remainder of the courses in the program of study may be at the 5000 levels. However, TTU policy does not allow more than 30 percent of the courses in a student's program of study to be dually numbered 4000 (5000) courses. Also, courses below the 5000 level are not counted toward a graduate degree; and, although they may appear on the written program as background requirements, these courses are not figured into degree requirements.

D. Methodologies and Techniques of Discipline

Real-world Nature of Research Projects

The most fundamental aspect of methodology adopted in imparting the student with MS level training is the requirement that each student work on a research project of real-world significance to the Civil Engineering discipline. Titles of conference and journal publications authored by students in Tables 9 and 10 and the thesis titles in Table 11a of Appendix 2 indicate that the real-world nature of the research project. The research projects, being directly relevant to the graduate course curriculum, allow students to practice the education acquired in the class room on a real-world problem pertinent to society. As an example, a student of the water resources area, after taking courses on Engineering Hydrology (CEE5420) and Water Resources Engineering (CEE 5440), can confidently tackle a hydrologic modeling problem for a real watershed where research is on-going.

Graduate Seminar Series and Internships

Other than advanced and inter-disciplinary course work, the graduate program also offers several other resources and tools for honing the research and critical thinking skills of the students. For example the graduate seminar series held every semester brings speakers from the industry and academia who are experts in their fields. Appendix 6 provides samples of seminar speakers who were invited for the graduate seminar series since it began in fall of 2006. Bringing in outside expertise allows students to gain a broader real-world perspective of their research area and identify the potential implications of their own research. Students also regularly present seminars on their research work for their fellow peers to critique.

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 been a venue for several graduate students to pursue 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. Recently, three students in the water area have recently taken part in a four week NSF funded field camp in the Nanjing Hydraulic Institute in China. The CEE Department strives to provide the opportunity to students to attend conferences and workshops. The College of Engineering also provides financial support to graduate students to cover travel expenses for attending conferences. Several CEE students have utilized this opportunity for travel to attend and present their work at conferences.

University Student Research Day

The University also organizes a Student Research Day during the first week of April where student research poster submissions are solicited. Prizes are given out to the best presenter. This 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. Table 9 in Appendix 2 summarizes the various conference presentations students have performed to hone their research and critical thinking skills.

E. Extra-disciplinary Experience

Graduate students in the Department of Civil and Environmental Engineering have a wide variety of opportunities to participate in enrichment programs outside the normal classroom or laboratory routine. They may continue to participate in all activities of the Student Chapter of the American Society of Civil Engineers, Sigma Xi and attend seminars of CEE professionals at a frequency of about two per month. They are invited to the ASCE-Nashville Section meetings on a monthly schedule

where seminars are presented on all aspects of civil engineering. The local student chapter regularly hosts speakers from the industry to talk about the emerging issues of the Civil Engineering profession.

In addition to campus and local enrichment opportunities, graduate students are encouraged to become involved in professional organizations and to attend conferences and present seminars and papers. Regional possibilities are numerous and include, among others, the prestigious Stonecipher Symposium, the TN Section AWRA which hosts a two day symposium every year with special sessions for graduate students, the TN Academy of Science which holds a two day symposium and a one day students conference, and the North American Lake Management Conference which has southeastern regional conferences each year. In addition, several national conferences are attended each year where students frequently have the opportunity to make presentations on their research (see Table 9 of Appendix 2). Our on-going survey of alumni students indicates that more than half of the students were members of pertinent professional societies such as Institute of Transportation Engineers (ITE), ASCE, AGU and ACI during their graduate candidature.

F. Comprehensive Examination

At or near the completion of the course requirements for the MS graduate degree, each candidate must pass a comprehensive academic examination and thesis defense conducted by the candidate's graduate advisory committee. The comprehensive examination begins with an open session in which the candidate makes an oral presentation and the members of the audience, including the committee, ask questions regarding the contents of the presentation and the research work the candidate has carried out towards his/her degree requirement. Members of the audience who do not belong to the examination committee are then asked to leave the examination hall and, in a closed session, the committee examines the candidate on the content of the thesis or dissertation as well as other relevant material. The candidate is then excused and the committee discusses the performance of the candidate on the exam and the contributions of the thesis/dissertation and votes to pass or fail the candidate in the examination. If the candidate passes the exam, the committee instructs the candidate on the changes, if any, needed on the thesis. If the candidate fails the exam, the committee informs the candidate regarding the additional work that the candidate shall undertake before attempting the next examination. All forms and decisions taken by the committee are documented and provided to the CEE department for inclusion in the student record file.

