UNC CHARLOTTE

Office of the Chancellor

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December 12, 2017

Dr. Kimberly van Noort
Vice President for Academic Programs and Instructional Strategy
University of North Carolina
Post Office Box 2688
Chapel Hill, North Carolina 27515-2688

Dear Kim:

Enclosed is UNC Charlotte's Request to Establish a Ph.D. in Civil Engineering. The proposed program will expand on our successful B.S. and M.S. programs in Civil Engineering and creates a pipeline of specially trained civil engineers with knowledge of the energy industry and specializations in one of three subareas: 1) structures and geotechnical, 2) environmental and geo-environmental, or 3) transportation.

Thank you for your consideration of this request. Provost Lorden or I would be pleased to respond to any questions that you may have.

Cordially,

Philip L. Dubois
Chancellor

cc: Joan F. Lorden, Provost and Vice Chancellor for Academic Affairs
Robert Johnson, Dean, William States Lee College of Engineering
Rollinda Thomas, Associate Vice President for Academic Programs

UNIVERSITY OF NORTH CAROLINA
REQUEST TO ESTABLISH
A NEW DEGREE PROGRAM – ANY DELIVERY METHOD

Date: 12/14/17

Constituent Institution: The University of North Carolina at Charlotte

Is the proposed program a joint degree program? Yes____ No____X_____

Joint Partner campus _____

Title of Authorized Program: Civil Engineering Degree Abbreviation: Ph.D.

CIP Code (6-digit): 14.0801 Level: B _____ M ____ I _____ D _____X_____

CIP Code Title: Civil Engineering

Does the program require one or more UNC Teacher Licensure Specialty Area Code? Yes_____No__X

If yes, list suggested UNC Specialty Area Code(s) here _____

If master's, is it a terminal master's (i.e. not solely awarded en route to Ph.D.)? Yes ___ No____

Proposed term to enroll first students in degree program: *Term* Spring *Year* 2019

Provide a brief statement from the university SACSCOC liaison regarding whether the new program is or is not a substantive change.

As required by the Policy Statement on Substantive Change for Accredited Institutions of the Commission Colleges, the University of North Carolina at Charlotte (UNC Charlotte) is required to submit a letter of notification and prospectus prior to implementation for new degree programs. Notification of this new degree program will be provided to SACSCOC after approval by the University of North Carolina Board of Governors and prior to implementation.

Identify the objective of this request (select one or more of the following)

- ☒ Launch new program on campus
- ☐ Launch new program online; Maximum percent offered online _____
  - ☐ Program will be listed in UNC Online
  - ☐ One or more online courses in the program will be listed in UNC Online
- ☐ Launch new site-based program (list new sites below; add lines as needed)
  - ☐ Instructor present (off-campus delivery)
  - ☐ Instructor remote (site-based distance education)

Site #1: University of North Carolina at Charlotte

9201 University City Blvd, Charlotte, Mecklenburg, NC *100%*

(address, city, county, state) *(max. percent offered at site)*

Supply basic program information for UNC Academic Program Inventory (API) and UNC Online

Minimum credit hours required (students without advanced standing)	72 credit hours
Expected number of full-time terms to completion	8 semesters

Do the following sections of your previously submitted and approved Request to Plan document require any change or updated information? If yes, note the items and explain.

Review Status (Campus)	Yes_____	No__X___
Description and Purpose	Yes_____	No__X____
Student Demand	Yes_____	No__X___
Societal Demand	Yes_____	No__X___
Unnecessary Duplication	Yes_____	No__X___
Enrollment	Yes_____	No__X___

Executive Summary

The proposed Ph.D. in Civil Engineering (CE) will provide doctoral-level education for students seeking CE careers in practice, research, and teaching/academia. The program is a terminal research degree that lays emphasis on the mastery of the CE discipline- specific concepts relevant to the resilience of critical facilities and civil infrastructure. Emphasis will be placed on demonstrating mastery of knowledge in a specific subject area of CE through advanced research skills and the ability to synthesize, create innovative ideas, and ultimately make original contributions to the discipline.

The proposed Ph.D. degree program requires successful completion of at least 72 approved graduate credits beyond the baccalaureate degree. Up to 30 approved credits from graduate courses taken during the student's master's degree, which may have been taken at another university, may be transferred towards the proposed program. Concentrations will include: 1) environmental and geo-environmental, 2) structural and geotechnical, and 3) transportation engineering.

The program will be administered on-campus by the Department of Civil and Environmental Engineering, (CEE), in the William States Lee College of Engineering (COE). The CEE Department is currently housed in the Energy Production and Infrastructure Center (EPIC) building and is integral to the vision of interdisciplinary research and education in energy funded by the North Carolina General Assembly: $76 million for the building and recurring funds for programming, faculty and staff.

The proposed Ph.D. program follows a natural evolution from the inter-institutional Ph.D. program with NC State and the current interdisciplinary Ph.D. program (Infrastructure and Environmental Systems) in

which the CEE Department participates. The proposed degree fits with strategic plans for both the department and the university. The new degree is endorsed by the department and college industry advisory boards and reflects the need to offer a complete set of degrees in CE to students in the Charlotte region and beyond.

Demand for a CE Ph.D. is broadly framed by the nexus of infrastructure and the economy. According to the American Society of Civil Engineers (ASCE)[1], "The United States needs to invest $1.4 trillion in infrastructure between 2016 and 2025 and $5.2 trillion by 2040; without such investments, the U.S. economy could lose almost $4 trillion and 2.5 million jobs by 2025 and $14.2 trillion and 5.8 million jobs by 2040 due to lost productivity. As a result, future federal, state, and local investments to repair and enhance ailing infrastructure may drive demand for civil engineers." While CE Ph.D. programs are common in states similar in size to North Carolina, North Carolina ranks last in terms of CE Ph.D. programs relative the population (see Hanover Research Report, Request to Plan, Appendix 1, Tables 8-9). Furthermore, Charlotte is the 17th largest city in the U.S. and is the **only city in the top 33 by population without a CE Ph.D**. program. The closest CE Ph.D. program is 100 miles away at the University of South Carolina in Columbia, South Carolina.

With more than 20 years of participation in the inter-institutional Ph.D. program with North Carolina State University (NCSU) and through 13 years of leading the interdisciplinary Infrastructure and Environmental Systems (INES) Ph.D. program at UNC Charlotte, the faculty of CEE Department have demonstrated the ability to build, support, enhance, lead, and sustain a Ph.D. program that is relevant to local, regional, state, national and international students and employers.

I. Program Requirements and Curriculum

A. Program Planning

1. List the names of institutions with similar degree programs regarded as high quality programs by the developers of the proposed program.

The following institutions have similar degree programs that are regarded as high quality programs.

Institution	**Program**
North Carolina State University	Ph.D. in Civil Engineering
Duke University	Ph.D. in Civil and Environmental Engineering
Virginia Tech	Ph.D. in Civil and Environmental Engineering
Georgia Institute of Technology	Ph.D. in Civil Engineering
Vanderbilt University	Ph.D. in Civil Engineering
The University of Tennessee Knoxville	Ph.D. in Civil Engineering

[1] ASCE (2016). Failure to Act: Closing the Infrastructure Investment Gap for America's Economic Future. https://www.infrastructurereportcard.org/the-impact/failure-to-act-report/.

2. List institutions visited or consulted in developing this proposal. Also discuss or append any consultants' reports or committee findings generated in planning the proposed program.

    a. We consulted with faculty and the chair of the Civil, Construction, and Environmental Engineering Department at North Carolina State University (NCSU) to establish that the target market and student demand do not significantly overlap. We have developed a program that complements rather than duplicates. In contrast to the Ph.D. program at NCSU, where a majority of students tend to favor heavy theoretical and computational research, the proposed UNC Charlotte program is focused on field and experimental research. A higher percentage of research activity at UNC Charlotte is funded by private sector/industry sources in comparison to NCSU. The proposed CE Ph.D. program supports the COE goal of meeting the Charlotte area's demand for engineering graduates and assisting EPIC to create a pipeline of specially trained civil engineers with knowledge of the energy industry. The program complements NCSU's interdisciplinary nuclear energy physical infrastructure program by focusing in power transmission line and energy-related solid and liquid waste management research activities. NCSU produces doctoral graduates whose employment objectives are focused on faculty positions at national and international research universities. We anticipate that our doctoral graduates will be employed by a wider range of employers including industry. In keeping with our niche as North Carolina' urban research university, and as a minority serving institution, the CE Ph.D. focuses on access to quality education and providing specially trained civil engineers to industry, and particularly to the energy industry in the Charlotte area.
    b. We also consulted with the chair of the Civil and Environmental Engineering Department at Duke University, Professor Mark Wiesner. Professor Wiesner expressed the benefits that can accrue to our state with the increased intellectual vitality of an additional Ph.D. program at UNC Charlotte. In a letter from Duke University in support of UNC Charlotte's request to plan the CE Ph.D. program (attached in Request to Plan, Appendix 2), Professor Wiesner wrote:

        - "I see no duplication between our program and that which you propose for a variety of reasons, some of which are included below.
        - There are only two Civil Engineering Ph.D. programs in North Carolina, neither of which are located in Charlotte.
        - Adding a Ph.D. program at Charlotte helps to increase the intellectual vitality of the region, creating more opportunities to collaborate on state, national, and international initiatives as well as externally funded grants and contracts.
        - The majority of our students focus on environmental engineering, while those who specialize in civil engineering tend to have a computational, material science, or risk/reliability focus; this is in contrast to your stated focus on experimental civil engineering research, e.g., large scale structural testing in your new high bay, soil/structure interaction, and so forth.

- The majority of our Ph.D. students pursue careers in academia as faculty, with a smaller fraction pursuing careers in government or non-government organization; in contrast with your focus on industry in general and the energy sector in particular."

c. Finally, we commissioned a market research study and analytics on demand for CE Ph.D., and capability of our faculty to effectively run a CE Ph.D. program, and comparative analysis of peer universities already offering CE Ph.D. program (report by Hanover Research, included in Request to Plan, Appendix 1).

Student demand was evaluated by an external consultant (Hanover Research) as well as through a survey of likely students. As noted in the Request to Plan (Appendix 1), student demand for CE Ph.D.s is increasing. International students represent a key audience, with enrollment having increased 11.5% nationwide between 2009 and 2014. Student demand is particularly strong and growing for the transportation specialization. Overall, doctoral enrollments in CE fields increased between 2011 and 2015. The demand for civil/environmental engineering expertise experienced a 16.2% average annual growth during this period.

Student demand for a CE Ph.D. at UNC Charlotte was also assessed by surveying a pool of likely candidates in the summer of 2015. The survey consisted of asking a set of questions to the students representing a diverse pool. The survey invitation was sent to the following potential students:

- Graduating seniors currently enrolled in the CEE Department;
- Alumni who have received a bachelor's degree in CE within the last ten years; and
- Alumni who have received a master's degree in CE within the last ten years.

The combined survey results for all survey participants (527 surveyed, 57 responded) indicate that more than 90% of the respondents are in favor of offering a CE Ph.D. degree program at UNC Charlotte, and 90% of the respondents would consider UNC Charlotte if they were to pursue the degree. Because of the lack of such a degree offered within a distance of 100 miles from Charlotte, some of these students are seeking out Ph.D. degrees in other universities and some are pursuing the multi-disciplinary Ph.D. offered via the INES program. The survey results show that the proposed CE Ph.D. program has a good pool of potential students for recruitment and the students will welcome the opportunity to pursue the CE Ph.D. degree at UNC Charlotte.

B. Admission. List the following:

1. Admissions requirements for proposed program (indicate minimum requirements and general requirements).

   In addition to the general requirements for admission to the Graduate School (see below), CEE Department seeks the following from applicants to the doctoral program:

Applicants with a Master's Degree in CE - Eligible to Pursue the Ph.D. Degree with Advanced Standing

- An earned master's degree in CE (Master of Science in CE, MSCE or Master of Science in Engineering, MSE with emphasis in CE)
- A master's degree GPA of 3.0 or better
- A satisfactory score (>50th percentile) from the aptitude portion of the GRE
- A statement of purpose
- Three letters of recommendation
- An acceptable TOEFL or IELTS score as required by UNC Charlotte for international students. In addition, TOEFL iBT must be a minimum score of 18 on each section of the test while the IELTS must be a minimum score of 6.5 in each section
- Any other appropriate credentials as required by the Graduate School

Applicants with a Bachelor's Degree in CE - Eligible to Pursue the Ph.D. Degree

- An earned bachelor's degree in CE (Bachelor of Science in CE, BSCE) from an ABET or internationally accredited college or university in CE
- A bachelor's degree GPA of 3.0 or better
- A satisfactory score from the aptitude portion of the GRE
- A statement of purpose
- Three letters of recommendation
- An acceptable TOEFL or IELTS score as required by UNC Charlotte for international students. In addition, TOEFL iBT must be a minimum of score of 18 on each section of the test while the IELTS must be a minimum score of 6.5 in each section
- Any other appropriate credentials as required by the Graduate School

Note 1: Admission for applicants currently in the MSCE program at UNC Charlotte requires a minimum GPA of 3.0, completion of all core courses in their area of concentration, completion of at least 15 credit hours at master's level, and acceptance by the Graduate School to the doctoral program at UNC Charlotte.

Note 2: Admission for applicants without an undergraduate degree in CE requires completion of MSE degree with emphasis in one of the CE concentrations and a GPA of 3.0 or better.

Entry to the Doctoral Program Before Completing a master's at UNC Charlotte

Current MSCE students at UNC Charlotte with outstanding academic performance that satisfy the requirements described above may be admitted to the CE Ph.D program before completing the master's degree requirements. These doctoral students will be dually enrolled with both master's and doctoral status, and may complete up to 15 credits toward their doctoral degree prior to graduating with their master's degree.

2. Documents to be submitted for admission (listing).

Application to the proposed doctoral program will follow existing Graduate School and CEE admissions processes. The UNC Charlotte application process is completely online. To apply for graduate studies in the CEE Department, all applicants must submit the following application materials to the UNC Charlotte Office of Graduate Admissions:

- Graduate School Application for Admission (online)
- Application Fee (payable online)
- Unofficial transcripts from all previous college-level institution(s) attended (submitted online); If admitted, official transcripts must be submitted to the Graduate School prior to joining the program. Certified translations (if needed) and degree certifications are required if the degree was earned outside the U.S.
- Official TOEFL scores
    - A minimum TOEFL score of 220 (computer-based), 557 (paper-based), or 83 (internet-based) or a minimum IELTS band score of 6.5 required from any applicant whose native language is not English.
- A statement of purpose (essay indicating research interest and potential faculty advisor) submitted online as part of the application submission process
- Three recommendations (submitted online by recommenders)
- Official GRE test scores
- A resume (submitted online)

C. Degree requirements. List the following

The doctoral degree is awarded for depth of knowledge in a field and completion of scholarly research that advances the knowledge base in the area of concentration. This level of achievement is demonstrated by a successful completion of appropriate coursework and a dissertation defense. See Section D below for complete program requirements.

1. Total hours required. State requirements for Major, Minor, General Education, etc.

   The Ph.D. in CE will require a minimum of 72 credit hours of study inclusive of only 18 credit hours of dissertation research post Bachelor's degree in CE. Applicants who hold a relevant master's degree in CE, either from UNC Charlotte or another institution, may be eligible to pursue the Ph.D. degree with advanced standing. Eligibility for this accelerated option must be made at the time of admission to the program, and is subject to review by the Graduate School. Under the advanced standing option, students must complete 42 credit hours, including only 18 credit hours of dissertation research. Students must also complete the Responsible Conduct of Research course (GRAD 8002) and the Academic Integrity course (GRAD 8990).

2. Other requirements (e.g. residence, comprehensive exams, thesis, dissertation, clinical or field experience, "second major," etc.).

   Each doctoral student with Advanced Standing must take and pass a qualifying exam before the end of the 4th semester from joining the doctoral program, while each doctoral student without a master's degree must take and pass a qualifying exam before the end of the 6th semester from joining the doctoral program. The written qualifying exam should cover at least four courses in the area of concentration, and is administered by the student's doctoral research advisor and doctoral committee. The written qualifying exam may be followed by an oral qualifying exam, administered by the student's doctoral research advisor and doctoral committee.

   Doctoral students with advanced standing, who have completed at least 18 credit hours of coursework and have at least a 3.0 GPA, are eligible to take the written qualifying exam. Doctoral students without a master's degree, who have completed at least 48 credit hours of coursework and have at least a 3.0 GPA, are also eligible to take the written qualifying exam. A doctoral student may attempt to pass the qualifying exam no more than twice. Failure to pass the written qualifying exam in two attempts or before the end of the 4th and 6th semester for students with advanced standing and students without a master's degree, respectively, will result in termination of enrollment in the doctoral program. Doctoral students who do not take the qualifying exam before the end of the specified semester but are terminated from the doctoral program may appeal to the CEE Department Appeals Committee to be reinstated by submitting an acceptable plan to take and pass the qualifying exam.

   After passing the qualifying examination, a student must propose a dissertation topic, prepare a written proposal, and submit it to the doctoral committee for review at least two weeks before the oral exam date. The oral exam, administered by the student's doctoral research advisor and doctoral committee, will include a presentation and defense by the student of his or her proposed research topic in

a forum open to the public. This oral exam should be successfully completed before the end of the 5th semester from joining the doctoral program by doctoral students with advanced standing, and, before the end of the 7th semester from joining the doctoral program by doctoral students without a master's degree. The doctoral student advances to candidacy after the dissertation topic and proposal has been approved by the student's doctoral committee and the Graduate School. The candidacy must be achieved at least 6 months before the doctoral degree is conferred.

For graduate programs only, please also answer the following:

3. Proportion of required program courses open only to graduate students

The following courses numbered 8000 or above are open only to doctoral students. Many of these courses will be cross-listed with existing courses at the 6xxx-level that may be taken by Master's students. The actual proportion is determined by the student's concentration.