In the comprehensive examination, the student must demonstrate the required breadth of knowledge in civil and/or environmental engineering, depth of knowledge in specific concentration areas, and the ability to integrate what has been learned. The CEE faculty empowers the graduate committee to handle the comprehensive examination and to report the results in writing to the Graduate School. The

Graduate School keeps the report on file indefinitely. Recently, it has become a trend to dual-list the presentation part of the comprehensive examination as a graduate seminar to increase attendance. All comprehensive examinations are publicized either via email and/or flyers on the announcement boards. Appendix 8 provides samples of oral presentations of graduating students during their comprehensive examination.

G. Research

Research Requirement and Monitoring

No more than six semester hours of CEE 6990 (Research and Thesis) credit may be counted towards the MS degree. Thesis credit is made available only in increments of 1, 3, 6, or 9 semester hours during any given semester. Graduate students are required to be registered for at least one course appropriate to the student's degree objective in order to have access to computer equipment, laboratories, library, and other university facilities and resources even if the student is working in absentia on research and thesis. A graduate student needs to be enrolled during the term in which the degree is awarded.

When a student makes satisfactory progress in research and thesis, a grade of *SP* (Satisfactory Progress) is assigned for credit earned. When satisfactory progress is not achieved, a grade of *NP* (No Progress) is assigned. However, a grade of *NP* will not satisfy either the program or degree requirements, and the student must register again for additional thesis credit. Only grades of *SP* and *NP* shall be used to indicate a student's progress in thesis credit.

Research Thesis Preparation

The Graduate School has published the "Guide to the Preparation of Theses and Dissertations" which serves as the official guide for all MS theses. Although examples in the manual are recommended for making footnotes, endnotes, and giving bibliographical references, the Civil and Environmental Engineering Department is encouraged to use those systems of citations that are most commonly used in its own profession. Any other departure from the manual must have the prior approval of the Dean of Graduate Studies. The manual can be purchased at the bookstore in the Roaden University Center or an online copy may be accessed at <http://www.tntech.edu/graduatestudies/thesis/default.asp>. Two acceptable copies of the MS thesis ready for binding, must be submitted to the Dean of Graduate Studies at least two weeks prior to the close of the semester in which the degree is to be conferred, or at an earlier date if such is specified in the University calendar. These copies will be hardbound for library reference purposes. Binding costs are paid by the degree candidate; the University pays microfilming costs. Authentic signatures (not photocopies) of members of the candidate's advisory committee are required on each approval sheet. Final approval of each thesis is

made by the Dean of Graduate Studies using the Guide to the Preparation of Theses and Dissertations as the approval standard.

CEE graduate students are expected to consult frequently with their major advisor during thesis preparation. The final rough draft should be in typed form, and at that point the only revisions made should be those suggested by the advisory committee. The student should allow ample time for the committee to study the thesis. MS students are asked to provide two weeks between thesis presentation to the committee and the final comprehensive examination.

CEE faculty have always required the student's thesis to be of a high quality in all respects – at least an A-level effort. This means that several drafts may be required before the committee approves the thesis. The student should expect to work closely with members of the committee to achieve this high standard. The final thesis remains the original work of the student, but it must be satisfactory to the committee and the Graduate School. Table 11a in Appendix 2 provides a complete listing of student's thesis title, the ensuing publications, patents and awards.

H. Communication

Each student is required to demonstrate the ability to communicate, both orally and in writing, in a manner and at a level that is appropriate to the degree and discipline. The absence of a non-thesis MS program and the mandatory requirement for an oral defense automatically guarantees that every student is subject to a rigorous scheme that results in improvement of the student's oral and writing communication skills.

Program Components on Communication Improvement

The CEE program has explicit program components to improve communication skills of students as follows. During the candidature, the graduate student would typically give present at least three oral presentations. The first is given to the student's advisory committee where a preliminary proposal is presented for committee approval. The next opportunity occurs at the graduate seminar series in front of the student and faculty body. At this forum, the student gets an opportunity to rectify the communication skills for his/her final comprehensive defense for graduation. The third opportunity is the final comprehensive examination which is also publicized as a public-domain seminar event. Additionally, most CEE graduate courses have a project component that require an oral presentation at the end of the semester. Students also attend a conference to present their work at scientific meetings such as the AGU, EWRI, TRB annual meetings, TN AWRA meeting, ACI (see Table 9 of Appendix 2). These opportunities improve the student's ability to communicate effectively. Although it is not a

requirement, students are expected to publish their research work in close collaboration with their major advisor. In addition to the final thesis, a journal quality publication or a conference proceeding is regarded by the advisory committee as a testament to the student's ability to communicate effectively in writing (see Tables 9 and 10 of Appendix 2 for student publications).