Environmental and Geo-Environmental Engineering Concentration

CEGR 8090	Special Topics in CE (3) *(environmental or geo-environmental engineering topic)*
CEGR 8141	Water Quality Modeling (3)
CEGR 8142	Bioenvironmental Engineering (3)
CEGR 8144	Environmental Biotechnology (3)
CEGR 8146	Advanced Groundwater Analysis (3)
CEGR 8163	GIS for Civil Engineers (3)
CEGR 8173	Environmental Aquatic Chemistry (3)
CEGR 8243	Physical Processes in Environmental Systems (3)
CEGR 8244	Chemical Fate and Transport (3)
CEGR 8245	Chemical and Biological Processes in Environmental Systems (3)
CEGR 8251	Foundation Engineering (3)
CEGR 8252	Soil Dynamics and Earthquake Engineering (3)
CEGR 8254	Experimental Soil Mechanics (3)
CEGR 8255	Slope Stability and Earth Structures (3)
CEGR 8892	Individualized Study (3)
CEGR 8893	Research Methods (3)

Structural and Geotechnical Engineering Concentration

CEGR 8090	Special Topics in CE (3) *(structural or geotechnical engineering topic)*
CEGR 8124	Masonry Design (3)
CEGR 8125	Structural Strengthening (3)
CEGR 8126	Analysis of Plates and Shells (3)
CEGR 8127	Fracture Mechanics and Fatigue (3)

CEGR 8128 Structural Optimization (3)
CEGR 8129 Structural Dynamics (3)
CEGR 8163 GIS for Civil Engineers (3)
CEGR 8222 Experimental Structural Mechanics and Nondestructive Evaluation (3)
CEGR 8251 Foundation Engineering (3)
CEGR 8252 Soil Dynamics and Earthquake Engineering (3)
CEGR 8254 Experimental Soil Mechanics (3)
CEGR 8255 Slope Stability and Earth Structures (3)
CEGR 8268 Advanced Soil Mechanics (3)
CEGR 8892 Individualized Study (3)
CEGR 8893 Research Methods (3)
MEGR 8141 Theory of Elasticity I (3)

Transportation Engineering Concentration

CEGR 8090 Special Topics in CE (3) *(transportation engineering topic)*
CEGR 8161 Traffic Control and Operation (3)
CEGR 8162 Computer Applications for Transportation Engineers (3)
CEGR 8163 GIS for Civil Engineers (3)
CEGR 8164 Traffic Safety (3)
CEGR 8166 Urban Transportation Networks: Operations and Optimization (3)
CEGR 8167 Discrete Choice Modeling (3)
CEGR 8181 Traffic Flow Theory (3)
CEGR 8182 Transportation Systems Analysis (3)
CEGR 8261 Traffic Signal Control Systems (3)
CEGR 8892 Individualized Study (3)
CEGR 8893 Research Methods (3)

3. Grades required

Grades of A or B are acceptable, but students may be allowed to earn up to two C's. An accumulation of two "C" grades or one "U" grade will result in termination of enrollment from the CE Ph.D. program. CE Ph.D. students suspended or terminated from the doctoral program may appeal once to the CEE Department Appeals Committee to be reinstated by submitting an acceptable plan to improve their grades and successfully complete the program.

4. Amount of transfer credit accepted

CEE accepts the transfer of related doctoral level courses (6 credit hours maximum) taken at another institution or from UNC Charlotte prior to admission to the doctoral program in CE. These courses must be part of the

recommended list of courses in the doctoral student's area of concentration. Further, these credit hours cannot be counted toward another degree.

5. Language and/or research requirements

English language proficiency is required. The Ph.D. in CE will conform to the established UNC Charlotte Graduate Admissions English Language Proficiency Requirements and Policies:
https://gradadmissions.uncc.edu/admissions-info/doctoral/
https://gradadmissions.uncc.edu/admissions-info/international-applicants/english-language-proficiency/.
These include official and satisfactory English language proficiency scores on the Test of English as a Foreign Language (TOEFL) or the International English Language Testing System (IELTS). A minimum score of 557 paper-based or 83 on the Internet-based TOEFL or a minimum overall band score of 6.5 on the IELTS are required for admission to the doctoral program.

As per UNC Charlotte Graduate Admissions policy, "Applicants who do not meet the minimum English language proficiency requirement will not be admitted to UNC Charlotte. They may, however, choose to enroll at UNC Charlotte's English Language Training Institute (ELTI) and then re-apply to the Graduate School. See ELTI's website: www.ielts.org for details.

6. Any time limits for completion

According to UNC Charlotte Graduate School policy, students are allowed a maximum of eight (8) calendar years from formal admission to the doctoral program to complete the program successfully.

D. For all programs, list existing courses by title and number and indicate (*) those that are required. Include an explanation of numbering system. List (under a heading marked "new") and describe new courses proposed. (Courses should be CEGR8XXXX)

Doctoral students who hold a relevant master's degree in Civil Engineering, either from UNC Charlotte or another institution, may be eligible to pursue the Ph.D. degree with advanced standing. Eligibility for this accelerated option must be determined at the time of admission to the program, and is subject to review by the Graduate School. The CE Ph.D. requires a total of **42** credit hours for students with advanced standing, and **72** credit hours for students without advanced standing.

Student with advanced standing must complete **24** credit hours of coursework that must include 15 hours within a concentration and 9 hours of electives. Students without advanced standing must complete **54** hours of coursework to include 45 hours within a

concentration and 9 hours of electives. Students must also complete the Responsible Conduct of Research course (GRAD 8002) and the Academic Integrity course (GRAD 8990). Each doctoral student with advanced standing is limited to one individual study class within the 24-credit hour coursework requirement.

To satisfy the 24 or 54 credit-hour coursework requirements, the proposed CE Ph.D. program will utilize existing CEGR 5XXX courses (for students without advanced standing only, no more than 15 credit hours) and additional courses with "new" CEGR 8XXX numbers. All courses listed here with 8xxx course numbers have previously been taught to Master's and INES Ph.D. students, using 6XXX and 8090 course numbers.

Civil Engineering Ph.D. Program Requirements

Required Courses (20 credits)

GRAD 8002*	Responsible Conduct of Research (2 credits)
GRAD 8990*	Academic Integrity (0 credits)
CEGR 8999*	Dissertation Research (18 credits)

Concentration (15 credits at the 8000 level for students with advanced standing, 45 credits with 30 credits at the 8000 level for students without advanced standing), to be chosen from the following

Environmental and Geo-Environmental Engineering Concentration

CEGR 5090	Special Topics in CE (3 credits) *(environmental engineering topic)*
CEGR 5141	Process Engineering (3 credits)
CEGR 5142	Water Treatment Engineering (3 credits)
CEGR 5143	Solid Waste Management (3 credits)
CEGR 5144	Engineering Hydrology (3 credits)
CEGR 5145	Groundwater Resources Engineering (3 credits)
CEGR 5146	Advanced Engineering Hydraulics (3 credits)
CEGR 5147	Stormwater Management (3 credits)
CEGR 5234	Hazardous Waste Management (3 credits)
CEGR 5235	Industrial Pollution Control (3 credits)
CEGR 5237	Environmental Risk Management (3 credits)
CEGR 5241	Chemical Processes in Water and Wastewater Treatment (3 credits)
CEGR 5242	Wastewater Treatment Plant Design (3 credits)
CEGR 5243	Topics in Environmental Health (3 credits)
CEGR 5247	Sustainability (3 credits)
CEGR 8090	Special Topics in CE (3 credits) *(environmental or geo-environmental engineering topic)*
CEGR 8141	Water Quality Modeling (3 credits)
CEGR 8142	Bioenvironmental Engineering (3 credits)

CEGR 8144	Environmental Biotechnology (3 credits)
CEGR 8146	Advanced Groundwater Analysis (3 credits)
CEGR 8163	GIS for Civil Engineers (3 credits)
CEGR 8173	Environmental Aquatic Chemistry (3 credits)
CEGR 8243	Physical Processes in Environmental Systems (3)
CEGR 8244	Chemical Fate and Transport (3 credits)
CEGR 8245	Chemical and Biological Processes in Environmental Systems (3 credits)
CEGR 8251	Foundation Engineering (3 credits)
CEGR 8252	Soil Dynamics and Earthquake Engineering (3 credits)
CEGR 8254	Experimental Soil Mechanics (3 credits
CEGR 8255	Slope Stability and Earth Structures (3 credits)
CEGR 8892	Individualized Study (3 credits) –"new"
CEGR 8893	Research Methods (3 credits) –"new"

Structural and Geotechnical Engineering Concentration

CEGR 5090	Special Topics in CE (3 credits) *(structural or geotechnical engineering topic)*
CEGR 5108*	Finite Element Analysis and Applications (3 credits) (required)
CEGR 5121	Prestressed Concrete Design (3 credits)
CEGR 5123	Bridge Design (3 credits)
CEGR 5125	Forensic Engineering (3 credits)
CEGR 5126	Codes, Loads, and Nodes (3 credits)
CEGR 5127	Green Building and Integrative Design (3 credits)
CEGR 5128	Matrix Methods of Structural Analysis (3 credits)
CEGR 5223	Timber Design (3 credits)
CEGR 5222*	Structural Steel Design II (3 credits) (required)
CEGR 5224*	Advanced Structural Analysis (3 credits) (required)
CEGR 5226*	Reinforced Concrete Design II (3 credits) (required)
CEGR 8090	Special Topics in CE (3 credits) *(structural or geotechnical engineering topic)*
CEGR 8124	Masonry Design (3 credits)
CEGR 8125	Structural Strengthening (3 credits)
CEGR 8126	Analysis of Plates and Shells (3 credits)
CEGR 8127	Fracture Mechanics and Fatigue (3 credits)
CEGR 8128	Structural Optimization (3 credits)
CEGR 8129	Structural Dynamics (3 credits)
CEGR 8163	GIS for Civil Engineers (3 credits)
CEGR 8222	Experimental Structural Mechanics and Nondestructive Evaluation (3 credits)
CEGR 8251	Foundation Engineering (3 credits)
CEGR 8252	Soil Dynamics and Earthquake Engineering (3 credits)
CEGR 8254	Experimental Soil Mechanics (3 credits)
CEGR 8255	Slope Stability and Earth Structures (3 credits)

CEGR 8268	Advanced Soil Mechanics (3 credits)
CEGR 8892	Individualized Study (3 credits) –"new"
CEGR 8893	Research Methods (3 credits) –"new"
MEGR 8141	Theory of Elasticity I (3 credits)

Transportation Engineering Concentration

CEGR 5090	Special Topics in CE (3 credits) *(transportation engineering topic)*
CEGR 5161*	Advanced Traffic Engineering (3 credits) (required)
CEGR 5162*	Transportation Planning (3 credits) (required)
CEGR 5171	Urban Public Transportation (3 credits)
CEGR 5181	Human Factors in Traffic Engineering (3 credits)
CEGR 5185*	Geometric Design of Highways (3 credits) (required)
CEGR 5182	Transportation Environmental Assessment (3 credits)
CEGR 5183	Traffic Engineering Studies (3 credits)
CEGR 5262	Traffic Engineering (3 credits)
CEGR 5271	Pavement Design (3 credits)
CEGR 8090	Special Topics in CE (3 credits) *(transportation engineering topic)*
CEGR 8161*	Traffic Control and Operation (3 credits) (required)
CEGR 8162	Computer Applications for Transportation Engineers (3 credits)
CEGR 8163	GIS for Civil Engineers (3 credits)
CEGR 8164	Traffic Safety (3 credits)
CEGR 8166	Urban Transportation Networks: Operations and Optimization (3 credits)
CEGR 8167	Discrete Choice Modeling (3 credits)
CEGR 8181	Traffic Flow Theory (3 credits)
CEGR 8182	Transportation Systems Analysis (3 credits)
CEGR 8261	Traffic Signal Control Systems (3 credits)
CEGR 8892	Individualized Study (3 credits) –"new"
CEGR 8893	Research Methods (3 credits) –"new"

Note: Courses without designated course numbers are currently being offered as Special Topic classes with appropriate course numbers yet to be provided.

Additional Coursework Requirement (9 credits)

Each student must take an additional 9 credit hours at the 8xxx-level, either in an area outside the concentration or outside the department. The coursework will be selected by the student, subject to the approval by the Ph.D. academic advisor.

TOTAL DEGREE: 44 credits (students with advanced standing) or 74 credits (students without advanced standing)

The existing and new courses listed above follow UNC Charlotte's Academic Policy: Course Numbering and Status (http://provost.uncc.edu/policies/course-numbering-status):

"5000-5999 Graduate Courses with Parallel Undergraduate Courses Listed at the 4000 Level: Not open to undergraduate students. The 5000 level can also be used for courses in programs such as MAT, where the students' undergraduate degrees are in another field and the course content is not at a "higher" level than advanced undergraduate courses in the same discipline. May include parallel undergraduate courses cross-listed at the 4000 level."

"8000-9999 Doctoral Work: The 8999 number is for dissertation work with the program. The 9000 level is used only for doctoral work beyond the program, and GRAD 9999 is used once all program requirements have been met."

II. Faculty

A. (For undergraduate and master's programs) List the names, ranks and home department of faculty members who will be directly involved in the proposed program. The official roster forms approved by SACSCOC may be submitted. For master's programs, state or attach the criteria that faculty must meet in order to be eligible to teach graduate level courses at your institution.

N/A

B. (For doctoral programs) List the names, ranks, and home department of each faculty member who will be directly involved in the proposed program. The official roster forms approved by SACSCOC may be submitted. Provide complete information on each faculty member's education, teaching and research experience, research funding, publications, and experience directing student research including the number of theses and dissertations directed.

Name and Rank	**Academic Degree/Education**	**Experience and Other Qualifications (teaching and research experience, research funding, publications, and experience directing student research including the number of theses and dissertations directed**
Dr. James E. Amburgey, Associate Professor	PhD (Environmental Engineering) Georgia Tech	12 years of experience in civil and environmental engineering education and research Authorship/co-authorship of 23 peer-reviewed papers Has served as PI on federally or externally funded research projects totaling US$928,416 dollars Served on 31 thesis/dissertation committees (chaired 19)
Dr. James D. Bowen, Interim Department Chair and Associate Professor	PhD (Civil Engineering) Massachusetts Institute of Technology	28 years of experience in civil and environmental engineering education, research, and consulting Authored or coauthored 46 articles including 22 appearing in peer-reviewed journals Served as PI, co-PI, and/or Technical Director on twenty federally or externally funded research projects totaling more than US$9.3 million dollars Served on 21 master's thesis committees (chaired 11) + seven PhD dissertation committees (chaired or co-chaired 3)
Dr. Nicole Braxtan, Assistant Professor	PhD (Structural Engineering) Lehigh University	6 years of experience in civil and environmental engineering education and research Authorship/co-authorship of 10 peer-reviewed papers Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on federally or externally funded research projects totaling US$168,454 dollars

		Served on 1 thesis committee (graduated) and 2 Dissertation committees (current) (chaired 1)
Dr. Shen-en Chen, P.E., Professor	PhD West Virginia University	23 years of experience in civil and environmental engineering education and research Authorship/co-authorship of 70 peer-reviewed papers, Books edited/chaptered - 13 Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on federally or externally funded research projects totaling US$6,263,030 dollars Served on 74 thesis/dissertation committees (chaired 28)
Dr. John L. Daniels, P.E., Chair and Professor	D.Eng (Civil Engineering) University of Massachusetts, Lowell	17 years of experience in civil and environmental engineering education and research Authorship/co-authorship of 42 peer-reviewed papers Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on federally or externally funded research projects in excess of US$3.5M dollars Served on 48 thesis/dissertation committees (chaired 13)
Dr. Wei Fan, P.E., Associate Professor	PhD (Civil Engineering) University of Texas at Austin	14 years of experience in civil and environmental engineering education and research Authorship/co-authorship of 81 peer-reviewed papers Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on federally or externally funded research projects totaling US$10,445,455 dollars

		Served on 24 thesis/dissertation committees (chaired 11)
Dr. Janos I. Gergely, S.E., P.E., Associate Professor	PhD (Civil Engineering) University of Utah	19 years of experience in civil and environmental engineering education and research Authorship/co-authorship of 78 peer-reviewed papers including 18 journals Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on federally or externally funded research projects totaling US$1,367,475 Served on 47 thesis/dissertation committees (chaired 23)
Dr. Rajaram Janardhanam, Professor	PhD (Civil Engineering) Virginia Polytechnic Institute & State University	34 years of experience in civil and environmental engineering education and research Authorship/co-authorship of 84 peer-reviewed papers Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on federally or externally funded research projects totaling US$3,0000,000 dollars Served on 95 thesis/dissertation committees (chaired 55)
Dr. Martin R. Kane, P.E., Associate Professor	PhD (Civil/Transportation Engineering) Michigan State University	22 years teaching and research Authorship/co-authorship of seven peer-reviewed papers Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on federally or externally funded research projects totaling US$650,000 dollars. Served on 75 thesis/dissertation committees (chaired 23)

Dr. Olya S. Keen, Assistant Professor	PhD (Civil Engineering) University of Colorado, Boulder	6 years of experience in civil and environmental engineering education and research Authorship/co-authorship of 15 peer-reviewed papers Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on federally or externally funded research projects totaling US$749,000 dollars Served on 9 thesis/dissertation committees (chaired 3)
Dr. Milind V. Khire, P.E., Professor	PhD (Civil & Environmental Engineering), University of Wisconsin – Madison	29 years of experience in civil and environmental engineering education and research Authorship/co-authorship of 28 peer-reviewed papers Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on federally or externally funded research projects totaling US$6.5M dollars Served on 20 thesis/dissertation committees (chaired 9)
Dr. Mariya Munir, Assistant Professor	PhD (Environmental Engineering) Michigan State University	2.5 years of experience in civil and environmental engineering education and research Authorship/co-authorship of 5 peer-reviewed papers Has served as PI and co-PI on federally or externally funded research projects totaling US$109,123 dollars Serving on 5 thesis/dissertation committees (chaired 1)

Dr. Vincent O. Ogunro, Associate Professor	PhD (Civil Engineering) Institut National des Sciences Appliquée, Lyon, France	20 years of experience in civil and environmental engineering education and research Authorship/co-authorship of 41 peer-reviewed papers Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on federally or externally funded research projects totaling US$4,646,955 dollars Served on 41 thesis/dissertation committees (chaired 16)
Dr. Miguel A. Pando, Associate Professor	PhD (Civil Engineering) Virginia Tech	14 years of experience in civil and environmental engineering education and research. Authorship/co-authorship of 105 peer-reviewed papers. Has served as PI, co-PI, and senior personnel on federal, state, and local grants and projects with externally research funding totaling over US$9 Million. Served on over 85 MS thesis/Ph.D. dissertation committees (chaired 41)
Dr. Srinivas S. Pulugurtha, P.E., Professor, Graduate Program Director	PhD (Civil Engineering) University of Nevada, Las Vegas	23 years of experience in civil and environmental engineering education and research Authorship/co-authorship of 144 peer-reviewed papers Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc.) on federally or externally funded research projects exceeding US$7.2M dollars Served on 96 thesis/dissertation committees (chaired 38)

Dr. William Saunders, P.E., Lecturer, Undergraduate Program Director	PhD (Civil Engineering) North Carolina State University	10 years of experience in civil and environmental engineering education and research Authorship/co-authorship of 1 peer-reviewed papers Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on federally or externally funded research projects totaling US$0 dollars Served on 5 thesis/dissertation committees (chaired 0)
Dr. Mei Sun, Assistant Professor	PhD (Civil and Environmental Engineering), Carnegie Mellon University	4.5 years of experience in civil and environmental engineering education and research Authorship/co-authorship of 7 peer-reviewed papers Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on federally or externally funded research projects totaling US$0 dollars Served on 2 thesis/dissertation committees (chaired 1)
Dr. Brett Q. Tempest, Associate Professor	PhD (Infrastructure and Environmental Systems) UNC Charlotte	9 years of experience in civil and environmental engineering education and research Authorship/co-authorship of 19 peer-reviewed papers Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on federally or externally funded research projects totaling US$1,918,000 dollars Served on 22 thesis/dissertation committees (chaired 7)

Dr. Kimberly A. Warren, Associate Professor, Director of Student Learning and Assessment	PhD (Civil Engineering) North Carolina State University	15 years of experience in civil and environmental engineering education and research Authorship/co-authorship of 34 peer-reviewed papers (includes journal and conference proceedings) Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on federally or externally funded research projects totaling US$2,704,088 dollars Served on 17 thesis/dissertation committees (chaired 10)
Dr. David C. Weggel, P.E., Professor	PhD (Civil Engineering) University of Texas at Austin	20 years of experience in civil and environmental engineering education and research Authorship/co-authorship of 53 peer-reviewed papers, 2 book chapters, and 3 manuals/specifications Served as PI or co-PI on federally- or externally-funded research projects totaling more than US$9 million dollars Served on 36 MSCE / 20 dissertation committees (chaired 11 MSCEs / 4 dissertations)
Dr. Matthew J. Whelan, Associate Professor	PhD (Civil and Environmental Engineering) Clarkson University	8 of years of experience in civil and environmental engineering education and research Authorship/co-authorship of 22 peer-reviewed journal papers and 22 peer-reviewed conference proceedings Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on federally or externally funded research projects totaling US$2.47M dollars

		Served on 13 thesis/dissertation committees (chaired 8)
Dr. Erika Weber, P.E., Lecturer	PhD (Civil Engineering) University of Utah	3 of years of experience in civil and environmental engineering education and research Authorship/co-authorship of 3 peer-reviewed papers Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on federally or externally funded research projects totaling US$0 dollars Served on 0 thesis/dissertation committees (chaired 0
Dr. Jy S. Wu, P.E., P.H., Professor	PhD (Chemical & Environmental Engineering) Rutgers University	Over 30 of years of experience in civil and environmental engineering education and research Authorship/co-authorship of 41 peer-reviewed papers Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on federally or externally funded research projects totaling US$3.1Million dollars Served on over 100 thesis/dissertation committees (chaired 8 Ph.D., 77 M.S.)

Dr. David Young, P.E., Professor	PhD (Civil Engineering) Virginia Tech	32 of years of experience in civil and environmental engineering education and research with 26 of them in administration as PhD program director, research center director, and academic department head. Authorship/co-authorship of 65 peer-reviewed papers and 35 professional technical reports. Has served as PI, co-PI, (Consultant, Contractor, Technical Expert, etc..) on 58 federally or externally funded research projects totaling US$2.0M dollars Served on 60 thesis/dissertation committees (chaired 20)

All faculty members are qualified to teach, chair and serve on graduate student committees, and fully engage in all graduate matters within COE and the University as appointed regular graduate faculty following the procedures for appointment:

http://graduateschool.uncc.edu/faculty-and-staff/graduate-faculty/graduate-faculty-appointment

C. Estimate the need for new faculty for the proposed program over the first four years. If the teaching responsibilities for the proposed program will be absorbed in part or in whole by the present faculty, explain how this will be done without weakening existing programs.

No new faculty hires are needed to implement the proposed CE Ph.D. program at this time. The master's and proposed CE Ph.D. program will require that approximately 28 graduate-level courses be taught each year (see graduate teaching load and course enrollment analysis in Appendix 2). This amount of graduate-level teaching is not considered problematic for the 25 faculty currently in the Civil and Environmental Engineering Department. The program would facilitate increased research productivity and external funding acquisition with the present faculty workforce. However, as the program grows over the years, more tenure-track faculty would likely be hired to meet the additional research and teaching loads and provide the needed technical expertise in the evolving program.

D. Explain how the program will affect faculty activity, including course load, public service activity, and scholarly research.

All the primary infrastructure (testing and modeling laboratories, computing resources and software, classrooms, and office space) is in place to implement the proposed CE Ph.D. program. The existing INES Ph.D. program provides evidence of our present capabilities and capacity; 7-12 additional doctoral students per year could be advised by our existing faculty and be accommodated by our research/scholarly infrastructure. The excellent testing and modeling labs, computational resources (hardware and software), and unique off-campus facilities are described in later sections.

III. Delivery Considerations. Provide assurances of the following (not to exceed 250 words per lettered item):

A. *Access* (online, site-based distance education, and off-campus programs). Students have access to academic support services comparable to services provided to on-campus students and appropriate to support the program, including admissions, financial aid, academic advising, delivery of course materials, and placement and counseling.

N/A. The proposed Ph.D. in CE will be offered 100% on the main campus of UNC Charlotte and no online or off-campus course will be offered.

B. *Curriculum delivery* (online and site-based distance education only). The distance education technology to be used is appropriate to the nature and objectives of the program. The content, methods and technology for each online course provide for adequate interaction between instructor and students and among students.

N/A. As in III(A) above, the proposed Ph.D. in Civil Engineering will be offered 100% on the main campus of UNC Charlotte.

C. *Faculty development* (online and site-based distance education only). Faculty engaged in program delivery receive training appropriate to the distance education technologies and techniques used.

N/A.

D. *Security* (online and site-based distance education only). The institution authenticates and verifies the identity of students and their work to assure academic honesty/integrity. The institution assures the security of personal/private information of students enrolled in online courses.

N/A.

IV. Library

A. Provide a statement as to the adequacy of present library holdings for the proposed program to support the instructional and research needs of this program.

Since 1995, the COE has been offering two doctoral programs (in Electrical and Mechanical Engineering) and since 2004 an interdisciplinary doctoral program in INES. Over the years, the UNC Charlotte Atkins library has systematically and painstakingly acquired and continue to build solid repertoires of materials to support these programs. Based on the analysis by the UNC Charlotte Engineering Librarian, Jeff McAdams, the current library holdings are adequate to support student research for this program. Students have access to relevant databases including *Compendex, Inspec, Web of Science, ASCE Digital Library, ScienceDirect, Environmental Sciences and Pollution Management, Materials Research Database* and many others. The library owns hundreds of thousands of e-books from Springer, Wiley, Elsevier, Cambridge and other publishers, mostly science and engineering subject matter, in addition to a growing print collection.

B. If applicable, state how the library will be improved to meet new program requirements for the next four years. The explanation should discuss the need for books, periodicals, reference material, primary source material, etc. What additional library support must be added to areas supporting the proposed program?

The library offers responsive support to research needs of the department and to all existing programs in which the department participates. Faculty and graduate student researchers can contact the engineering librarian directly for one-time purchase materials that are needed. For ongoing subscriptions needed, the librarian will work with faculty in the department to prioritize and make requests of the library and university to support new research materials needed to propel the work forward.

C. Discuss the use of other institutional libraries.

The library has a well-received Interlibrary Loan (ILL) Department. It is the highest rated service that the library offers. Faculty, students, and staff can make requests through an easy-to-use web interface, with the capability of auto-filling from any of our databases. Book chapters, conference proceedings, and journal articles are scanned and delivered electronically from other institutions as PDF files within 24-48 hours. Print books are mailed and delivered within 5 business days. Any materials that the library is unable to borrow from other libraries will be purchased if available for sale.

IV. Facilities and Equipment

A. Describe facilities available for the proposed program.

Structural and Materials Facilities

High-Bay Structures Lab

The EPIC Building houses the High-Bay Structures Lab, a three-story, 7500 square-foot space for testing full-scale or model structures and foundations under large static or quasi-dynamic loads. This facility is one of only ten such laboratories in the U.S. The Lab features interior and exterior strong-floor foundations; two 32-ft tall, 1.2 million pound capacity strong walls in an L-shaped plan; three geotechnical test pits (12ft square x 5ft deep, 12ft square x 10ft deep, and 10ft in diameter x 10ft deep); two free-standing structural steel reactions frames (one spanning over the geotechnical test pits); two tandem/independent 30-ton overhead cranes that run the length of the lab; and a second-level mezzanine with control room and observation area. Numerous actuators and jacks, pumps and hoses, supporting hydraulic equipment, data acquisition systems, sensors/instrumentation, and a wealth of heavy-lifting equipment and tools are available for use in the lab. The High-Bay Lab is also supported by a fabrication/machine shop, an exterior courtyard, and numerous nearby rooms for specialized testing.

ISERRT Center

The Infrastructure Security and Emergency Responder Research and Training (ISERRT) Center's mission is to make positive contributions to the security and resilience of infrastructure, personnel, and related assets through basic and applied research, education, and training. ISERRT Center personnel developed and operate two open-arena blast/impact/ballistics/fire testing facilities, the ISERRT Facility in Gastonia NC and the military-grade ISERRT-M Facility in Maxton NC.

The Physical Security Lab supports modeling efforts, field testing of structures, and testing of structures and components conducted at the ISERRT or ISERRT-M Facilities. Further, the Lab is the "learning community" base for all students involved in physical security research.

Other structural and materials facilities are listed below.

- Experimental Structural Dynamics and Health Monitoring Lab
- Construction Materials Development Lab
- Structural Materials Testing Lab
- Visualization Lab

Geoenvironmental/Geotechnical Facilities

Advanced Geomaterial Testing Lab

The advanced geomaterial testing lab several geotechnical testing devices aimed at the advanced characterization of geomaterials under complex loading. This lab features a GDS combined

Advanced Dynamic Cyclic Simple Shear (AdvDCSS) device that is one of only four in the world. This device is a testing system that can be used for dynamic cyclic simple shear and dynamic cyclic triaxial testing used to study the dynamic properties and liquefaction susceptibility of geomaterials under cyclic loading that simulates actual earthquake loading. This device is also equipped to measure dynamic properties of geomaterial under different suction pressures and unsaturated conditions. This lab also houses a Geocomp advanced cyclic triaxial system that allows study of liquefaction of sands and industrial byproducts, as well as the determination of engineering properties and characterization for complex projects such as tunnels, earth dams, deep excavations, etc. Additional to these two main testing devices in this lab, there is a resonant column device and a direct simple shear device.

Geo-centrifuge Lab

The geo-centrifuge laboratory has a footprint of approximately 600 sq.ft and it houses two geo-centrifuges. The larger centrifuge is a 10-ft-diameter centrifuge with a swing basket that can contain samples up to $1ft^3$ in volume and 250 lbs mass that can be subjected to a G level up to 200 G. This centrifuge is used for graduate courses in geotechnical and geoenvironmental engineering and for carrying out research pertaining to hydraulic properties of waste materials. The smaller centrifuge is of the size of a washing machine and is exclusively for testing soil and waste samples for unsaturated hydraulic properties. It can accommodate up to 6 samples having volume less than 1 L and it can subject the samples to a maximum gravity loading of 4,000 G. This centrifuge is used for research as well as for a graduate level course that covers properties of soils and waste.

Unsaturated Geomaterials Testing Lab

The unsaturated geomaterial testing lab houses several devices to measure the unsaturated properties of soils and coal combustion byproducts. Housed in this lab are several devices to measure the soil-water characteristics curve including 6 Soilmoisture 2-1/4 in diameter tempe cells (0 – 2 bars); Soilmoisture pressure plate extractors (1 bar and 5 bars); Soilmoisture volumetric pressure plate extractor with the Hysteresis attachments; Decagon WP4 Dewpoint Potentiameter (0 – 3000 bars). In addition to these bench top and lab scale devices are several decagon field tensiometers for field measurement.

Other geotechnical and geo-environmental laboratories include:

- Field and In-situ Testing Lab
- Geosynthetic Materials Testing and Performance Lab
- Pavement Materials Performance Lab
- Soil and Rock Dynamics Experimentation Lab

Transportation Facilities

The EPIC Building houses two transportation labs, one focusing on transportation modeling and simulation (Transportation Modeling and Simulation Lab) and the other focusing on intelligent transportation systems, traffic operations and optimization (Information Technology Services

Tool). Both the labs are equipped with state-of-the-art computers that have traffic simulation software (Synchro/SimTraffic and VISSIM), transportation planning software (TransCAD), geometric design software, and geo-spatial data processing and analysis software. They are also equipped with NADS MiniSim driver simulator, surveying equipment, traffic signal controllers, a sign retro-reflectometer, and devices such as video cameras, bluetooth detectors, global positioning systems (GPS), and Jamar counters to collect traffic counts and analyze transportation system performance. These devices are used to conduct engineering as well as observation studies using the real world transportation network as its lab. Furthermore, a 100-feet test rail track (prototype) was constructed outside the EPIC building to research and evaluate innovative track construction, design strategies and operation of trains.

USDOT Transportation Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE)

The U.S. Department of Transportation Center for Advanced Multimodal Mobility Solutions and Education (also called CAMMSE) is a multi-campus University Transportation Center led by UNC Charlotte. A consortium of five universities, CAMMSE includes UNC Charlotte, the University of Texas at Austin (UT Austin), the University of Connecticut (UConn), Washington State University – Pullman (WSU), and Texas Southern University (TSU), each with unique records as education hubs engaging diverse populations and nurturing the success of all students. CAMMSE will address the FAST Act research priority area of "Improving Mobility of People and Goods" by focusing on developing advanced technology, methods and models for multimodal transportation (including highway, air, rail, freight, public transit, bicycle and pedestrian) as well as educating and developing an effective workforce. A collaborative research, education and outreach partnership will harness advanced (computing, smartphones and communication) technologies and ubiquitous data for creating sustainable, efficient and growth-enabling multimodal transportation systems using cutting edge analytical methods and models. As a result, research performed by the Center will deliver impactful products to local, regional, and national stakeholders that support economic development, significantly improve mobility of people and goods, reduce congestion, promote safety and social equity, preserve the environment, and preserve the existing transportation system.

Environmental Facilities

The EPIC Building houses over 10,000 square feet of multi-user environmental wet chemistry and analytical lab on the 3rd floor of the building. This facility houses a wide array of analytical instruments and bench testing spaces with different built-in hoods and material handling devices. The key analytical instruments in CEE Environmental research lab are summarized below:

Analytical Instruments:

- Thermo Fisher iCAP Qc ICP-MS with autosampler

- Agilent 1100 HPLC with quaternary pump, diode array detector, autosampler and column thermostat
- Hewlett Packard 5890 Series II GC with 7673 MS detector and autosampler
- Shimadzu GC-2014 gas chromatograph
- Varian Cary100Bio UV/Vis spectrophotometer (200-900 nm wavelength range, 4 AU vertical range)
- Hach DR2800 Vis spectrophotometer (340-900 nm range) compatible with Hach TNTplus vials, portable
- Fisher Scientific AR 50 and Accumet XL15 pH meters (4)
- Hach ISFET multiparameter benchtop unit for pH (0.00-14.00), conductivity (0-200 mS), TDS (0-200 ppt), temperature (0-100 °C), dissolved oxygen (0-19.99 ppm)
- Fisher Scientific AP125 Accumet portable multiparameter probe for pH (-2.00 to 20.00), oxidation-reduction potential (-2000.0 to +2000.0 mV), temperature (-5 to 100 °C) and ion concentration with preprogrammed calibration points
- Chemtrac Electrokinetic charge analyzer titrator ECAT 2100 (titrates coagulant addition to neutral charge point or another endpoint; data is downloadable)
- Hach AL-DT digital alkalinity titrator (10-4000 mg/L $CaCO_3$)
- Malvern Instruments multipurpose titrator MPT-2 (2)
- Malvern Instruments Zetasizer Nano-ZS with MPT-2 titrator (colloid dispersion or flocculation as a function of pH, conductivity or liquid additive volume; molecular size and molecular weight; 3.8-100 microns zeta potential range with 10 mg/mL sensitivity; 0.3 nm-10.0 micron particle/molecular size range with 0.1 mg/mL sensitivity; 980 Da-20 MDa molecular weight measuring range)
- Malvern Instruments Zetasizer 4 particle analyzer with Series 7032 Multi-8 correlator
- Malvern Instruments Zetasizer 3000 HS particle analyzer (particle size distribution and zeta potential in 2 nm – 3 mm range)
- Brinkmann 2010 particle size analyzer (particle size distribution)
- Coulter Counter ZM (particle or microbial cell counting and size distribution)
- Coulter Multisizer (particle size, volume, count and surface area; range 0.4-1200 micron)
- Met One laser particle counter (flow rate 100 mL/min; particle sizes 2, 3, 5, 8, 12 and 15 micron)
- LiQuilaz laser particle counter with LS 200 liquid sampler (measures concentrations/counts of particles down to 0.2 micron)
- MGN International, Inc. RION laser liquid particle counter
- Brookhaven Instruments Corporation BI-DCP particle sizer (range 0.01-30 micron)
- Brookhaven Instruments Corporation ZetaPALS zeta potential analyzer with computer (zeta potential of low dielectric, high viscosity, high salinity and near the IEP solutions; zeta potential range 1 nm-100 micron; particle size range <0.3 nm - >3 micron; molecular weight range 1 kDa – 25 MDa)
- Pen-Kem, Inc. Lazer Zee Meter Model 102 (electrophoretic mobility of colloids)
- Rank Brothers, Ltd. Micro-electrophoresis apparatus with a microscope (electrophoretic mobility of suspended particles; from > 20 micron to < 0.2 micron depending on refracting index compared to that of the medium and on particle density)

- Zeta-Meter 3.0 connected to a microscope
- Fisher surface tensiomat Model 21 (surface tension of liquids)
- Hach 2100 AN turbidimeter (2) (up to 10,000 NTU; compliant with reporting requirements for EPA Method 180.1)
- Sievers 800 portable total organic carbon analyzer (range 0.05-50,000 ppb) (2)
- Lachat IL 500 total organic carbon analyzer (uses UV-persulfate method; 0.002-10000 mg/L range)PerkinElmer LS-5 fluorescence spectrophotometer (measures fluorescence, phosphorescence and luminescence)
- Turner Designs TD-360 mini-fluorometer (light source range 360-400 nm with peak at 365 nm; detector range 300-1100 nm)
- Rank Bros. Photometric Dispersion Analyzer PDA-2000 with flow-through cell (dispersant and flocculant performance testing)
- Shimadzu TOC-L/CPN with ASI-L autosampler and total nitrogen TNM-L unit

Analytical Instruments in Affiliated Labs:

- Dionex ICS-3000 ion chromatography system with autosampler (housed in the CEE/IDEAS laboratories in Cameron Building)
- Thermo Fisher Accela/Velos HPLC-MS ion trap with diode array detector and autosampler (housed in RACheL in Burson Building)

Water Treatment:

- Phipps and Bird 6-unit mixer with 2L B-Ker jars with sample collection taps (2)
- Low pressure mercury vapor UV collimated beam (max irradiance approximately 0.1 mW/cm^2)
- Xylem flow through UV reactor with a low pressure mercury vapor lamp and digital sensors
- Del Ozone LG-7 ozone generator (7 g/h of ozone at > 4 L/min flow)

Microbiology and Molecular Biology:

- Jouan C412 centrifuge with analog controls (RPM and 30 min timer) and digital RPM display
- IEC MicroMax centrifuge (1000-15000 RPM range, digital controls and 99 min timer, two acceleration and deceleration modes
- Shelton Scientific VSB-14 Micro Centrifuge with analog controls (up to 13000 RPM and 30 min)
- Thermo Electron Corporation Centra CL3R centrifuge with digital RPM (up to 8500 RPM, depends on the rotor), timer (up to 99 min) and temperature control (-9 to 40 °C) and two acceleration and deceleration modes
- Scienceware Lightbox Petit (for viewing slides, plates, petri dishes, etc.)
- Turner TD-20e Luminometer