III. QUALITATIVE STANDARDS

A. Student Experience

Peer-to-Peer Student Interaction

The CEE graduate program has grown steadily since its last review in 1999. As mentioned earlier, more than nine new students have typically entered the program each year since 2002, which is about two more than the previous 30-year average (Figure 1). The sustained growth of the student body has allowed students to be immersed within a group of peers and enrich his/her graduate experience both on the individual and collective level. For example, collective participation in student orientation and graduate seminars has now become a regular phenomenon since 2005 (see Appendix 6). This is one 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. There is a plan for establishment of a parallel seminar series to be managed and run entirely by the student through a CEE Graduate Student Council in future. Additionally, students 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 regularly seen multiple submission of graduate student work often in the same area of specialization. Several CEE students have won the best poster/paper award at this event (see Tables 5a and 5b, Appendix 2 for a statistical summary). Most students are also members of their respective scientific/professional bodies, such as ASCE, AGU, ITE, ACI, PCI, and Sigma Xi etc.

Student Off-campus Experience

The student's plan of study shown in Appendix 7 demonstrate that the CEE graduate program does not accept any short course or Co-op, field camp, workshop experience towards degree objectives. While these are encouraged as enrichment experience, they do not satisfy the necessary condition for graduation. Most often than not, such activity has been closely monitored and authorized only when there was sufficient justification. For example, three students in the Water/Environment specialization participated in NSF-sponsored field camp in China in 2005 and 2006. Because the field camp was to be held in Nanjing Hydraulic Institute, the participation was considered appropriate. The CEE graduate program does not currently offer any distance learning opportunities.

Student Enrichment Opportunities

Students also utilize a wide range of enrichment opportunities to ensure a healthy scholarly environment. The graduate seminar series, already described in earlier sections, is the most notable example as it is sustained by student participation and presentations. Students also attend other seminar series from other departments (e.g. Chemical Engineering Seminar series). 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 (Appendix 6 provides a summary of Stonecipher Symposium seminar). Students also regularly attend national-level conferences where they present their research in public. Table 9 of Appendix 2 provides a list of conference attendances by a sample of students where the student was the speaker. In Table 10 (Appendix 2), a list of journal publications that has ensued from the research work is summarized.

B. Graduate Faculty Quality

Faculty Credentials

One hundred percent of current CEE faculty holds a terminal degree (PhD) in a specialized field of Civil Engineering. All are also members of the TTU Graduate Faculty. They are listed below with their faculty rank, terminal degree and terminal degree university, and professional registration. Areas of specialization can be found in Table 2a of Section 1.

Faculty Scholarly Activity

Faculty Honors and Recognition The faculty of the Department of Civil and Environmental Engineering are widely recognized for their contributions to the University and the civil engineering profession. A sample of most recent honors and recognition by faculty are summarized as follows:

Daniel A. Badoe

- Co-organizer of a joint meeting of the Tennessee and Kentucky Travel Demand Model-User Groups in Bowling Green, Kentucky, October 2006.
- Co-organizer of a workshop on “Travel Demand Modeling with TRANSCAD”, held at Tennessee Technological University, Cookeville, Tennessee, June 12 –14, 2007.
- Kinslow Research Award, 2003-2004, TTU.

George R. Buchanan

- Capelenor Award, in 2004-2005 for excellence in research, TTU.
- Kinslow Award in 2005 for paper titled "*Layered Versus Multiphase Magneto-Electro-Elastic Composites*," TTU.

Steven Click

- Awarded a 1-year, \$100,000 grant in 2007 from the Tennessee Department of Transportation for the project "Application of Non-Traditional Interchange Treatments to Improve Interchange Quality of Service and Preserve the Service Life of Narrow Over-and Underpass Roadways."
- TTU Tablet PC Initiative Award, 2007
- Invited speaker for the Transportation Research Board's Traffic Signal Systems Committee Annual Meeting Workshop on "Operating Traffic Signal Systems in Oversaturated Conditions," January 21-25, 2007.
- Awarded a TTU QEP grant for the 2006-2007 academic year to improve critical thinking and real-world problem solving in CEE 6410 – Advanced Traffic Control.
- TTU Exemplary Course Award for his innovative use of technology in CEE 4640/5640 – Highway Engineering, 2006
- Invited speaker for the Transportation Research Board's Traffic Signal Systems Committee Summer Meeting, July 10-12, 2006.

L.K. Crouch

- Caplenor Faculty Research Award. 2006-2007, TTU.
- Awarded a 2-year, \$192,508 FHWA grant. The project, *Rapid Repair of Highway and Airfield Pavements*, represents the first CEE research project funded via direct Congressional appropriation, 2005
- Highlights of research featured in two issues of the industry trade journal, *Tennessee Concrete*. 2005.

Robert Craig Henderson

- Developed the 2005 edition of the ACI national masonry code as an executive voting member of the ACI 530 Masonry Standards Joint Committee and Chairman of the Infilled Frame Subcommittee.
- Selected to serve as one of ten executive voting members of the ACI 530 Masonry Standards Joint Committee (Building Code Requirements for Masonry Structures).

Faisal Hossain

- Outstanding PhD Thesis Award from the School of Engineering at the University of Connecticut, 2005.

- Interviewed and featured in an American Geophysical Union article describing research on management of arsenic contamination.
- Associate Editor for the Journal of American Water Resources Association (JAWRA) on Artificial Intelligence and Advanced Computing for Water Resources since August 2006.
- Member of the Science Team of NASA's Precipitation Measurement Mission (PMM) for 2007-2010.

David H. Huddleston

- AcademicKeys Who's Who in Engineering Education. 2004
- Manchester Who's Who Among Executives and Professionals 2005
- Selected to be a participant in the first Regents Academic Leadership Institute. 2006.
- Corresponding member of the ASCE Curriculum Committee for Academic Prerequisites. 2007.

Benjamin Mohr

- Awarded a 3-year, \$220,767 NSF grant in the first year as a member of the CEE faculty.
- ORAU Ralph E. Powe Junior Faculty Enhancement Awards. 2007
- 2nd place recipient of the ASEE Southeastern Section New Faculty Research Award. 2007.
- Patent for "Methods for Internally Curing Cement-Based Materials and Products Made There from," (US Patent #11/738,906).

Vincent S. Neary

- Organized three technical sessions in Ecohydraulics for the ASCE-EWRI World Environmental Congress, Tampa Bay, Florida, May 1-5, 2007.
- Organized and chaired two meetings of the Everglades model technical review panel, Lafayette, LA, November 24, 2006, and March 27, 2007.
- Selected to Serve as Member of Technical Advisory Group, "Envisioning the Future of the Gulf Coast Symposium" (www.futureofthegulfcoast.org), One of thirty invited international scientists and engineers specializing in large scale wetland and river restoration who helped draft recommendations to the Governor's Office for saving the coastal wetlands of Louisiana, April 25-27, 2006.
- Invited Speaker, "Effects of Urbanization on Watershed Hydrology," Caney River Watershed Compact, January 18, 2005.
- Co-organizer. Special Session Eco-hydraulics: State-of-the-Art and Future Directions IASME/WSEAS International Conference on Fluid Mechanics, , Corfu Island, Greece, August 17-19, 2004

Guillermo Ramirez

- Visiting professor at Universidad Nacional de Colombia, June-July 2006

Selected (Recent) Faculty Publications

Most faculty have remained very active in pursuing publication of their research work in scholarly journals. Below, a sample of recent and scholarly faculty publications is listed:

Daniel Badoe

- “Modeling Trip Generation with Data from Single and Two Independent Cross-Sectional Travel Surveys,” *ASCE Journal of Urban Planning and Development* Vol. 130, no. 4, December 2004, pp. 167 – 174
- “Unit of Analysis in Conventional Trip-Generation Modelling: An Investigation,” *Canadian Journal of Civil Engineering*, September 30, 2003.
- “Impact of Transit Pass Ownership on Daily Number of Trips Made by Urban Public Transit, Forthcoming,” *ASCE Journal of Urban Planning and Development*, Vol. 133, no. 4, December 2007, p. 1-8.

George Buchanan

- “Free vibration of a transversely isotropic thick-walled toroidal shell,” *International Journal of Structural Stability and Dynamics*, Vol. 6, No. 3, 359-376, 2006.
- “Galerkin finite element derivation for vibration of a thermopiezoelectric structure”, *Journal of Sound and Vibration*, Vol.294, 362-367, 2006.
- “Elastic compensation simulation of elastic/plastic axisymmetric circular plate bending using a deformation model”, *International Journal of Non-linear Mechanics*, Vol.41, 377-387, 2006.

L.K. Crouch

- “Lessons from the TDOT/TCA/ACPA Maturity Project Lesson 2: Field-cured Cylinders: Are They the Right Choice”, *Tennessee Concrete*, Vol. 18, No. 3, Winter 2004.
- “2004 TCA Pervious PCC Research at TTU: 5 Questions”, *Tennessee Concrete*, Vol. 18, No. 3, Winter 2004.

Craig Henderson

- “The Effect of Prior Out-of-plane Damage on the In-plane Behavior of Unreinforced Masonry Infilled Frames,” *The Masonry Journal*, 24(1), (2006).
- “Designing Interactive Instructional Tools to Serve Both Students and Instructors,” *Computers in Education Journal*, Vol. 16(4), pp. 36-50, (2006).
- Masonry Standards Joint Committee. ACI 530-05 / ASCE 6-05 / TMS 602-05. *Building Code Requirements for Masonry Structures*.