- Roche LightCycler for real-time PCR
- Perkin Elmer DNA Thermal Cycler 480 PCR DNA amplifier
- Thermodyne TempTronic PCR DNA amplifier
- Bio-Tek Instruments microQuant microplate reader with computer (reads 6-, 12-, 24-, 48-, 96-, and 384-well microplates; 200-999 nm wavelength range in 1 nm increments, 2.4 nm bandpass; ELISA and other assays)
- Integra Biosciences Fireboy Plus portable Bunsen burner
- Heat Systems – Ultrasonics, Inc. Sonifier Model W185 cell disruptor
- Scientific Industries disruptor genie
- Fisher Scientific dry bath incubator (analog control centrifuge tube incubator)
- Lab-Line slide warmer (slightly above ambient to 65 °C; digital temperature readout)
- Bio-Rad AS-100 HRLC automatic sampling system (refrigerated)
- New Brunswick Scientific Excella multi-position shaker for 250 mL Erlenmeyer flasks
- Forma Scientific orbital shaker (1" orbital motion) with digital timer (1 min – 200 hr), speed (25-525 RPM) and temperature controls (5 °C above ambient to 60 °C)
- Nuaire TS AutoFlow CO_2 water-jacketed incubator
- Steris built-in industrial size autoclaves
- Tuttnauer/Brinkmann tabletop programmable digital autoclave Heidolph 2540EP (23 L capacity; 105-137 °C temperature range; 0-59 min timer; 0-40 psi pressure; 0-99 min drying time; low water indicator; printer)

Sample Preparation:

- Denver Instruments S1-114 analytical balance (d = 0.1 mg)
- Mettler Toledo SB 12001, Shimadzu TX323L and Acculab Vicon balances
- Balance for higher weights with counterweights
- Dionex Thermo Scientific ASE350 accelerated solvent extractor (solid and semisolid samples; 24 sample autosampler)
- Barnstead EASYpure UV/UF reagent grade (ultrapure) water purification system (18.2 MΩ-cm resistivity)
- Barnstead NANOpure Diamond (up to 15 L/day of ultrapure water with 18.2 MΩ-cm resistivity)
- Barnstead NANOpure Infinity (ASTM Type I water with 18 MΩ-cm resistivity at 1.5 L/min maximum flow)
- Pall Corporation 3-port vacuum filtration manifold
- Gelman Sciences 3-port vacuum filtration manifold
- Millipore LabScale tangential flow filtration system
- Blender, Microwave

Miscellaneous:

- Digital and analog peristaltic pumps capable of accommodating a variety of flows (MasterFlex, Rainin Rabbit-Plus and Watson Marlow)

- Fisher Scientific vortex genie mixers (2) and multitube vortex mixer
- Fisher Scientific Isotemp oven (220 °C maximum temperature
- Fisher Scientific 750 series programmable muffle furnace (50-1125 °C)
- Precision Model 184 water bath (5.2 gal; ambient temperature to 99.9 °C; analog + thermometer temperature control; temperature stability ±0.2°C at 37°C)
- Curtin Matheson Scientific, Inc. Equatherm dual water bath with individual analogue controls (13.5 and 10 L chambers, 25-100 °C range)
- Lauda Brinkmann EcoLine RE120 refrigerated recirculating bath (20 L, -30 to 120 °C)
- Ludl Electronic Products, Ltd. Lamp power supply (75 W xenon; 100 W mercury)
- Zeiss AttoArc HBO 100 W microscope light source (for illumination of fluorescent-stained specimens)
- Zeiss Standard 25 ICS transmitted light microscope (brightfield, darkfield, phase contrast and polarization contrast techniques)
- Alloy Products Corp. 3-port stainless steel pressurized vessel (155 psi; -20 to 100 °F)
- KD Scientific digital syringe pump (2)
- IKA Labortechnik BO 6 digital
- Hoshizaki industrial ice maker
- Lancer industrial size dual dishwasher connected to the building deionized water system

B. Describe the effect of this new program on existing facilities and indicate whether they will be adequate, both at the commencement of the program and during the next decade.

Existing facilities are adequate for the proposed Ph.D. in CE considering the successful participation of CEE Department faculty members in the INES Interdisciplinary Ph.D. program since 2004.

C. Describe information technology and services available for the proposed program.

Computational Resources (Hardware and Software)

The CEE Department, COE, and University develop and maintain several computational resources, such as research computer clusters with hundreds of cores, dedicated computers/workstations for data acquisition in the labs and field, computer labs for graduate/undergraduate classes and research, and a wealth of individual computers for faculty, staff, and graduate student offices.

Numerous commercial and in-house computer programs support faculty and graduate student research, design, and instruction.

Computer hardware and software, technical support, and operation and maintenance support is provided within COE's network of over 400 Linux and Windows XP machines with peripherals such as laser and color printers, large format plotters, scanners, digitizers, tape drives and shared hard disk storage. This system, known as the Mosaic

Computing Environment or just Mosaic, is operated by a professional IT staff employed by the COE. The Mosaic system is centrally managed and configured to take advantage of a robust network-based infrastructure. The hardware network is designed such that users cannot corrupt or modify the systems they use. This locked down mode ensures that each time someone logs in to a Mosaic managed computer they are assured of getting a pristine system.

Included among these network computers are three four or eight core Linux compute servers with as much as 64 GB of RAM for the most computationally intensive jobs. Also available at the University level is a multi-processor grid computer system. The COE's computer network also provides hardware and software maintenance, repair, software upgrades, and technical support. In addition, all of the LINUX and XP machines have access to a broad range of Civil and Environmental software, data visualization, (e.g. GNU plot, AVS, TecPlot, Matlab), GIS/CAD (AutoCAD, ArcGIS), and programming (Fortran, C++, and several other compilers).

In addition to Mosaic which is a dedicated COE computing system, the Information and Technology Services (ITS) at UNC Charlotte provides a campus wide technology support and services for all colleges including email. The Center for Teaching and Learning (CLT) provides platforms and support for all instructional technology. For high performance computing, the University Research Computing (URC) Group at UNC Charlotte was established in 2003 to provide the unique computing needs of the diverse colleges by developing shared computing facilities and offering specialized services that would be difficult for individual research groups or departments to provide internally. The URC cluster with multi-core nodes currently supports parallel processing using the MPI standard. URC provides a unified storage environment that is shared across all of the research clusters including 300 TBs of general user storage space and 100 TBs of scratch storage.

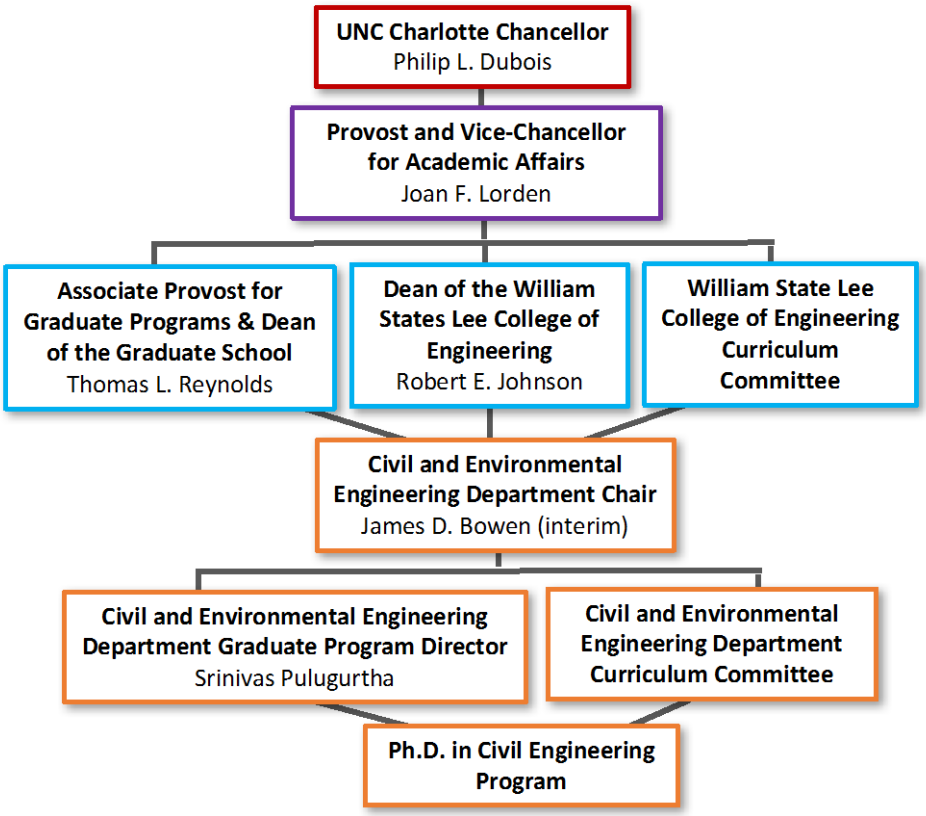
D. Describe the effect of this new program on existing information technology and services and indicate whether they will be adequate, both at the commencement of the program and during the next decade.

The existing information technology and services within the College currently serve three Ph.D. programs and are more than adequate to serve the proposed CE Ph.D. program. Since all of these Ph.D. programs are computationally intensive, and since changes and advances in technology are ongoing, continued investment in the information technology and services of the COE will continue to be an essential part of future success. Ongoing development of the COE's information technology and services resources will be guided by its professional staff with input from a faculty advisory committee. Classrooms and research facilities will continue to be tightly integrated with the College's various curricula and research programs. The COE's ITS infrastructure will be updated continuously to ensure that the system remains advanced, secure, and readily available to all College personnel.

V. Administration

A. Describe how the proposed program will be administered, giving the responsibilities of each department, division, school, or college. Explain any inter-departmental or inter-unit administrative plans. Include an organizational chart showing the "location" of the proposed new program.

The proposed Ph.D. in CE degree program will be administered within the CEE Department, which is part of the William States Lee COE, as illustrated by the COE organizational chart below. The CEE Department has a Graduate Program Director who will direct recruiting, admissions, advising, and oversight of graduate students within the Ph.D in CE program. The Graduate Program Director currently fulfills these functions for the Master's programs administered by the CEE Department. A professional graduate advisor assists the Graduate Program Director in advising and recruiting. Faculty committees assist with recruiting, admissions, and student advising. The Graduate Program Director will report to the CEE Department Chair, who has ultimate responsibility for all programs within the CEE Department. The CEE Department Chair reports to the Dean of COE and consults with the Senior Associate Dean for Academic Affairs in the COE. The Dean of COE reports to the Provost who in turn reports to the Chancellor.



Ph.D. in Civil Engineering Organizational Chart

B. For joint programs only, include documentation that, at minimum, the fundamental elements of the following institutional processes have been agreed to by the partners:

1. Admission process
2. Registration and enrollment process for students
3. Committee process for graduate students
4. Plan for charging and distributing tuition and fees
5. Management of transcripts and permanent records
6. Participation in graduation
7. Design of diploma

N/A

VII. Accreditation and Licensure

A. Where appropriate, describe how all licensure or professional accreditation standards will be met, including required practical, internships, and supervised clinical experiences.

The proposed Ph.D. program is not subject to licensure or professional accreditation standards.

The CEE Department is subject to accreditation standards for its Bachelors of Science in CE (BSCE) degree that is accredited by the Accreditation Board for Engineering and Technology (ABET). ABET accreditation is maintained on a six-year cycle in which the departments in the COE undergo a rigorous internal and external review process that typically takes 18 months to complete. The CEE Department completed an outstanding ABET review visit in 2016 – 2017 academic with final exit statement praising our program with no concerns, weaknesses or deficiencies. The CEE Department has a history of consistently performing well in ABET accreditation.

B. Indicate the names of all accrediting agencies normally concerned with programs similar to the one proposed. Describe plans to request professional accreditation.

UNC Charlotte is accredited by the Commission on Colleges of the Southern Association of Colleges and Schools (SACS) to award baccalaureate, master's, and doctoral degrees.

There are no plans to request additional professional accreditation for the proposed CE Ph.D. program.

C. If the new degree program meets the SACSCOC definition for a substantive change, what campus actions need to be completed by what date in order to ensure that the substantive change is reported to SACSCOC on time?

As required by the Policy Statement on Substantive Change for Accredited Institutions of the Commission on Colleges, the University of North Carolina at Charlotte (UNC Charlotte) is required to submit a letter of notification for new degree programs prior to implementation. Notification of this new degree program will be provided to SACS after approval by the University of North Carolina Board of Governors and prior to implementation.

D. If recipients of the proposed degree will require licensure to practice, explain how program curricula and title are aligned with requirements to "sit" for the licensure exam.

N/A

VIII. Supporting Fields. Discuss the number and quality of lower-level and cognate programs for supporting the proposed degree program. Are other subject-matter fields at the proposing institution necessary or valuable in support of the proposed program? Is there needed improvement or expansion of these fields? To what extent will such improvement or expansion be necessary for the proposed program?

No additional subject-matter fields or cognate programs are required to support the proposed CE Ph.D. program. We will capitalize on our existing doctoral programs and graduate school support to implement the program. After four years, an evaluation will be conducted to examine the efficacy of the curriculum. Potential changes in the curriculum may be identified at that time, but no significant changes are anticipated.

IX. Additional Information. Include any additional information deemed pertinent to the review of this new degree program proposal.

None

X. Budget

A. Complete and insert the Excel budget template provided showing incremental continuing and one-time costs required each year of the first four years of the program. Supplement the template with a budget narrative for each year.

The budget and budget narrative for each of the first four years of the program are provided on the following pages.

SUMMARY OF ESTIMATED ADDITIONAL COSTS FOR PROPOSED PROGRAM

INSTITUTION	UNC Charlotte	DATE	14-Dec-17
Program (CIP, Name, Level)	14.0801, Civil Engineering, Doctorate		
Degree(s) to be Granted	Ph.D. in Civil Engineering	Program Year	Year 1 (2018-2019)
Differential tuition requested per student per academic yr	$0		
Projected annual FTE students	2		
Projected annual differential tuition	$0		
Percent differential tuition for financial aid			
Differential tuition remainder	0		

ADDITIONAL FUNDS REQUIRED - BY SOURCE

	Reallocation of Present Institutional Resources (CEE Dept)	Enrollment Increase Funds	Graduate Assistant Support Program (GASP)	Other New Allocations, Research Grants	Total
EPA/SPA Regular Salaries					
Graduate Program Director Stipend	10,000	0	0	0	10,000
EPA Academic Salaries					
	0	0	0	0	0
Social Security	0	0	0	0	0
State Retirement	0	0	0	0	0
Medical Insurance	0	0	0	0	0
Graduate Stipends and Payments					
RA/TA Salary, 2 at $22000	33,000			11,000	44,000
Tuition Award, 2 at $11054	0		22,108	0	22,108
Fee Payment, 2 at $4961	7,442			2,481	9,922
Supplies and Materials					
(Identify)	0	0	0	0	0
Current Services					
(Identify)	0	0	0	0	0
Travel	$6,747	3,253	0	0	10,000
Communications	$2,000	0	0	0	2,000
Printing and Binding	$2,000	0	0	0	2,000
Advertising	$1,000	0	0	0	1,000
Fixed Charges					
(Identify)	0	0	0	0	0
Capital Outlay (Equipment)					
(Identify)	0	0	0	0	0
Libraries	0	603		0	603
TOTAL ADDITIONAL COSTS	**62,189**	**3,856**	**22,108**	**13,481**	**101,633**

Narrative:

Year 1, Budget Narrative

EPA/SPA Regular Salaries Stipends

The Ph.D. in CE will be operated and administered in the CEE Department. The program will be led by the Graduate Program Director, who also manages the Master's program in the Department. The Director will receive an annual stipend of $10,000. The amount is in keeping with stipend amounts paid by the Department for Program duties. Funding for the stipend will come from reallocation of funds currently directed towards the Master's program.

Graduate Stipends, Tuition Payments, Fee Payments

For budgeting purposes, it is assumed that eight students will join the CE Ph.D. program in year one, which will increase overall Ph.D. enrollment by two students (6 of 8 are assumed to transfer from the INES Ph.D. program). It is assumed that teaching assistant (TA) support will represent 75% (6 of 8) of student stipends, with the remainder paid through grant supplied research assistant (RA) support. The Graduation Assistant Support Plan (GASP) run by the graduate school is assumed to fund 100% of tuition payments. In-state students are assumed to represent 50% of the total student enrollment.
Fee payments are allocated to the CEE Department (via TAs) and to research grants (via RAs) using the same percentages as that for student stipends. Tuition and fees are based upon those of the current academic year (2017-2018) with an annual 2.0% inflation rate. TA and RA stipends are inflated at this same 2% rate.

Travel

Funds will be used to support travel by the Graduate Program Director for recruiting and program development and to support student educational travel awards.

Communications, Printing and Binding, Advertising, Library

Funding is needed for the production, publication, and distribution of program promotional materials in trade publications, mass media, and at academic conferences. These funds will also support preparation, printing, and distribution of annual reports and other program documents. As enrollment increases, funding will also be needed to support the library's acquisition of reference materials beyond those available at the outset of the program.

SUMMARY OF ESTIMATED ADDITIONAL COSTS FOR PROPOSED PROGRAM

INSTITUTION	UNC Charlotte	DATE	14-Dec-17
Program (CIP, Name, Level)	14.0801, Civil Engineering, Doctorate		
Degree(s) to be Granted	Ph.D. in Civil Engineering	Program Year	Year 2 (2019-2020)
Differential tuition requested per student per academic yr	$0		
Projected annual FTE students	6		
Projected annual differential tuition	$0		
Percent differential tuition for financial aid			
Differential tuition remainder	0		

ADDITIONAL FUNDS REQUIRED - BY SOURCE

	Reallocation of Present Institutional Resources (CEE Dept)	Enrollment Increase Funds	Graduate Assistant Support Program (GASP)	Other New Allocations, Research Grants	Total
EPA/SPA Regular Salaries					
Graduate Program Director Stipend	$10,000	$0	$0	$0	$10,000
EPA Academic Salaries					
	$0	$0	$0	$0	$0
Social Security	$0	$0	$0	$0	$0
State Retirement	$0	$0	$0	$0	$0
Medical Insurance	$0	$0	$0	$0	$0
Graduate Stipends and Payments					
RA/TA Salary, 9 at $22440	$100,980			$100,980	$201,960
Tuition Award, 9 at $11275	$9,996		$79,494	$9,996	$99,486
Fee Payment, 9 at $5060	$22,771			$22,771	$45,542
Supplies and Materials					
(Identify)	$0	$0	$0	$0	$0
Current Services					
(Identify)	$0	$0	$0	$0	$0
Travel	$0	10,000	0	$0	$10,000
Communications	$0	2,000	0	$0	$2,000
Printing and Binding	$0	2,000	0	$0	$2,000
Advertising	$362	638	0	$0	$1,000
Fixed Charges					
(Identify)	$0	$0	$0	$0	$0
Capital Outlay (Equipment)					
(Identify)	$0	$0	$0	$0	$0
Libraries	$0	$2,713	$0	$0	$2,713
TOTAL ADDITIONAL COSTS	**$144,110**	**$17,350**	**$79,494**	**$133,747**	**$374,701**

Narrative:

Year 2, Budget Narrative

EPA/SPA Regular Salaries Stipends

As described in year 1, administration of the CE Ph.D. program will reside in the CEE Department. Ongoing support is needed for the Graduate Program Director's stipend. The stipend amount of $10,000 is funded through reallocation of Master's program support provided by the COE. The stipend amount is in keeping with that paid for program administration duties.

Graduate Stipends, Tuition Payments, Fee Payments:

For budgeting purposes, total enrollment in the CE Ph.D. program is assumed to grow to sixteen students (8 new students, 8 returning) in year 2, with an overall increase in Ph.D. enrollment by seven students (1 of 8 new students are assumed to transfer from the INES Ph.D. program). In year two, it is assumed that TA support will represent 50% of student stipends (8 of 16 awards are assumed to be TAs), with the remainder paid through grant supplied RA support. The GASP run by the graduate school is assumed to fund 80% of tuition payments. In-state students are assumed to represent 50% of the total student enrollment. Fee payments are allocated to the CEE Department (via TAs) and to research grants (via RAs) using the same percentages as that for student stipends. Tuition and fees are based upon those of the current academic year (2017-2018) with an annual 2.0% inflation rate. TA and RA stipends are inflated at this same 2% rate.

Travel

Continued funding is needed to support travel by the Graduate Program Director for recruiting and program development and to support student educational travel awards.

Communications, Printing and Binding, Advertising, Library

Continued funding is needed for the production, publication, and distribution of program promotional materials in trade publications, mass media, and at academic conferences. These funds will also support preparation, printing, and distribution of annual reports and other program documents. As enrollment increases, funding will also be needed to support the library's acquisition of reference materials beyond those available at the outset of the program.

SUMMARY OF ESTIMATED ADDITIONAL COSTS FOR PROPOSED PROGRAM

INSTITUTION	UNC Charlotte	DATE	14-Dec-17
Program (CIP, Name, Level)	14.0801, Civil Engineering, Doctorate		
Degree(s) to be Granted	Ph.D. in Civil Engineering	Program Year	Year 3 (2020-2021)
Differential tuition requested per student per academic yr	$0		
Projected annual FTE students	17		
Projected annual differential tuition	$0		
Percent differential tuition for financial aid			
Differential tuition remainder	0		

	ADDITIONAL FUNDS REQUIRED - BY SOURCE				
	Reallocation of Present Institutional Resources (CEE Dept)	Enrollment Increase Funds	Graduate Assistant Support Program (GASP)	Other New Allocations, Research Grants	Total
EPA/SPA Regular Salaries					
Graduate Program Director Stipend	10,000	0	0	0	10,000
EPA Academic Salaries					
	0	0	0	0	0
Social Security	0	0	0	0	0
State Retirement	0	0	0	0	0
Medical Insurance	0	0	0	0	0
Graduate Stipends and Payments					
RA/TA Salary, 17 at $22889	145,916			243,194	389,110
Tuition Award, 17 at $11501	14,161		150,155	23,602	187,918
Fee Payment, 17 at $5161	32,904			54,840	87,744
Supplies and Materials					
(Identify)	0	0	0	0	0
Current Services					
(Identify)	0	0	0	0	0
Travel	$0	10,000	0	0	10,000
Communications	$0	2,000	0	0	2,000
Printing and Binding	$0	2,000	0	0	2,000
Advertising	$0	1,000	0	0	1,000
Fixed Charges					
(Identify)	0	0	0	0	0
Capital Outlay (Equipment)					
(Identify)	0	0	0	0	0
Libraries	0	5,124	0	0	5,124
TOTAL ADDITIONAL COSTS	**202,981**	**20,124**	**150,155**	**321,636**	**694,896**

Narrative:

Year 3, Budget Narrative

EPA/SPA Regular Salaries Stipends

As described in year 1, administration of the CE Ph.D. program will reside in the CEE Department. Ongoing support is needed for the Graduate Program Director's stipend. The stipend amount of $10,000 is funded through reallocation of Master's program support provided by the COE. The stipend amount is in keeping with that paid for program administration duties.

Graduate Stipends, Tuition Payments, Fee Payments:

For budgeting purposes, total enrollment in the Civil Engineering Ph.D. program is assumed to grow to 24 students (8 new students, 16 returning) in year three, with an overall increase in Ph.D. enrollment of 17 students (0 of 8 new students are assumed to transfer from the INES Ph.D. program). By the third year of the program, no new students are assumed to be transfers from the INES Ph.D. program, although seven students will still be in the CE PhD program that had originally started in INES. In year three, it is assumed that TA support will represent 38% of student stipends (9 of 24), with the remainder paid through grant supplied RA support. TA support is assumed to cover three semesters of a student's eight semesters in the program, a support rate that is at or slightly below the level of TA support for the other three Ph.D. programs in the COE. The GASP run by the graduate school is assumed to fund 80% of tuition payments. In-state students are assumed to represent 50% of the total student enrollment. Fee payments are allocated to the CEE Department (via TAs) and to research grants (via RAs) using the same percentages as that for student stipends. Tuition and fees are based upon those of the current academic year (2017-2018) with an annual 2.0% inflation rate. TA and RA stipends are inflated at this same 2% rate.

Travel

Continued funding is needed to support travel by the Graduate Program Director for recruiting and program development and to support student educational travel awards.

Communications, Printing and Binding, Advertising, Library

Continued funding is needed for the production, publication, and distribution of program promotional materials in trade publications, mass media, and at academic conferences. These funds will also support preparation, printing, and distribution of annual reports and other program documents. As enrollment increases, funding will also be needed to support the library's acquisition of reference materials beyond those available at the outset of the program.

SUMMARY OF ESTIMATED ADDITIONAL COSTS FOR PROPOSED PROGRAM

INSTITUTION	UNC Charlotte	DATE	14-Dec-17
Program (CIP, Name, Level)	14.0801, Civil Engineering, Doctorate		
Degree(s) to be Granted	Ph.D. in Civil Engineering	Program Year	Year 4 (2021-2022)
Differential tuition requested per student per academic yr	$0		
Projected annual FTE students	32		
Projected annual differential tuition	$0		
Percent differential tuition for financial aid			
Differential tuition remainder	0		

ADDITIONAL FUNDS REQUIRED - BY SOURCE

	Reallocation of Present Institutional Resources (CEE Dept)	Enrollment Increase Funds	Graduate Assistant Support Program (GASP)	Other New Allocations, Research Grants	Total
EPA/SPA Regular Salaries					
Graduate Program Director Stipend	10,000	0	0	0	10,000
EPA Academic Salaries					
	0	0	0	0	0
Social Security	0	0	0	0	0
State Retirement	0	0	0	0	0
Medical Insurance	0	0	0	0	0
Graduate Stipends and Payments					
RA/TA Salary, 25 at $23347	218,874			364,790	583,664
Tuition Award, 25 at $11731	51,816		138,175	86,359	276,350
Fee Payment, 25 at $5265	49,356			82,260	131,616
Supplies and Materials					
(Identify)	0	0	0	0	0
Current Services					
(Identify)	0	0	0	0	0
Travel	$0	10,000	0	0	10,000
Communications	$0	2,000	0	0	2,000
Printing and Binding	$0	2,000	0	0	2,000
Advertising	$0	1,000	0	0	1,000
Fixed Charges					
(Identify)	0	0	0	0	0
Capital Outlay (Equipment)					
(Identify)	0	0	0	0	0
Libraries	0	7,535	0	0	7,535
TOTAL ADDITIONAL COSTS	**330,046**	**22,535**	**138,175**	**533,410**	**1,024,166**

Narrative:

Year 4, Budget Narrative

EPA/SPA Regular Salaries Stipends

As described previously, administration of the CE Ph.D. program will reside in the CEE Department. Ongoing support is needed for the Graduate Program Director's stipend. The stipend amount of $10,000 is funded through reallocation of Master's program support provided by the COE. The stipend amount is in keeping with that paid for program administration duties in the Department.

Graduate Stipends, Tuition Payments, Fee Payments:

For budgeting purposes, total enrollment in the CE Ph.D. program is assumed to grow to 32 students (8 new students, 24 returning) in year four, with an overall increase in Ph.D. enrollment of 32 students. As in year three, it is assumed that TA support will represent 38% of student stipends (12 of 32 are assumed to be TA's), with the remainder paid through grant supplied RA support. TA support is assumed to cover three semesters of a student's eight semesters in the program, a support rate that is at or slightly below the level of TA support for the other three Ph.D. programs in the COE. The GASP run by the graduate school is assumed to drop to 50% of tuition payments in year four. In-state students are assumed to represent 50% of the total student enrollment. Fee payments are allocated to the CEE Department (via TAs) and to research grants (via RAs) using the same percentages as that for student stipends. Tuition and fees are based upon those of the current academic year (2017-2018) with an annual 2.0% inflation rate. TA and RA stipends are inflated at this same 2% rate.

Travel

Continued funding is needed to support travel by the graduate program director for recruiting and program development and to support student educational travel awards.

Communications, Printing and Binding, Advertising, Library

Continued funding is needed for the production, publication, and distribution of program promotional materials in trade publications, mass media, and at academic conferences. These funds will also support preparation, printing, and distribution of annual reports and other program documents. As enrollment increases, funding will also be needed to support the library's acquisition of reference materials beyond those available at the outset of the program.

XI. Evaluations Plans.

A. Criteria to be used to evaluate the quality and effectiveness of the program, including academic program student learning outcomes.

The UNC Charlotte Ph.D. in CE will provide research intensive doctoral-level education for students seeking CE careers in practice, research and teaching/academia. The program will lay emphasis on the mastery of the CE discipline-specific concepts relevant to the resilience of critical facilities and civil infrastructure. Emphasis will be placed on demonstrating mastery of knowledge in a specific subject area of CE through advanced research skills, the ability to synthesize, create innovative ideas and ultimately make original contributions to the discipline. Consequently, the program requires students to have mastery and understanding of complex systems and critical infrastructure to make contributions to the advancement of knowledge in critical facilities and civil infrastructure. Our evaluation plans for the proposed Ph.D. in CE encompass the criteria to evaluate the quality and effectiveness of the program as well as the Student Learning Outcomes (SLO), Measures (Metrics), and Plan/Schedule. The program evaluation will be focused on the program objectives (restated below) and the SLOs. The program evaluation will be conducted through internal assessments and external reviews process.

The objectives of CE Ph.D. program include:

- Prepare research engineers, professional engineers, and scholars/academicians who will be leaders in developing, maintaining, and managing the emerging critical infrastructure;
- Develop research engineers who have deep understanding of the subject matter to support and expand the base of research in rapidly growing fields related to critical infrastructure in the Charlotte region, North Carolina, and across the nation and world;
- Provide a range of educational and research experience for a diverse group of students to participate in research initiatives at UNC Charlotte, Private, Public, and International institutions; and,
- Prepare future civil and environmental engineering educators, scholars, and professionals who are at the frontiers of understanding of critical infrastructure development.

The criteria that will be used to evaluate the planned CE Ph.D. program objectives including those that address operational efficiency as well as program impact are presented below.

- Criterion 1: Demonstrate mastery of the fundamental concepts, models, advanced research skills, and their applications to complex systems in critical facilities and civil infrastructure.
- Criterion 2: Ability to recruit, retain, and graduate excellent Ph.D. students.
- Criterion 3: Level of contribution of doctoral students and their advisors to advances in engineering, science, and technology through publications, presentations, short-courses and patents.
- Criterion 4: Level of employment of graduates from the program and service of such graduates in leadership positions in academic, government, international agencies, and the private sector within and outside the State of North Carolina.

B. Measures (metrics) to be used to evaluate the program (include enrollments, number of graduates, and student success).

The following measures will be used to evaluate the performance of the proposed CE Ph.D. program with respect to the criteria described above.

Criterion 1

Greater than 90 % of students have proposal outstanding or good on completion of their Ph.D. qualifying exam and successfully defended the dissertation.

Criterion 2

Number of UNC Charlotte graduates recruited, retained, and graduated; number of non-UNC Charlotte graduates recruited, retained, and graduated; diversity of recruited Ph.D. students and local versus international institutions where they gained their B.S. and M.S. degrees.

Criterion 3

Two research articles published by doctoral students and their advisers on average; number of projects that were affected in North Carolina and elsewhere through research conducted by program students and their advisers; number of presentations and short-courses taught by doctoral degree candidates.

Criterion 4

Number of program graduates who are gainfully employed in their field of study; number of program graduates who serve in leadership positions and/or win professional awards.

C. The plan and schedule to evaluate the proposed new degree program prior to the completion of its fourth year of operation.

Since the proposed Ph.D. program is expected to take about 8 – 10 years to mature and achieve steady state, the measures for evaluating program success, listed above, will not be realized in four years. Therefore, evaluation of the program will assess progress toward the steady-state goals. The program will be evaluated internally at the end of each year for the first four years. SLOs will be assessed and reports will be submitted to the COE and the University every year (sample rubric and report are included in Appendix 3). At the end of the second year an external review will be conducted.

The evaluation reports written at the end of the fourth year will be submitted to the Office of Academic Affairs. The report will include information on the extent to which UNC Charlotte has met projected enrollments and degrees conferred, and the readiness of the university to continue funding the program on the level provided at the end of the fourth year. These reports will be submitted as a part of UNC Charlotte's long-range planning submission. Every 2 years of operation, an internal evaluation will be conducted by CEE Department Graduate Committee. At the end of the second year, evaluation report including external and CEE Department Graduate Committee review will be submitted to the Dean of COE for his review. Based on the results of these reviews, deficiencies, structural and programmatic inconsistencies in the program will be addressed. The

Graduate School and the Office of Academic Affairs at UNC Charlotte also have mechanisms and processes in place for providing oversight on all graduate programs. The proposed program will be assessed to determine if it is meeting the four-year milestones described below.

- Program enrollment in the fourth year should approach 30 students.
- During the fourth year of the proposed program, scholarly activities including presentations, journal publications, and grant activity by the CEE Faculty will be assessed. New external funding generated annually by the CEE Department faculty should exceed $2.0M. External funding should be supporting a minimum of 20 RAs.
- The program should have produced its first graduate by the fourth year of operation.
- Changes in the proposed program will be implemented as necessary to allow achievement of program goals.

XII. Attachments. Attach the final approved Request to Plan as the first attachment following this document.

Appendix 1: Request to Plan
Appendix 2: Analysis of Faculty and Student Resources Needed to Support the Civil Engineering Ph.D. Program at UNC Charlotte
Appendix 3: Student Learning Outcomes Assessment Plan and Report

This proposal to establish a new degree program has been reviewed and approved by the appropriate campus committees and authorities.

Chancellor: Philip Nuhoi Date: 12/18/17

Chancellor (Joint Partner Campus): _____ Date: _____

UNC CHARLOTTE

Office of the Chancellor

9201 University City Boulevard, Charlotte, NC 28223-0001
t/ 704.687.5700 f/ 704.687.1700 www.uncc.edu

January 19, 2017

Dr. Kimberly van Noort
Vice President for Academic Programs and Instructional Strategy
University of North Carolina
Post Office Box 2688
Chapel Hill, North Carolina 27515-2688

Dear Kim:

Enclosed is UNC Charlotte's Request to Plan a Ph.D. in Civil Engineering. The proposed program will expand on our successful existing B.S. and M.S. programs in Civil Engineering and will be housed in our state-of-the-art Energy Production and Infrastructure Center (EPIC) building. The program supports the collegiate goal of meeting the Charlotte area's demand for a graduate program while creating a pipeline of specially trained civil engineers with knowledge of the energy industry and the ability to concentrate their studies in environmental, geotechnical, structural or transportation engineering.

Thank you for your consideration of this request. Provost Lorden or I would be pleased to respond to any questions that you may have.

Cordially,

Philip L. Dubois
Chancellor

cc: Joan F. Lorden, Provost and Vice Chancellor for Academic Affairs
Robert Johnson, Dean, William States Lee College of Engineering
Courtney Thornton, Associate Vice President for Research and Graduate Education
Cody Thompson, Coordinator for Academic Planning

UNIVERSITY OF NORTH CAROLINA

REQUEST TO PLAN

A NEW DEGREE PROGRAM – ANY DELIVERY METHOD

THE PURPOSE OF ACADEMIC PROGRAM PLANNING: Planning a new academic degree program provides an opportunity for an institution to make the case for need and demand and for its ability to offer a quality program. The notification and planning activity described below do not guarantee that authorization to establish will be granted.

Date: January 19, 2017

Constituent Institution: The University of North Carolina at Charlotte

Is the proposed program a joint degree program? Yes____ No____X_____

Joint Partner campus _____

Title of Authorized Program: Civil Engineering Degree Abbreviation: Ph.D.

CIP Code (6-digit): 14.0801 Level: B _____ M ____ I _____ D _____X_____

CIP Code Title: Civil Engineering

Does the program require one or more UNC Teacher Licensure Specialty Area Code? Yes_____No__X

If yes, list suggested UNC Specialty Area Code(s) here _____

If master's, is it a terminal master's (i.e. not solely awarded en route to Ph.D.)? Yes ___ No____

Proposed term to enroll first students in degree program: *Term* Fall *Year* 2018

Provide a brief statement from the university SACSCOC liaison regarding whether the new program is or is not a substantive change.

As required by the Policy Statement on Substantive Change for Accredited Institutions of the Commission on Colleges, the University of North Carolina at Charlotte (UNC Charlotte) is required to submit a letter of notification and prospectus prior to implementation. Notification of this new degree program will be provided to SACS after approval by the University of North Carolina Board of Governors and prior to implementation.

Identify the objective of this request (select one or more of the following)

- ☒ Launch new program on campus
- ☐ Launch new program online; Maximum percent offered online _____
  - ☐ Program will be listed in UNC Online
  - ☐ One or more online courses in the program will be listed in UNC Online
- ☐ Launch new site-based program (list new sites below; add lines as needed)
  - ☐ Instructor present (off-campus delivery)

☐ Instructor remote (site-based distance education)

Site #1: University of North Carolina at Charlotte

9201 University City Blvd, Charlotte, Mecklenburg, NC	*100%*
(address, city, county, state)	*(max. percent offered at site)*

Supply basic program information for UNC Academic Program Inventory (API) and UNC Online

Minimum credit hours required	72 credit hours
Expected number of full-time terms to completion	8 semesters

1. Review Status.

a. List the campus bodies that reviewed and commented on this request to Plan proposal before submission to UNC General Administration. What were their determinations? Include any votes, if applicable.

The Dean of the William States Lee College of Engineering has requested this proposal and has consulted with the Provost as per "Campus Procedures for Review and Approval to Plan Programs". This proposal was reviewed by the following units/Offices:

1. The Civil and Environmental Engineering Faculty
2. The Dean of the Lee College of Engineering
3. The Dean of the Graduate School
4. The Office of Academic Affairs

All the reviews and determinations were positive.

b. Summarize any issues, concerns or opposition raised throughout the campus process and comment periods. Describe revisions made to address areas of concern.