Faisal Hossain

- “Flood Prediction in the Future: Recognizing Hydrologic Issues in anticipation of the Global Precipitation Measurement Mission - Opinion Paper,” *Water Resources Research*, Vol. 44, (doi:10.1029/2006WR005202) 2006.
- “Is Correlation Dimension a Reliable Proxy for the Number of Influencing Variables required to Model Risk of Arsenic Contamination in Groundwater? *Stochastic Environmental Research and Risk Assessment*,” (doi: 10.1007/s00477-006-0098-6), 2007.
- “The Emerging role of Satellite Rainfall Data in Improving the Hydro-political Situation of Flood Monitoring in the Under-developed Regions of the World,” *Natural Hazards* (Special Issue), 43:199-210. Invited Paper (doi 10.1007/s11069-006-9094-x), 2007.

Xiaoming (Sharon) Huo

- “Experimental Study of Early-Age Behavior of High Performance Concrete Deck Slabs under Different Curing Methods,” *Construction and Building Materials*, Vol.10, pp. 1049-1056, December 2006.
- “A Simplified Method of Lateral Distribution of Live Load Moment,” *ASCE Journal of Bridge Engineering*, Vol. 9, No. 4, July/August 2004, pp.382-390.
- “Finite Element Modeling of Slab-on-Beam Concrete Bridge Superstructures,” *Computer and Concrete*, Vol. 1, No. 3, August 2004, pp. 355-369.
- “Sensitivity of Live Load Distribution Factors to Vehicle Spacing,” *ASCE Journal of Bridge Engineering*, October 2004.

David H. Huddleston

- “Water Distribution Network Analysis Using Excel,” *ASCE Journal of Hydraulic Engineering*, Vol. 130, No. 10, pp. 1033-1035, October. 2004.
- “A Proposed Computer-Assisted Graphics-Based Instruction Scheme for Stochastic Theory in Hydrological Sciences,” *Computers in Education Journal*, Vol. 17, No. 2, pp. 16-25, April, 2007.

Benjamin Mohr

- “Supplementary Cementitious Materials for Mitigating Kraft Pulp Fiber-Cement Composite Degradation,” *Cement and Concrete Research*, April 2007.
- “Microstructural and Chemical Effects of Wet/Dry Cycling on Pulp Fiber-Cement Composites,” *Cement and Concrete Research*, 36(7): 1240-1251, 2006.
- “Aligned Kraft Pulp Fiber Sheets for Reinforcing Mortar”, *Cement and Concrete Composites* 2006, 28(2): 161-172, 2006.

Vincent S. Neary

- “Hydrologic modeling as a development tool for HGM functional assessment models”, *Wetlands*, 26:1, 161-180. 2006.
- “Factors Affecting Estimates of Average Watershed Slope”, *ASCE Journal of Hydrologic Engineering*, 2005, 10(2), 133-140.
- “Hydrologic modeling study with NEXRAD precipitation in Middle Tennessee.” *Journal of Hydrologic Engineering*, 9(5): 339-349, 2004.

Guillermo Ramirez

- “Frictionless contact in a layered piezoelectric medium characterized by complex eigenvalues,” *Journal of Smart Materials and Structures*, pp.1287-1295, August 2006.
- “Frictionless Contact in a Layered Piezoelectric Half-Space”, *Journal of Smart Materials and Structures*, Vol. 12, pp. 612-625, 2003.

Recent Faculty Participation in Workshops/Conferences and Other Peer Service

Faculty have also remained active in providing leadership in their respect areas of research and professional societies. For example, many faculty regularly review project proposals for funding, attend panels organized by federal agencies to select proposals for funding, review submitted manuscripts to journals, review books, book chapters etc. Additionally, faculty also chair sessions at conferences, deliver seminars as invited speakers and perform editorial duties for scholarly journals. A statistical summary of faculty activity on this aspect during the 2002-2007 period is provided below. Details of such activity may be provided upon request.

Daniel Badoe

- **Invited Seminars: 3**
- **External Thesis Review: 8**
- **Manuscripts and Proposals reviewed: 124**
- **Sponsors for which research proposals were reviewed:** NSF, Israel Science Foundation, Maryland Agricultural Experimentation Station.
- **Journals for which manuscripts were reviewed:** European Journal of Operations Research, Journal of Transportation Research Board, Journal of Land Use Policy, Journal of Transport Geography.

George Buchanan

- **Invited Seminars: 1**
- **External Thesis Review: 1** (For Indian Institute of Technology, Madras)

- **Manuscripts and Proposals reviewed:** 29
- **Publishers for which books were reviewed:** Springer-Verlag, Thompson Engineering.
- **Journals for which manuscripts were reviewed:** ASCE Journal of Engineering Mechanics, Mechanics Research Communications, Journal of Vibration and Control, Journal of Sound and Vibration, Thin-walled Structures, Acta Mechanica, Journal of Mechanics of Materials and Structures.