Apart from requests for data and revisions, no issues, concerns or opposition were raised during the campus process and comment periods to date. Revisions have focused on providing greater context on demand for the program. Additional consultation, review and analysis was completed by Hanover Research, Inc. and Academic Analytics, LLC (Appendix 4). Subsequent data and industry letters of support have corroborated the need. Dhiaa Jamil, President of Regulated Generation and Transmission for Duke Energy noted that "With more than 250 regional energy corporations located in Charlotte, there is ample need for discipline-specific specialization in the three core areas of engineering, i.e.,

mechanical, electrical, and civil. UNC Charlotte is able to meet our needs in mechanical and electrical engineering, however civil engineering remains incomplete without a Ph.D. program". Likewise, Rich Keagy a Vice President from AECOM, the nation's #1 ranked Global Engineering Design Firm confirmed that "To develop the best workforce and be responsive to our industry, you must educate students at all levels (BS, MS, and Ph.D.) and do it with the best faculty" (see Appendix 3). Retaining the best faculty requires a Ph.D. program.

2. Description and Purpose

a. Provide a 250-word or less description of the proposed program, including target audience, delivery method, hours required, program core and concentrations (if applicable), post-graduate outcomes for which graduates will be prepared, and other special features. For programs with an online component, describe whether the delivery is synchronous with an on-campus course, partially synchronous, asynchronous, or other.

The proposed Ph.D. in Civil Engineering (CE) will provide doctoral-level education for students seeking civil engineering careers in practice, research and teaching/academia. The program is a terminal research degree that lays emphasis on the mastery of the civil engineering *discipline-specific* concepts relevant to the resilience of critical facilities and civil infrastructure. Emphasis will be placed on demonstrating mastery of knowledge in a specific subject area of CE through advanced research skills, the ability to synthesize, create innovative ideas and ultimately make original contributions to the discipline. The program will be administered on-campus by the Department of Civil and Environmental Engineering, (CEE), in the William States Lee College of Engineering (COE) at UNC Charlotte. The CEE Department is currently housed in the Energy Production and Infrastructure Center (EPIC) building and is integral to the vision funded by the North Carolina General Assembly: $76 million for the building and recurring funds for programming, faculty and staff. The proposed Ph.D. degree program requires successful completion of at least 72 approved graduate credits beyond the Baccalaureate degree. Up to 30 approved credits from graduate courses taken during the student's Masters' degree, which may have been taken at some other university, may be transferred towards the proposed program. Concentrations will include environmental, geotechnical, structural and transportation

engineering. Student outcomes will include a specialized knowledge in these concentrations, creative research skills, leadership and excellent communication skills.

b. How does the proposed program align with system, institutional and unit missions and strategic plans?

The proposed Ph.D. in CE is consistent with strategic plans and missions at all levels as well as the unique conditions that have evolved in the City of Charlotte, UNC Charlotte and the energy industry.

System Alignment

On February 12, 2016, UNC System President Margaret Spellings emphasized affordability, accessibility, accountability and quality. This proposal is consistent with each of those values:

Affordability: Tuition and Fees for engineering programs at UNC Charlotte are the lowest in the system while state dollars invested in the graduate program are matched by external investment through research. The vast majority of students in the Ph.D. program in Civil Engineering will be funded through external contracts. Research awards for the Department exceeded $4 million during fiscal year 2015-2016, among the highest of any unit on campus.

Accessibility: In contrast to the one other school in the UNC system which offers a Ph.D. in Civil Engineering (NC State), UNC Charlotte is focused on access. Our student demographics, which qualify UNC Charlotte as a minority serving institution with a large proportion of Pell Grant recipients and first generation students, make this clear. While scaled commensurately, this need for access extends throughout the academic spectrum, from bachelors to Ph.D. Access especially extends to working professionals in Charlotte, who wish to pursue a Ph.D. without leaving their jobs.

Accountability: The proposed Ph.D. program follows a natural evolution from the inter-institutional Ph.D. program with NC State and the current interdisciplinary Ph.D. program. Accountability of future success is ensured by the student and industry-driven demand for the program, as reflected by the EPIC program and documented by reports from Hanover Research

(Appendix 4). EPIC was the driving force of the $76 million dollar building and is guided by an industry advisory board. This board supports this Ph.D. proposal and will also hold it accountable.

Quality: The faculty and facilities which will house the Ph.D. are outstanding. The civil engineering faculty consists of 25 members with credentials from all over the country. The most recent hires, in January 2016, feature faculty with degrees from Lehigh University, Princeton University, and Carnegie Mellon University. The new EPIC building contains facilities and equipment which exist nowhere else in the country, such as the Advanced Cyclic Shear device for evaluating the response of foundation soils to field-relevant seismic forces and vibration.

Institutional Alignment

As North Carolina's urban research university, the proposed Ph.D. in civil engineering enables UNC Charlotte to meet its institutional mission which is to:

> *"Leverage its location in the state's largest city to offer internationally competitive programs of research and creative activity, exemplary undergraduate, graduate, and professional programs, and a focused set of community engagement initiatives"*
>
> *"Maintain a particular commitment to addressing the cultural, economic, educational, environmental, health, and social needs of the greater Charlotte region"*

The proposed Ph.D. in Civil Engineering is closely aligned with a number of our university goals including those which:

a. Deliver high quality, affordable, and effective educational programs that produce educated and responsible citizens and a competitive workforce**,**
b. Stimulate increased research, creative activities, and community engagement with a focus on programs and partnerships that address the major needs of the Charlotte region, and

c. Enhance opportunities for learning and working together in a socially and culturally diverse world.

Program and Unit Alignment

- Alignment with INES Ph.D. Program:

Currently, civil and environmental engineering (CEE) faculty deliver the interdisciplinary Infrastructure and Environmental Systems (INES) Ph.D. program in conjunction with six other departments across three colleges. This Ph.D. program focuses on the *interdisciplinary* nature of infrastructural and environmental systems. As an interdisciplinary Ph.D. program, INES draws faculty expertise from a broad array of disciplines: civil and environmental engineering, geography and earth sciences, engineering management, engineering technology, architecture, chemistry, biology, economics and finance.

- *INES Ph.D. Program co-existence with CE Ph.D. Program:*

Since its establishment in fall 2004, a majority of the students enrolled in the INES Ph.D. program have been directed and sponsored by CEE faculty. Through spring 2012, more than 80% of the students in the program were enrolled in and advised by CEE faculty, however this percentage has declined as other departments have begun to participate more fully in the program (Figure 1).

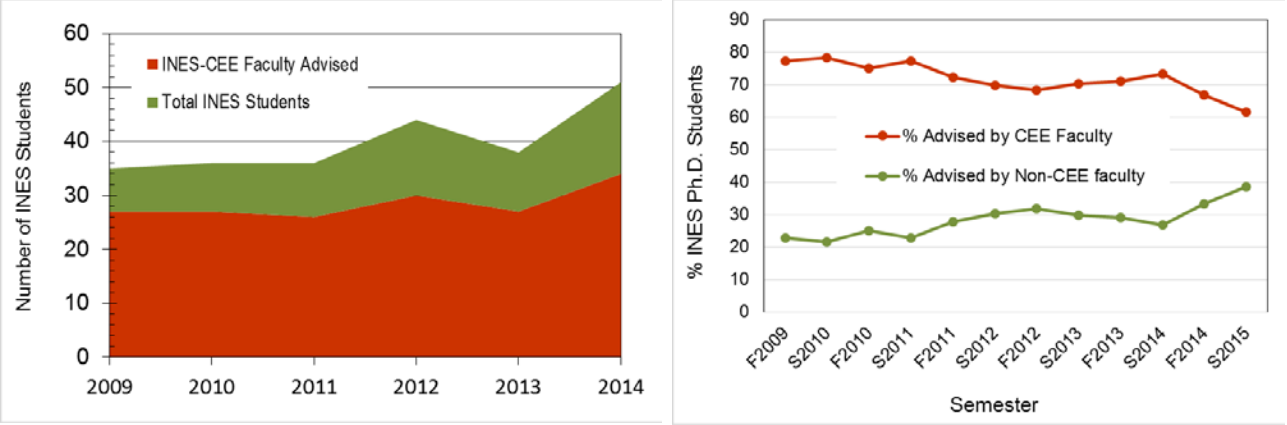


Figure 1: Recent INES Student Enrollment Summary and Relationship with CEE Faculty

Specifically, enrollment of students directed by faculty in geography and earth sciences, systems engineering, engineering technology and architecture has grown steadily. It is expected, however, that the INES Ph.D. program will continue to appeal to those CEE students who seek interdisciplinary work, especially in the environmental sciences and its nexus with sustainability. Given these factors, and as Figure 2 indicates, the INES Ph.D. is predicted to maintain something close to its current enrollment even once the CE Ph.D is established. This is supported by conservative extrapolations of the recent growth in CEE and other departments. For example, the annual INES Ph.D. program enrollment reached 50 students in less than ten years of operation, with most advised by CEE faculty. It reasonably follows that enrollment in the proposed CE Ph.D. program, which appeals to a pool of students not currently served, will reach at least 30 students within four years of establishment. Furthermore, recent enrollment numbers in the other Ph.D. programs within the college of engineering (e.g. Electrical and Mechanical Engineering, Figure 3) support the enrollment projections for the INES and CE PhD programs.

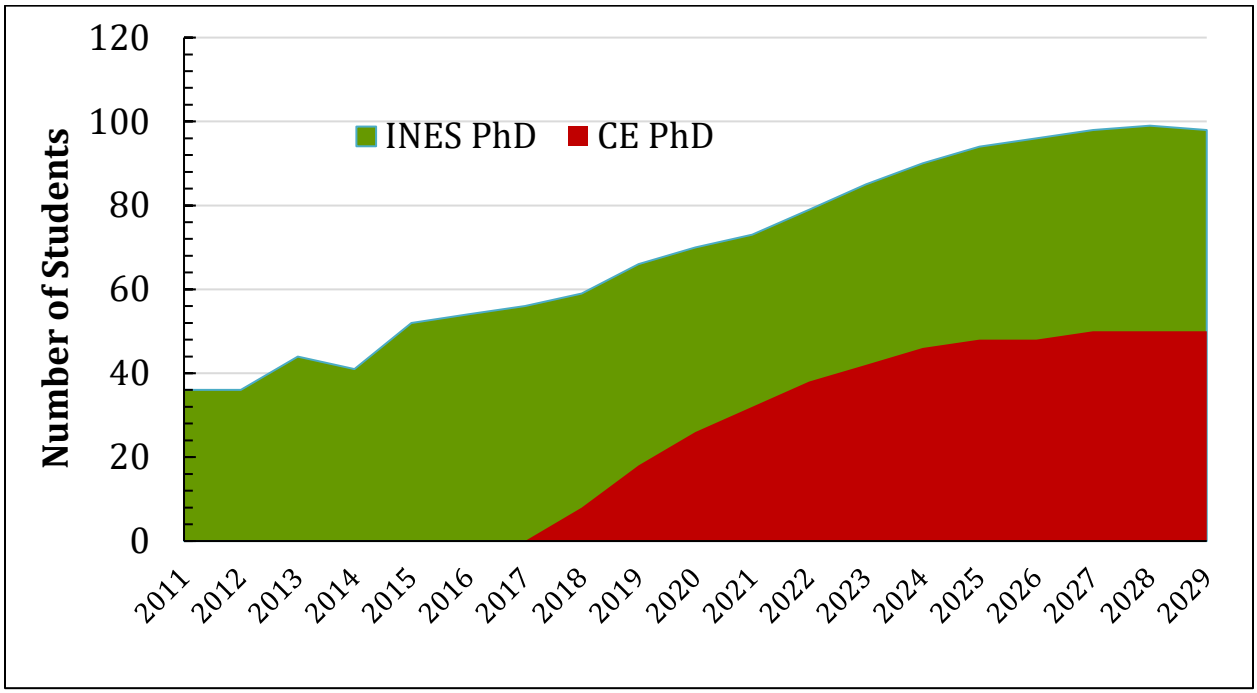


Figure 2: Projected INES Ph.D. Enrollment Growth in Co-existence with Proposed CE Ph.D. Degree Program

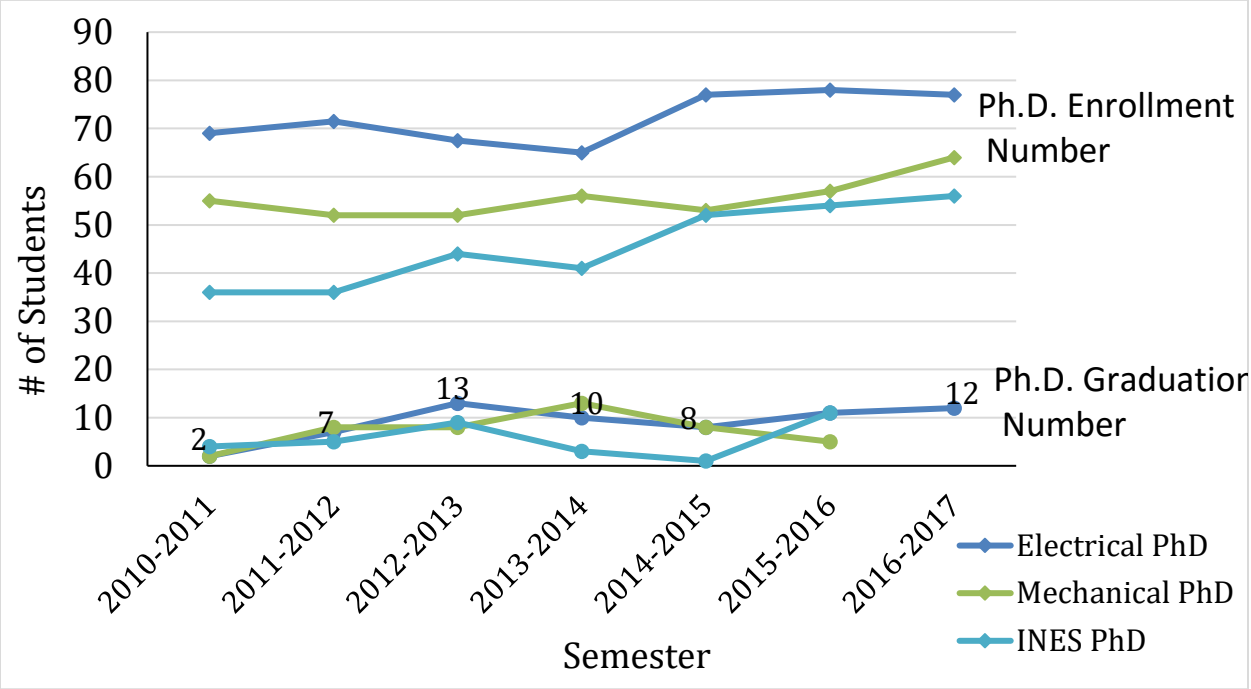


Figure 3: Recent Enrollment and Graduation Numbers of Ph.D. Programs in the College of Engineering, UNC Charlotte

- Initiatives to maintain INES Ph.D. Enrollment:

In anticipation of the CE Ph.D. establishment that is expected to significantly reduce CEE faculty participation in the INES Ph.D. program, Dr. Jy Wu, program director of INES Ph.D., has launched some initiatives to expand and grow student demand and enrollment. Speaking about the opportunities of increasing enrollment in the interdisciplinary INES Ph.D. program, Dr. Wu stated that: "Student enrollments among different participating programs/departments change cyclically, with enrollment in one program up while in other program may be down, but generally INES still continues to make steady growth in enrollment." A snapshot of current enrollment number in the INES Ph.D. program indicates a further decline in the percentage of students supervised by CEE faculty to 47.6% and that of other programs increasing to 52.4% of enrollment. Overall enrollment in the INES Ph.D. has increased from 50 students in the 2014 - 2015 academic year to 56 students in the 2016 -2017 academic year despite graduating 11 Ph.D. students in that span.

- *Growth in Other Feeder Programs at the College of Engineering:*

There is significant growth in MS graduation from Engineering Technology and Construction

Management (ETCM) and System and Engineering Management (SEEM) programs (Figure 4). These two programs now form a major feeder program for student demand in INES Ph.D., accounting presently for approximately 20% of total enrollment in the program. In addition, students supervised by CEE faculty on most interdisciplinary research projects typically obtain the MS Engineering (Civil option), which creates another important source of student demand in the INES Ph.D. Also, student demand is typically spurred by research funding growth. Trends in research awards in CEE, ETCM, and to a lesser amount SEEM are growing and compare favorably well with other two Engineering departments with Ph.D. programs (ECE, MEES) (Figure 5). These two Ph.D. programs currently have enrollment in the range of 56 - 77 students. On the basis of research funding only, CEE and ETCM are capable of funding and supporting more than 50 Ph.D. students as well.