Steven Click

- **Invited Seminars:** 5
- **Manuscripts and Proposals reviewed:** 8
- **Journals for which manuscripts were reviewed:** ITE Journal, Journal of the Transportation Research Board

L.K. Crouch

- **Invited Seminars:** 11
- **Manuscripts and Proposals reviewed:** 6
- **Journals for which manuscripts were reviewed:** Journal of Environmental Management, ACI Materials Journal, ASCE Journal of Materials in Civil Engineering, Portland Cement Association R&D.

Dennis George

- **Invited Seminars:** 6
- **Sessions Chaired:** 1
- **Manuscripts and Proposals reviewed:** 179
- **Journals for which manuscripts were reviewed:** Water Research, Water Environment Research, Canadian Journal of Water Quality, ASCE Journal of Environmental Engineering, ASCE Journal of Hydrologic Engineering
- **Sponsors for which proposals were reviewed:** NSF, NASA, USDA, US EPA

Robert Craig Henderson

- **Sessions Chaired:** 3
- **Manuscripts and Proposals reviewed:** 8
- **Journals for which manuscripts were reviewed:** The Masonry Journal, Journal of Structural Engineering, Structural Engineering and Mechanics, Earthquake Spectra.

Faisal Hossain

- **Invited Seminars:** 5
- **Sessions Chaired:** 2
- **Manuscripts and Proposals reviewed:** 85
- **Journals for which manuscripts were reviewed:** Journal of Hydrometeorology, Computers and Geosciences, IEEE Transactions in Geosciences and Remote Sensing, Remote Sensing of the Environment, Journal of American Water Resources Association, Non-linear Processes in Geophysics, ASCE Journal of Hydrologic Engineering.
- **Sponsors for which proposals were reviewed:** NSF and NASA.

David H. Huddleston

- **Invited Seminars:** 3
- **Manuscripts and Proposals reviewed:** 5
- **Journals for which manuscripts were reviewed:** ASCE Journal of Hydrologic Engineering, Computers in Education Journal, ASCE Journal of Hydraulic Engineering.
- **Sponsors for which proposals were reviewed:** NSF, Mississippi Department of Environmental Quality.

Xiaoming (Sharon) Huo

- **Invited Seminars:** 8
- **Sessions Organized:** 1
- **Manuscripts and Proposals reviewed:** 151
- **Journals for which manuscripts were reviewed:** ASCE Bridge Engineering Journal, ASCE Structural Engineering Journal, ASCE Material in Civil Engineering,

Benjamin Mohr

- **Invited Seminars:** 5
- **Manuscripts and Proposals reviewed:** 15
- **Journals for which manuscripts were reviewed:** ASCE Journal of Materials in Civil Engineering, ACI Materials Journal, ACI Concrete International, Cement and Concrete Research.

Vincent S. Neary

- **Invited Seminars:** 19
- **Sessions Chaired:** 6
- **Manuscripts and Proposals reviewed:** 55

- **Journals for which manuscripts were reviewed:** Advances in Water Resources, IAHR Journal of River Basin Management, ASCE Journal of Hydraulic Engineering, AGU Journal of Geophysical Research, IAHR Journal of Hydroinformatics, ASCE Journal of Hydrologic Engineering.
- **Sponsors for which proposals were reviewed:** NSF, USGS and SEAC.

Funded Research Production by Faculty

As discussed briefly in section one, the CEE faculty has a good record of research production during the past five years (2002-2007). Table 1a of Appendix 2 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. Dr. Dennis George, Director of the Water Center, is a CEE faculty member and is responsible for managing and maintaining the annual State funding at a level of approximately \$1.15 million per year. Dr. George also writes proposals and generates external funding in addition to the State funding. In Table 1a Dr. George's external funding is that in addition to the State funding. In Table 11a of Appendix 2, more details of each funded project (project title, sponsor) are provided.

Faculty Teaching Load

In order for faculty to be successful in pursuing their research career and be effective mentors for graduate students, teaching load is compatible with the needs of the graduate program. Table 12 in Appendix 2 shows the teaching load of each faculty per term during 2002-2007. A particular new aspect to note from this table is that since the last review in 1999, the CEE program now tries to accommodate a reduced teaching load for newly recruited faculty during their start-up years. This allows new faculty to be successful in obtaining research grants and developing their own research program. This reduced teaching load is complemented with support from the Centers of Excellence in the form of start up packages such as graduate student, travel funds or seed money for initiating proof of concept research. Signs of effectiveness of this strategy are being witnessed now (notice the * for faculty recruited after 2002). All three newly recruited faculty have been consistently successful in securing external funding (mostly federal) and advising graduate students through those externally funded projects. The most recent (2006-2007) average annual publication rate by faculty has also increased. It is expected that this upward trend will continue all the way to 2015 and guide CEE towards becoming a nationally recognized graduate program.