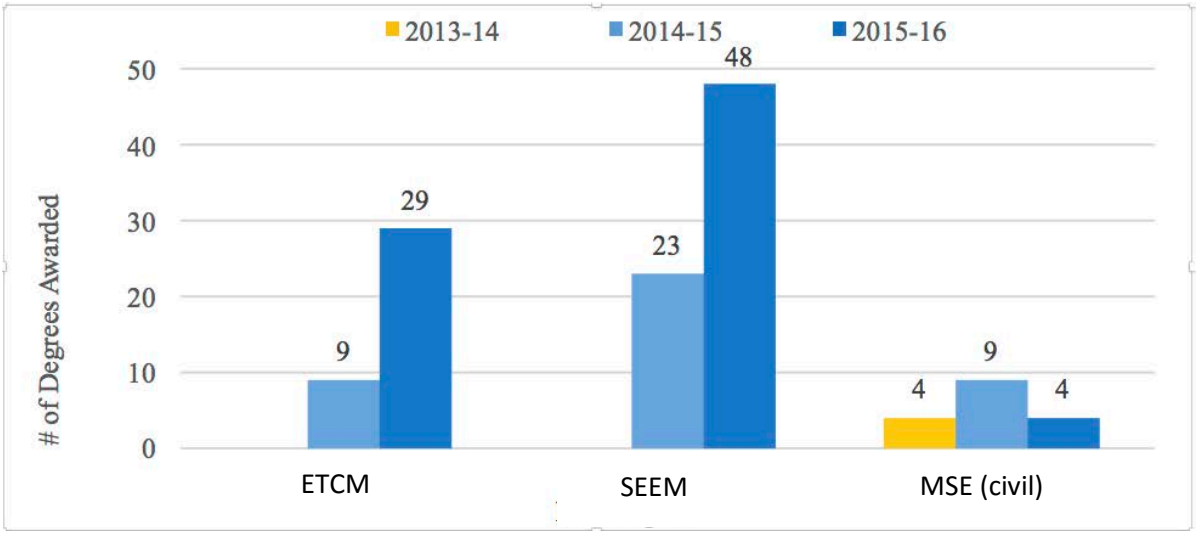


Figure 4: MS graduation in Engineering Technology & Construction Management, System Engineering Management and MS Engineering (Civil Option)

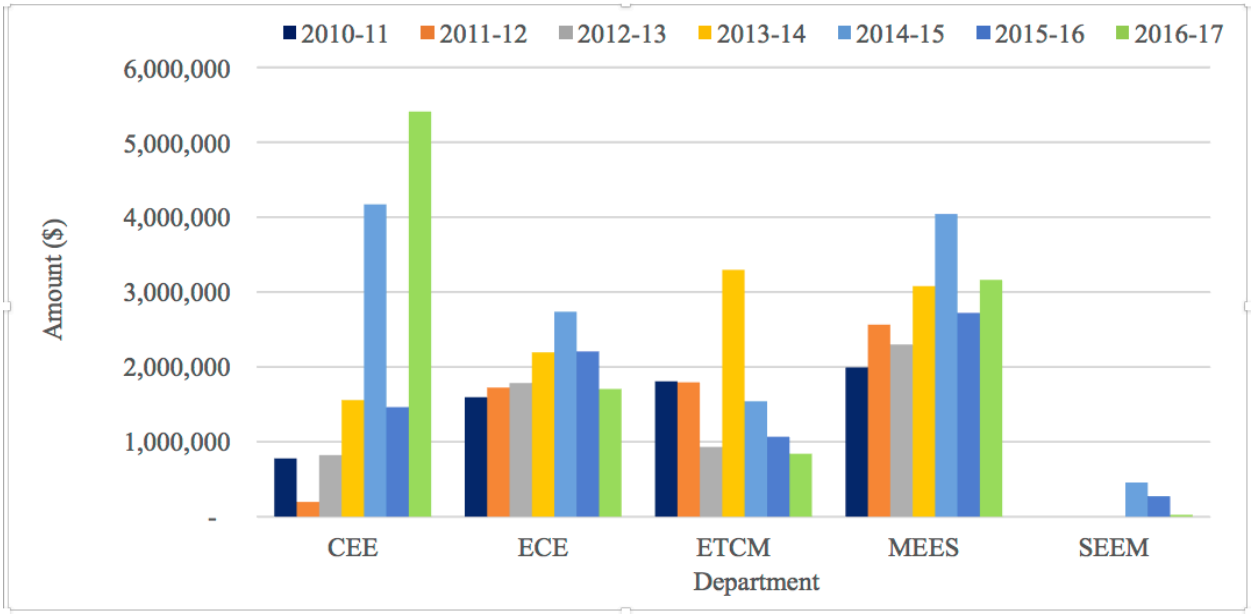


Figure 5: Recent research funding data of college of Engineering programs at UNC Charlotte

- *Growth in Non-Engineering Feeder Programs at UNC Charlotte*

In addition to the student demand growth in SEEM and ETCM, other non-engineering programs participating in the interdisciplinary INES Ph.D. have seen enrollment increases as well. This is principally attributable to deliberate outreach initiatives of the INES program director and to recent faculty hires at the Assistant Professor levels in Geography/Earth Science (GES) and Architecture. Furthermore, the INES strategic plan is to expand focus areas to include food-water-energy (FWE) nexus, environmental science, policy and management that will attract interest and participation of faculty from management, business/business information systems & operations management, economic, policy and sciences (biology, ecology and chemistry).

- *External Collaboration/Feeder Programs*:

The INES Ph.D. program has an active, long-term relationship with the China University of Mining and Technology (CUMT) in Ph.D. education. Several faculty at the China University are INES Ph.D. graduates. An outreach program is underway to grow this relationship further and to replicate/expand the success of CUMT/INES Ph.D. collaboration in other universities in China. In the USA, the INES Ph.D. program is also collaborating with the University of Illinois at Urbana-Champaign in the area of water-energy nexus and will expand the research to food-water-energy (FWE) nexus. The FWE nexus will draw faculty expertise from Geography and Earth Science

GES, Economics, Business and Management into INES. INES is also engaging other campuses in the UNC system and EPIC affiliates on renewable energy research and expects growth in student demand from this area.

Alignment with COE Programs

The proposed CE Ph.D. is consistent with the William States Lee College of Engineering (COE) vision of providing quality educational experiences and discovering and disseminating knowledge that serves the citizens and industries of local, national and international communities. The proposed program supports a College goal of meeting the Charlotte area's demand for a graduate program while assisting EPIC in creating a pipeline of specially trained civil engineers with knowledge of the energy industry.

The proposed Ph.D. in CE is also in the Department of Civil and Environmental Engineering 2015-2020 strategic plan as incorporated into the overall university strategic planning process and is endorsed by the Department and college industry advisory boards. It reflects a natural evolution to offer a complete set of degrees to the citizens in the Charlotte region and beyond.

With more than 20 years of participation in the inter-institutional Ph.D.[1] program with North Carolina State University (NCSU) and through 11 years of leading the interdisciplinary Infrastructure and Environmental Systems (INES) Ph.D. program at UNC Charlotte, the faculty of CEE have demonstrated the ability to build, support, enhance, lead, and sustain an interdisciplinary Ph.D. program that is relevant to local, regional, state, national and international students and employers.

Now is the time for the CEE Department to meet growing student and employer demand for a discipline-specific Ph.D. Program in Civil Engineering.

The proposed program will fulfill the state's mandate for EPIC to drive innovation within electrical, civil and mechanical engineering disciplines with new advancements in the energy fields while educating a new generation of engineering professionals. EPIC was designed to supply

[1]Details are available at https://studentservices.ncsu.edu/your-classes/exchange-programs/inter-institutional-program/

highly trained engineers and increase research capacity to meet the demands of the energy industry and regional economic development goals. Disciplines critical to the energy industry are electrical engineering (e.g., power generation) mechanical engineering (e.g., plant systems), and civil engineering (e.g., plant infrastructure). Currently, the university is able to meet the state mandate in two of these three fundamental engineering disciplines. All three levels (B.S., M.S., and Ph.D.) are vital for EPIC, industry, and the state to succeed. As shown in Figure 6, Electrical Engineering and Mechanical Engineering have had Ph.D. programs at UNC Charlotte since 1993. It is time for Civil Engineering to join them and complete this basic set of program offerings.

The proposed Ph.D. in Civil Engineering program will have a direct link with departments in the William States Lee College of Engineering. Courses and research will be held in classrooms, lecture halls, conference rooms and various research laboratories in the 200,000 ft^2 EPIC building. Among these are the High-Bay Structures Lab, Advanced Geosystems Lab, Geocentrifuge Laboratory, the Pavement Materials Performance Lab, Water Resources Research Lab, the Geosynthetics Research Lab, the Traffic Controls and Simulation Lab the Transportation Modeling Lab, Geo-environmental Labs, Air Quality Lab, Water Quality Labs, Wastewater Lab, Materials Characterization Lab, Remote Sensing Lab, and Failure Analysis Lab. Students in the proposed program will have opportunities to conduct research and participate in programs in university centers and institutes in addition to EPIC: Infrastructure Security and Emergency Responder Research and Training Facility (ISERRT), Infrastructure, Design, Environment and Sustainability Center (IDEAS), and Coal Ash and Liquids Management (CALM).

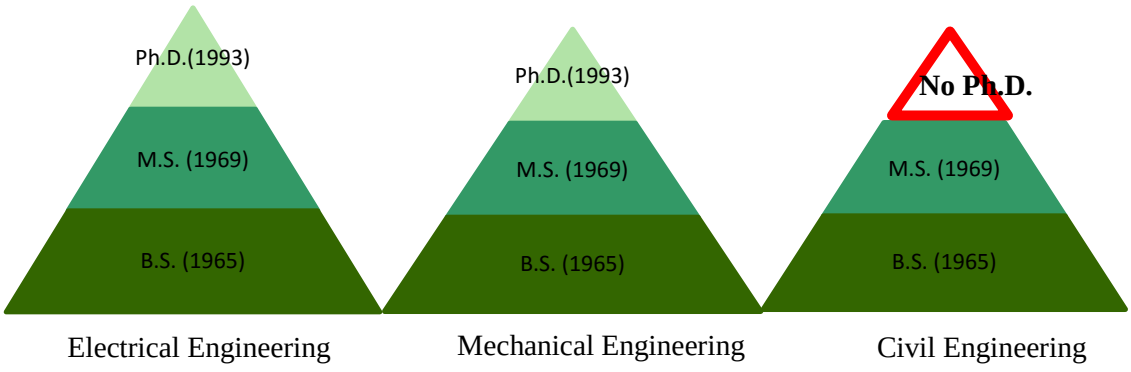


Figure 6. Comparison of Program Offerings (and year first offered) in Electrical and Mechanical Engineering at UNC Charlotte. Civil Engineering and the EPIC Program Remain Incomplete without a CE Ph.D. Program

City of Charlotte and Industry Alignment

UNC Charlotte is an urban research institution located in the largest commercial and industrial city in the Carolinas. In leveraging its geographical location in the state, UNC Charlotte has embarked in the implementation of institutional, human resources, instructional, and infrastructure improvement efforts to position it to serve as many as 35,000 undergraduate and graduate students by year 2020. UNC Charlotte accounts for 61% of the enrollment growth in the UNC system from the fall of 2009 to the fall of 2015.

In article published on August 19, 2015 in *Business Climate*, Kevin Litwin stated:

> *"With a powerful core of research, development and engineering assets, and a growing base of manufacturing related to everything from renewables to nuclear to fossil fuels, Charlotte USA has earned the title 'The New Energy Capital.' After all, more than 260 companies tied to the energy sector make their home in the region, employing 28,000 workers and drawing advanced manufacturing and research groups as part of the resources and expertise that fuel innovation"*

Also Rhonda Bishop, general manager of corporate services for Mitsubishi Nuclear Energy Services stated the motivation and the attraction to area as follows:

> *"Charlotte provides a great business climate and living environment for our employees."*

Of the 28,000 workers employed by the energy industry in Charlotte area, 11,000 are engineers, and the majority are UNC Charlotte alumni. The growth in this energy sector results in additional growth in other related sectors of the economy including infrastructure systems.

In an economic impact analysis study demonstrating the collective value of the UNC system, the return on investment findings by Economic Modeling Specialists International (EMSI) (2015) recognized UNC Charlotte for a 440% average return on investment for taxpayers, yielding a 5.4 benefit-cost ratio or $5.40 returned to the region for every dollar spent for the fiscal year 2012 - 2013. For the same period, start-up companies and UNC Charlotte alumni currently employed in

Charlotte region contributed $2.1 billion and $1.4 billion, respectively. Commenting on this study, the UNC Charlotte chancellor, Dr. Philip L. Dubois, states:

> *"UNC Charlotte provides an indispensable value to our region, higher education is a key economic driver in the Charlotte region, the UNC study affirms UNC Charlotte's economic value proposition and that more than ever, Charlotte-area businesses and industries look to the University for student and faculty talent and partnerships to drive innovation and help spur job growth".*

The university has strengthened its partnership with high-technology specialty and technology intensive industries including physical facility procurement companies (e.g., AECOM and AREVA), energy utilities (e.g., Duke Energy), manufacturing companies (e.g., Siemens and Westinghouse), design and construction management firms (e.g., CB&I), and research development and demonstration institutions (e.g., EPRI) in the Charlotte region. UNC Charlotte, through EPIC, has already invested heavily in infrastructure and research facilities to support the doctoral-level education and research in civil engineering. With a well-established engineering program, excellent research and instructional facilities, partnership with technology intensive industry employers and healthy return on investment, UNC Charlotte is a desirable, unique, and cost effective place to initiate the proposed Ph.D. in Civil Engineering program.

The need for a terminal degree in CE is also related to recent efforts by the American Society of Civil Engineering (ASCE), which is the primary professional organization for civil engineers and is supported by many employers in consulting, government and industry. Consistent with ASCE Policy 465[2], the master's degree in CE is emerging as the entry-level degree. A bachelor's degree is not enough for entry into the profession. As such, those seeking to distinguish themselves from entry-level status will be more likely to pursue a Ph.D. The market for jobs in industry will increase, even for Ph.D. graduates, especially given that the Bureau of Labor Statistics has forecasted the civil engineering job growth rate to be 20% over the coming decade, which is twice

[2] ASCE Policy 465, available at http://www.asce.org/issues-and-advocacy/public-policy/policy-statement-465---academic-prerequisites-for-licensure-and-professional-practice/

as much as the national average and four to five times that of any other engineering subdiscipline. According to the Science and Engineering Indicators, as published by the National Science Foundation, approximately 80% of Ph.D. graduates in engineering enter industry.

In the future, master's degrees will focus more on providing the required technical expertise primarily through coursework, and the proposed Ph.D. degree in CE will emphasize advanced studies and industry relevant research. Demand for Ph.D. graduates in CE is not limited to the research and development (R&D) industry, community colleges and universities, but also to filling the increasing demand of these graduates from CE consulting and contracting companies. An example of this is the support letter from Rich Keagy, a Vice President at AECOM who indicated:

> *"A Ph.D. is not just useful for a career in academia. AECOM is ranked number one among global design firms, and we need the expertise at all levels. While appropriately fewer in number as compared to BS and MS, we routinely hire employees with Ph.Ds.' in Civil Engineering, for example Dr. Kula Kulasingam who now serves as a senior lead geotechnical engineer here in Charlotte"*.

Worldwide, CE companies are changing their business models from providing a commodity service to providing innovative, system-wide solutions. These models require employees who have more advanced knowledge of their respective technical areas of CE.

Beyond the energy industry, civil engineering infrastructure represents the basis on which our everyday life, our community and business depends. It is fundamental to the economy and standard of living. The North Carolina Chamber reported (NC Chamber website, accessed October 2015) "*there are currently nine million people living in North Carolina. By 2030, the population is expected to grow to 12 million, making North Carolina the seventh most populated state in the nation.* In answering a question about NC's readiness, the Chamber said, "*it is necessary to look at our state's infrastructure and transportation systems and their vital roles in economic development, daily commerce and quality of life."*

In September, 2014, the U.S. Treasury Department reported (Expanding our Nation's Infrastructure through Innovative Financing) that *"President Barack Obama launched the Build America Investment Initiative to expand private investment and collaboration in major infrastructure sectors. The President recognizes that high quality and reliable infrastructure is essential to our economy and our quality of life. Our nation needs to continually modernize and maintain our infrastructure to make the United States an attractive place for businesses to operate and for people to live. If we fail to provide and maintain adequate infrastructure, the consequences will be severe."* And that sentiment is broadly shared with bipartisan support, e.g., consider the 2016 Connect NC Bond Referendum which calls for $2 billion in statewide investments in infrastructure.

Because of the importance of civil infrastructure and its impact on every aspect of people's lives, the American Society of Civil Engineers (ASCE) initiated a report card to grade the condition of the nation's physical facilities every four years. The report card is widely cited by the national press and various governments, and it presents a grim picture of continuing deterioration of our physical facilities (Table 1). The increasing occurrence and intensity of natural and human-induced extreme events accelerates the rate of deterioration of aging civil engineering infrastructure. In addition to the need for upgrading life-line infrastructure, there is the attendant need for specialized education and training. The production of Ph.D. level technical staff has not kept up with industry demand, as exacerbated by shifting demographics. For example, the EPRI/Carnegie Mellon Electricity Industry Center workshop on the Aging Workforce in Utility Industry, *"found that 80% of utility human resource executives rank the aging workforce as the number one concern*" (George, 2007). The utility industry, like operators of other critical facilities such as refineries, harbors, and specialized waste management systems, is confronting issues of aging workforce while dealing with deteriorating facility assets.

While the need for interdisciplinary knowledge has increased, discipline-specific training remains vital to ensure there is a supply of experts who can lead advanced design. These experts contribute to the development of standards and building/construction codes as well as forensic analysis. Great technical depth is needed for the design and analysis of critical components within engineering facilities. In trying to address the engineering and institutional failures responsible for the New

Orleans disaster following Hurricane Katrina and other recent infrastructure disasters, the ASCE Hurricane Katrina External Review Panel urged that:

> *"Organizations responsible for critical life-safety facilities be organized and operated to enable, not to inhibit, a focus on safety and that engineers continually evaluate the appropriateness of design criteria, always considering how the performance of individual components affects the overall performance of a system."* *(ASCE Hurricane Katrina External Review Panel, 2007)*

In this context, there is a need for professionals with advanced training in the discipline-specific fundamentals of civil engineering.

Table 1: ASCE Report Card of America's Infrastructure from 1988 - 2013

Category	1988*	1998	2001	2005	2009	2013
Aviation	B-	C-	D	D+	D	D
Bridges	-	C-	C	C	C	C+
Dams	-	D	D	D+	D	D
Drinking Water	B-	D	D	D-	D-	D
Energy	-	-	D+	D	D+	D+
Hazardous Waste	D	D-	D+	D	D	D
Inland Waterways	B-	-	D+	D-	D-	D-
Levees	-	-	-	-	D-	D-
Public Parks and Recreation	-	-	-	C-	C-	C-
Rail	-	-	-	C-	C-	C+
Roads	C+	D-	D+	D	D-	D
Schools	D	F	D-	D	D	D
Solid Waste	C-	C-	C+	C+	C+	B-
Transit	C-	C-	C-	D+	D	D
Wastewater	C	D+	D	D-	D-	D
Ports	-	-	-	-	-	C
America's Infrastructure GPA	C	D	D+	D	D	D+
Cost to Improve	-	-	$1.3 trillion	$1.6 trillion	$2.2 trillion	$3.6 trillion

**The first infrastructure grades were given by the National Council on Public Works Improvements in its report Fragile Foundations: A Report on America's Public Works, released in February 1988. ASCE's first Report Card for America's Infrastructure was issued a decade later.*

Each of the above types of infrastructure include components which require the expertise of specialized Ph.D. level civil engineers, and intersect with CEE Department faculty expertise as listed below:

- large-scale testing and validation of buildings, structural members/components and geostructures
- physical security of critical facilities
- structural health monitoring, diagnostics, and forensic engineering
- structural rehabilitation
- seismic performance analysis of structures
- advanced and innovative construction materials
- soil-structure interaction
- engineering and hydraulic properties of waste materials
- management of energy and industrial waste
- performance of waste containment systems
- innovative improvement techniques of geosystems
- multimodal transportation systems
- transportation systems planning, analysis, traffic safety, signal optimization and human factors
- intelligent transportation systems
- fuel consumption and vehicle emissions modeling
- modeling interaction between users and transportation infrastructure
- physical, chemical and biological treatment processes of water
- analysis, detection, and treatment of emerging contaminants in water
- water quality and watershed management.

Because of the need to continually predict and update performance assessments for infrastructure that is aging beyond its original service life, the demand for research engineers with advanced degrees will continue to grow.

c. What student-level educational objectives will be met by the proposed program?

The graduates of the Ph.D. in Civil Engineering program will have mastery and understanding of complex systems and critical infrastructure to make contributions to the advancement of knowledge. The program meets the documented growing demand from prospective students and employers within government, private industry and academia. The educational objectives designed to achieve these goals are:

- to prepare students for careers as doctoral-level research engineers, professional engineers, and scholars/academicians who will be leaders in developing the emerging critical infrastructure;
- to involve students in the support and expansion of the base of research in rapidly growing fields related to critical infrastructure in the Charlotte region, North Carolina, and across the nation and world;
- to enhance the educational experience in engineering for all students, graduate, and undergraduate, at a level consistent with North Carolina's EPIC mandate;
- to expand the educational experience of students by participating in the activities of our research initiatives at UNC Charlotte such as EPIC, Infrastructure Security and Emergency Responder Research and Training Facility (ISERRT), Infrastructure, Design, Environment and Sustainability (IDEAS) Center, and Coal Ash and Liquid Management Office (CALM); and
- to help prepare future educators, scholars, and professionals who are at the frontiers of understanding of critical infrastructure development.