C. Teaching/Learning Environment

Auxillary support for CEE faculty

There are two full-time secretaries, one part-time secretary and one technician employed by the CEE department. Each faculty is assigned one secretary to look after his/her various needs related to teaching, graduate students and office work. It must be noted that with the advent of personal computers, the need for constant personalized secretarial support has diminished. However, the secretaries continue to perform a vital function to ensure prompt services for faculty. For example, all project related expenditures and purchasing are looked after by a dedicated secretary trained in business matters. All student records related to admissions, advisory committee and coursework performance are kept in order by another secretary. Secretaries also assist faculty to dispense their service work, such as seminar organization, chairing sessions and serving as editors of journals. The full-time technician frequently sets up/fixes hardware in the research laboratories to ensure that a student's research progress is not hampered. Many faculty display a summary of their research in display boards outside their office which are maintained and set up by the technician.

Centers 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 budget 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.

Library Support for Faculty and Students

The library support available to faculty is considered adequate. As already noted in Section 2 and in Appendix 1, CEE faculty and students have access to more than 50 scholarly journals through the library. Many journals are now available electronically, which makes their access more convenient for the faculty. The electronic databases subscribed to by TTU provide access to students and faculty to virtually any published research thesis relevant to Civil Engineering.

New Laboratory and Office Support

Three new laboratories and many classrooms have been renovated since the last review in 1999. A new laboratory named "Cement and Concrete Composites Laboratory" has been set up in 2007. The centerpiece of this lab is an Instron 100-kN universal testing machine (UTM) with closed loop controls and assorted accessories including tension grips, 3/4-point flexure fixtures, and extensometers for tensile and flexure testing. Primary funding for this equipment was provided by the National Science

Foundation (CMS-0556015) with additional cost-sharing provided by the TTU Department of Civil and Environmental Engineering, the TTU Center for Energy Systems Research, a Hands-on-Learning grant, and the State of Tennessee. This new state of the art laboratory is expected to further enrich and enhance student research experience in the Materials/Transportation area of specialization.

Office space for faculty and students is adequate. Each faculty is assigned a room equipped with a PC desktop and a printer. All graduate assistants are assigned a desk with a PC and internet connection. Various research related software (such as MATLAB, MAPLE, C, STAADPRO, ArcGIS etc.) are available through the University for office usage at a discounted license price. The University computer center staff provides dedicated service to faculty when new software is required to be purchased. The college of engineering maintains a full-time computer support staff for setting up of new computer hardware, troubleshooting etc.

D. Program Evaluation

One way of evaluating the success of the graduate program and identifying remedial measures to correct existing weaknesses is to track student performance after graduation. Recent reports in terms of awards, placement, exposure to seminars, workshops and industry feedback indicate that graduate students are well prepared for a professional career in civil engineering. Our on-going efforts to collect data from alumni indicate that at least 60% of graduates have secured placement in industry or academia, while several have gone on to pursue a PhD at prestigious institutions. Students graduate in a fairly timely manner taking on the average about 2.28 (± 1.14) years to complete their degree (see Table 8 Appendix 1).

While student performance after graduation appears satisfactory, there remain additional aspects to monitor for maintaining program quality. For example, the CEE curriculum committee regularly reviews the relevance of the curriculum and faculty would often propose new additions to maintain sophistication of coursework. Between 2002-2007 14 new and timely graduate courses were designed and taught by faculty in various areas. These courses bring in newer insights to the field as well as an inter-disciplinary depth and breadth that have now become a common feature of Civil Engineering profession today. Table 13 in Appendix 2 provides a listing of the new courses that have been added as part of curriculum enhancement along with a brief justification.

E. CLOSING STATEMENT

Current Outlook of CEE MS Program

The CEE MS program has evolved significantly since the last review conducted in 1999. While graduate enrollment has increased modestly to from 6 to over 9 per year, quality attributes in all other categories, particularly during the most recent years, have been most encouraging and surpassed expectations. Our limited alumni survey record indicates that prestigious universities (such as University of Texas and the University of Southern California) continue to place tremendous confidence in the quality of our MS graduates for their PhD program. More than 60% of graduates have consistently secured placement in industry, state and national organizations across the nation. Research expenditure and faculty publications have witnessed an upward trend since 2004. An increasingly higher number of faculty continue to receive national/international level accolades, serve as editors of journals, review proposals/manuscripts and organize/chair sessions in recognized conferences. A greater number of students have begun to participate in international summer camps to practice their education overseas. More students participate in conferences and make oral presentations. Their thesis work has regularly been published in scholarly journal publications for global recognition. This was not a common observation several years ago.

Our recently launched BS/MS fast-track program has further strengthened the quality of the MS program. The new program is well aligned with the Department's goals to develop a graduate program of high quality as well as the University's goals of focusing on upper division undergraduate education and preparing students for graduate studies. It is anticipated that the program will have a positive impact on graduate student enrollment by attracting top quality undergraduates.

As discussed earlier, to monitor and continually enhance graduate program quality, CEE established a dedicated Graduate Affairs Committee for the first time in 2005. Through this committee, structural enhancements to the graduate program for our MS students have been added. Most notable additions are: 1) regular graduate seminar series with participation by students and recognized experts from the nation; 2) regular orientation for new students; 3) training students in proposal writing and issues on plagiarism; 4) increased frequency of mentorship of graduate students by the committee; and 5) launch of a graduate handbook for graduate students.

In summary, the unique features of the CEE MS program for the current reporting period of 2002-2007 can be summarized as follows:

- ✓ Formation of Graduate Affairs Committee in fall of 2005.
- ✓ Launch of BS/MS Fast-Track Program in fall of 2007.
- ✓ Revitalization of Graduate Seminar Series and Student Mentoring Program in 2006.
- ✓ Launch of Graduate Student Handbook in 2007.
- ✓ Higher Number of Student accolades and faculty recognition.
- ✓ Regular graduate Student Orientation on: Plagiarism, Proposal/thesis writing, communication skills, plan of study.
- ✓ Higher Faculty Peer-reviewed Publications (20 per year).
- ✓ Increasing trend in research expenditure – \$530,000 in 2007.
- ✓ Higher Number of Awards of Nationally Competitive Research Funding – National Science Foundation, NASA, DOT, FHWA.

Vision for the Future

Where does the Department of Civil and Environmental Engineering want to be a decade from now? It is not enough to be satisfied with the status quo of quality in the MS program. An agenda is needed to maintain the reputation that was built over many years of dedicated service by faculty. Recently, in the fall of 2007, input from the CEE Advisory Board was therefore sought in anticipation of structural changes anticipated in the Civil Engineering profession by 2015. The Advisory Board is made up of CEE alumni who have been extremely successful as practicing engineers or academics in the nation. The Advisory board identified that the CEE graduate program should have the foresight to address the following key and emerging areas in various sub-disciplines in order to maintain and enhance the reputation of our graduate program:

- 1) **Environmental/Water Resources:** Focus on Sustainable design (in all relevant CEE courses) and the implications of global warming; Implement courses on 'Green engineering' (in all relevant CEE courses).
- 2) **Transportation/Materials:** Focus on Traffic Systems optimization; Train students to write traffic impact studies that are becoming common for any large scale construction project; focus on traffic asset management and on the use of environmentally friendly construction materials (such as porous concrete).
- 3) **Structural Mechanics/Structural Engineering:** Focus on the design of Cable systems; Implement courses on structural system stability and composite materials; focus on

alternative use of cementitious products; Train students on self-health monitoring of large structures.

CEE plans to implement the long-term suggestions raised by the Advisory Board above in the future planning cycles. CEE has therefore embraced a long-term vision to further raise the quality to a level that will earn recognition from within and outside the nation by 2015. This vision is in sync with the overall vision of TTU. Currently, TTU is regarded as a top engineering school in the South, with particularly strong undergraduate programs in engineering. To build upon this legacy, the university's leadership has embarked upon a longer-term vision to transform TTU into a nationally recognized, midsized *research and teaching* institution by 2015. Along these lines, major steps have been taken to hire new faculty, expand facilities and promote research activities. Concurrently, the CEE Department is fully committed to the vision of TTU. Namely, the goal to become one of the nation's leading institution for Civil Engineering research and instruction, with strong national/international visibility. Towards this vision of CEE, the following quantifiable targets have been identified as goals to achieve by 2015 for the CEE graduate program:

- ✓ Establish nationally-recognized niche areas of research in 'High Performance Concrete', 'Nano-composites', 'Hydrologic Remote Sensing Applications', 'Real-time Bridge Monitoring', 'Eco-Hydraulics'.
- ✓ Increase out-of-state US enrollment to the graduate program by 25%.
- ✓ Increase External Research Expenditure beyond 1 Million USD per year by 2015.
- ✓ Increase annual scholarly research journal publication by 100% by 2015.
- ✓ An NSF-funded REU/IGERT for more cohesive intra-Department faculty cooperation on research and graduate education by 2015.
- ✓ Increase global visibility through strategic partnership with national/foreign institutions.

So far, the trends revealed during the recent years appear very promising. Newly recruited faculty under the able mentorship of senior faculty are providing a thrust to the graduate program. With additional recruitment of productive and energetic faculty under the stable mentorship by existing dedicated faculty, CEE has confidence that the aspirations of the MS program as articulated above will carry the program on a path of national fame.