Performance Metrics and Comparison with Departments at Peer Group Institutions

To provide context to the description and purpose of the proposed Ph.D. in Civil Engineering, Academic Analytics, LLC was contracted to perform an analysis of the Department's productivity. Two reports were generated, one which compares UNC Charlotte with 154 other similarly named departments and another with a peer group (Table 2). These reports are contained in Appendix 4. Of these two reports, the comparison with peer groups is most relevant. The peer group includes the following institutions:

Table 2: Peer Group Institutions

Institution	Civil Engineering Ph.D. Program in Place?
Portland State University	Yes
University of Toledo	Yes
University of Colorado Denver	Yes
University of Texas Arlington	Yes
Old Dominion University	Yes
University of New Mexico	Yes
Florida International University	Yes
University of Wisconsin – Milwaukee	Yes
University of Nevada, Las Vegas	Yes
University of Massachusetts Lowell	Yes
University of Texas at San Antonio	Yes
University of Rhode Island	Yes
University of Louisville	Yes
Western Michigan University	Yes
University of North Carolina Charlotte	**No**

Notwithstanding the current lack of a civil engineering Ph.D. program, faculty in the CEE Department faculty compare exceptionally well to the peer group. For example, the Department leads all other peer institutions (and most of the 154 departments nationwide) in terms of publication in conference proceedings. Specifically, relative to the peer group, the CEE Department at UNC Charlotte is above average relative to its peers in terms of scholarship, as shown in Table 3.

Table 3: Selected Scholarship Categories

Scholarship Category in which CEE Department at UNC Charlotte is <u>above average</u>

Number of faculty with a journal article
Total number of journal articles
Number of faculty with a citation
Conference proceedings per author
Number of conference proceedings per faculty
Number of faculty with a conference proceeding
Percent of faculty with a conference proceeding
Total conference proceedings

The CEE Department excels in applied research, precisely the type of research valued by the Energy Production and Infrastructure Center (EPIC), as supported by the State of North Carolina and firms in the private sector as demonstrated in the letters of support (e.g., Duke Energy, AECOM, GeoPier). This type of research lends itself to publication in conference proceedings at the high reported rate. This level of industry activity also leads to journal publications, as noted by our Department having an above average number of faculty with a journal article. The CEE Department is above average in the peer group relative to research grants/contracts, as shown below in Table 4.

Table 4: Selected Grants/Contracts Categories

Grants/Contracts Category in which CEE Department at UNC Charlotte is <u>above average</u>
Number of faculty with a grant
Percent of faculty with a grant
Total number of grants

The CEE Department is one of the most research intensive departments at UNC Charlotte. At one point this past year, the Department had the highest funding in the College of Engineering, despite other departments having a Ph.D. program. This funding supports master's and interdisciplinary Ph.D. students and derives from the Department's consistent generation of proposals. University tabulated data for awards and expenditures are provided below in Figure 7.

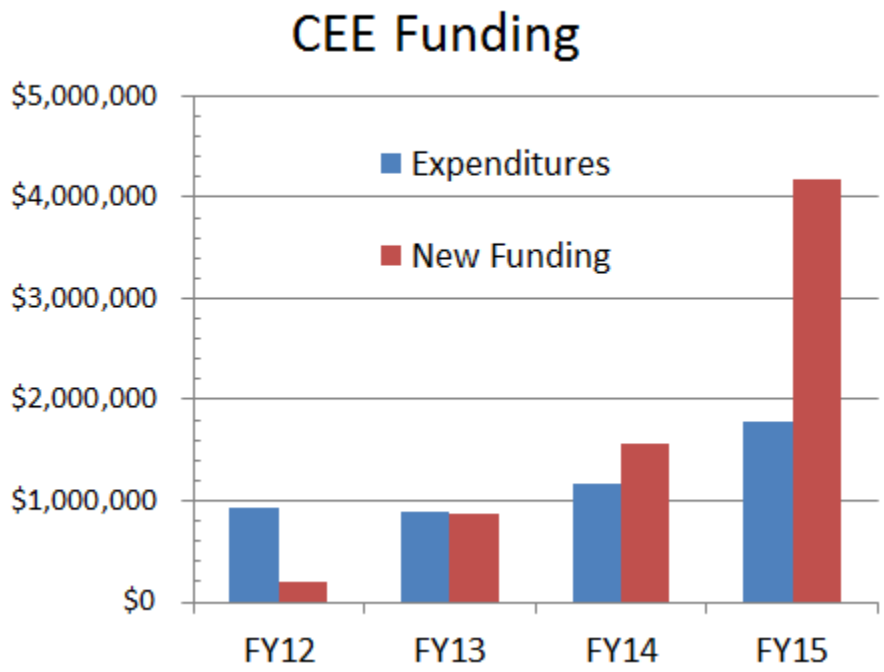


Figure 7. New Awards and Research Expenditures in the CEE Department at UNC Charlotte

Although not captured by Data Analytics LLC, the CEE Department also conducts an above average number of industry-sponsored contracts, as well as contracts by the U.S. Department of Transportation and North Carolina Department of Transportation. Omission of this data does not impact other schools the same way because the fraction of our research attributed to these sources is higher. Moreover, our faculty conduct extensive field-based research (e.g., instrumentation of a highway, bridge, or other large infrastructure). Such research is more time consuming (e.g., time between award, execution and publication) as compared to research relegated to a laboratory bench or computer workstation.

Scholarly Activity

As stated previously, all peer group institutions have a Ph.D. program in Civil Engineering. In spite of the fact that the CEE Department at UNC Charlotte does not have a Ph.D. program in Civil

Engineering, the CEE Department has performed well (above average) in terms of scholarly publications. These categories include the number of faculty with a journal article and a citation. The lack of performance in some categories pertaining to journal articles is attributed to the inability to attract more passionate and qualified Ph.D. students (who are more interested in Ph.D. in Civil Engineering program).

The CEE Department has done exceptionally well in terms of conference proceedings publications (Academic Analytics, LLC). We attribute this to the nature of grants / projects conducted by the CEE Department (sponsored by federal, state, regional and local agencies as well as the private sector). These grants/projects have an applied bent; their primary intent is to generate outputs that lead to implementable outcomes. For this work, our faculty identify outlets (conference proceedings) that are more readily accessible to the public and private sector (than journals). This is also correlated to faculty involvement in professional committees of various organizations.

Grants and Awards

In the area of grants and awards, UNC Charlotte faculty in CEE compare favorably to departments in our peer group in terms of number of faculty members with grants. The difference UNC Charlotte and our peers in terms of dollar amount either per grant, per faculty or total grant dollars in the Academic Analytics Report, is attributable to several factors: the report does not capture funding provided to the CEE department by state, regional and local agencies, or the private sector. Funding from these sources is disproportionately higher at UNC Charlotte compared to peer institutions. The CEE department's emphasis on applied and field-related research is also related to the absence of a Ph.D. program.

The number of honorific awards credited to faculty of the CEE department at UNC Charlotte is below the average of the peer group. This is to be expected for a department whose research programs are relatively young. Honorific awards are more likely to accrue in departments which have had active research program for much longer. Nevertheless, the CEE Department at UNC Charlotte compares favorably in this category relative to several other established programs.

We anticipate that the addition of a Ph.D. program in Civil Engineering would lead to an increase in the number and size of grants, faculty awards, and journal articles published while sustaining or improving the number of conference proceedings published.

Summary Rationale for CE Ph.D. at UNC Charlotte

The recent Carnegie Classification of UNC Charlotte as a doctoral-granting institution with high research activity shows our university's growth as a public research university and reinforces our institution's role as North Carolina's urban research university. A Ph.D. in Civil Engineering will advance the university's mission by:

- Meeting employer and student demand.
- Improving the quality of existing programs by enhancing the recruitment and retention of excellent faculty.
- Supporting economic development goals for Charlotte and the State of North Carolina with faculty who can secure external funding and lead research and development activities.
- Addressing the incomplete offerings in basic engineering disciplines for a university in North Carolina's largest city
- Increasing research funding and providing greater access to graduate education.
- Leveraging the use of state funded facilities (e.g., 7,500 ft^2 environmental lab, three-story high bay).
- Supporting the mission of the state-funded Energy Production and Infrastructure Center.
- Addressing aging U.S. and North Carolina infrastructure with discipline-specific expertise.
- Steming the documented loss from Charlotte of students who want a disciplinary degree in civil engineering.

The rationale for the proposed program is supported by industry advisory boards and reports by Academic Analytics and Hanover Research (Appendix 4).

3. <u>Student Demand.</u> Provide documentation of student demand. Discuss the extent to which students will be drawn from a pool of students not previously served by the institution.

Student demand was evaluated by an external consultant (Hanover Research) as well as through a survey of likely students. As noted in Appendix 4, student demand for civil engineering Ph.D.s is increasing. International students represent a key audience, with enrollment having increased 11.5% nationwide between 2009 and 2014. Student demand is particularly strong and growing for the transportation specialization. Overall, doctoral enrollments in civil engineering fields increased between 2011 and 2015. The demand for civil/environmental engineering expertise experienced a 16.2 percent average annual growth during this period.

Student demand for a Ph.D. in Civil Engineering at UNC Charlotte was also assessed by surveying a pool of likely candidates in the summer of 2015. The survey consisted of asking a set of questions to the students representing a diverse pool.

A survey invitation was sent to the following potential students:

- Graduating seniors currently enrolled in the CEE Department;
- Alumni who have received a bachelor's degree in Civil Engineering within the last ten years; and
- Alumni who have received a master's degree in Civil Engineering within the last ten years.

The combined survey results for all survey participants (527 surveyed, 57 responded) are presented in Table 5. The survey results indicate that more than 90% of the respondents favor of offering a Ph.D. in Civil Engineering program at the UNC Charlotte. Because of the lack of such a degree offered within a distance of 150 miles from Charlotte, some of these students are seeking out Ph.D. degrees in other universities and some are pursuing the multi-disciplinary Ph.D. offered via the INES program. The survey results show that this Ph.D. program has a good pool of potential students for recruitment and the students will welcome the opportunity to pursue the Ph.D. in Civil Engineering at UNC Charlotte.

Table 5: The Aggregated Survey Results for All Survey Participants (n = 57)

Survey Question	Responses in Favor of Ph.D. Degree in CE	Responses neutral or not in favor of Ph.D. Degree in CE
Currently, the Department of Civil and Environmental Engineering at UNC Charlotte offers BS and MS. Should it offer Ph.D. as well?	94%	6%
Are you interested in pursuing a Ph.D. in Civil Engineering? (Yes or No)	39%	61%
If you are or if you were interested in pursuing a Ph.D. in Civil Engineering, would you consider UNC Charlotte? (Yes or No)	90%	10%

Students who seek the Ph.D. in Civil Engineering are simply lost to the institution. They do not enroll because the degree they seek is unavailable at UNC Charlotte. Several students who are not currently associated with UNC Charlotte and are interested in pursuing Ph.D. in Civil Engineering at UNC Charlotte have contacted current faculty and our graduate coordinator to explore such opportunities. Prospective students are frustrated by the absence of a basic Ph.D. program in civil engineering, with representative communication presented in Appendix 1. Former and current B.S. and M.S. students of UNC Charlotte who are interested in a Ph.D. in CE add to the pool of those not served.

4. Societal demand

As noted in the Market Analysis prepared by Hanover Research (Appendix 4), demand for a civil engineering Ph.D. is broadly framed by the nexus of infrastructure and the economy. In particular, Hanover Research cites data from the American Society of Civil Engineers in asserting that "The

United States needs to invest $1.4 trillion in infrastructure between 2016 and 2025 and $5.2 trillion by 2040; without such investments, the U.S. economy could lose almost $4 trillion and 2.5 million jobs by 2025 and $14.2 trillion and 5.8 million jobs by 2040 due to lost productivity. As a result, future federal, state, and local investments to repair and enhance ailing infrastructure may drive demand for civil engineers." This demand is met in other states, and as Hanover Research observes, Civil Engineering Ph.D. programs are common in states similar in size to North Carolina. North Carolina ranks last in terms of Civil Engineering Ph.D. programs relative the population (see Tables 8-9),. Likewise, Charlotte is the 17th largest city in the U.S. and is the only one in the top 33 by population without a Civil Engineering Ph.D. The closest program is 100 miles away at the University of South Carolina in Columbia, South Carolina.

a. Labor market information (projections, job posting analyses, and wages)

i. Specific to North Carolina

The state of North Carolina ranks 29th in land area, with an estimated 48,618 square miles and population of 9,953,687, making it the 9th largest states in the U.S. According to NCWorks (www.ncworks.gov)[3], the occupational profile of North Carolina indicates that the 2015 estimated median annual wage of Civil Engineers is $72,920. There are over 3,000 employers that hire Civil Engineers in the state of North Carolina. Although no specific labor market data is available in NCWorks for graduates with a CE Ph.D., the projected annual openings for civil engineers at all degree levels is estimated as 409. The number of job openings advertised online in North Carolina for Civil Engineers at all degree levels in March 2016 was 380. CE Ph.D.s are regularly hired by industry (e.g., attached support letter from AECOM) and they represent a viable fraction of these overall numbers, easily 10% or approximately 40 positions per year. Also, these general numbers are indicative of the demand for the CE Ph.D. in terms of the continued need for faculty (with a CE Ph.D.) to educate those pursuing a bachelors or masters.

As of April 13, 2016, there are 226 general civil engineering jobs openings posted with only 58 potential candidates in the workforce looking for jobs. Similarly, for the related environmental engineering occupation, 69 projected annual openings are anticipated. There are 18 jobs openings

[3] https://www.ncworks.gov/vosnet/Default.aspx (accessed on April 14, 2016)

presently posted with equal 18 potential candidates in the workforce looking for job. The 2015 median annual estimated wages for environmental engineers were $72,910. The long term projections for civil engineers in North Carolina indicate that there would be a need for an additional 2,000+ civil engineers by 2022 (www.ncworks.gov). More than 50% of these openings would be due to growth in the civil engineering sector. The state's market analysis projects the highest career prospects based on wages, projected growth rate and projected job openings in NC. Civil engineering occupations are assigned 5 star ratings by the new NC Star Jobs[4] rating program, indicating high demand and career prospects.

ii. Based on national occupational and industry projections

The Bureau of Labor Statistics has forecasted the civil engineering job growth rate to be 20% over the coming decade (Job outlook, 2014 – 2024), which is faster than the national average for all occupations and two to three times that of any other engineering subdiscipline. As of May 2015, the national estimates of employment and mean wage of civil engineers are 275,210 and $87,940, respectively. About 1.8% of total employment in the U.S. pertains to Architecture and Engineering. For Charlotte, 1.5% of total employment is within Architecture and Engineering. The Bureau of Labor Statistics (www.bls.gov) projects that both professional and business services and educational services will see a 0.9% growth over the next decade. The educational services industry (community colleges, colleges, universities and professional schools) as well as management, scientific and technical consulting services are the two industry groups that will experience the largest growth in wage and salary.

b. Projections from professional associations or industry reports

NSF Science and Engineering (S&E) Indicators (NSF, 2014) shows that the scientists and engineers in the workforce with S&E doctorates are more evenly distributed between the

[4] http://nccareers.org/starjobs/star_jobs.html (accessed on April 14, 2016). Star ratings are assigned based on wages, projected growth rate, and projected job openings, and each occupation has a rating of between 1 and 5 stars. Occupations with 5 stars are considered to have much better career prospects than occupations with fewer stars.

business/industry sector (46%) and the education sector (45%). For engineering this is tilted in favor of business/industry (80%). This is consistent with representative support letters from the EPIC advisory board, AECOM and GEOPIER, as provided in Appendix 2. Moreover, with more than 250 regional energy corporations located near UNC Charlotte, the demand for highly specialized engineers with expertise in all related subdisciplines of traditional civil engineering will continue to rise given the aging workforce in the sector. A high percentage of our graduates will be employed by many of these high-technology specialty and technology intensive companies (e.g., AECOM and AREVA), energy utilities (e.g., Duke Energy), design and construction management firms (e.g., CB&I), and Research Development & Demonstration institutions (e.g., EPRI) in the Charlotte region. For example, AECOM, ranked number one among global design firms, indicated the need for expertise at all levels, as noted in their letter of support (Appendix 2).

Within the education sector, there are employment opportunities for graduates in four year institutions, as well as emerging employment opportunities in two-year Associate Engineering (AE) programs in North Carolina. Specifically, there is anticipated need for engineering instructors and faculty at North Carolina community colleges with the new Uniform Articulation Agreement between Associate in Engineering Programs and Baccalaureate Engineering Programs that allows students to begin engineering studies at any North Carolina community college (Appendix 3). Twenty North Carolina community colleges have been approved to offer AE programs (Appendix 3). Considering the 20% job growth forecasted by the U.S. Bureau of Labor Statistics for civil engineering graduates through 2022, (nearly double the national average of all occupations and four times higher than any other engineering discipline), corresponding demand for faculty is forecasted in 4-year institutions and particularly in these newly established two-year programs. A conservative faculty demand of 3 – 4 per AE program for the civil engineering option will result in need for 60-80 new civil engineering faculty/instructors in the next 5 -7 years.

The December 2015 issue of AcademicKeys' eFlier for Engineering[5] features 88 faculty openings, 14 senior administrative positions and 7 post-doctoral opportunities in civil engineering related disciplines. A majority of these positions are for entry-level Ph.D. graduates with background in the traditional civil engineering areas. At the time of this writing, both NC State and UNC Charlotte have advertised and are looking at hiring new faculty in the civil engineering disciplines. As stated previously, 298 job openings for civil engineers were advertised online in North Carolina in November 2015.

c. Other (alumni surveys, insights from existing programs, etc.)

Evidence indicates that the nine-month salary range for CE Ph.D. graduates hired as faculty is $85,000 to $95,000, up from $65,000-$75,000 a decade ago. This is well supported by the National Association of Colleges and Employers (NACE) published report which indicates that the 2016 projected average salaries for engineering students with doctoral degrees is $95,055[6].

Some relevant insights were also obtained from the recent survey of the INES Ph.D. graduates with civil and environmental engineering (CEE) background. The data shows that the INES Ph.D. graduates with CEE background are distributed among education sector (43%), business/industry sector (30%), research and development institution sector (3%), and government/regulatory sector (3%) (Figure 8). Of the 23 respondents, 78% of all of them are currently employed in US, including 35% employed in the NC.

[5] https://engineering.academickeys.com/all/landing_client.php

[6] http://www.naceweb.org/s02102016/technical-majors-advanced-degree-grads-class-of-2016.aspx?terms=phd%20OR%20salary

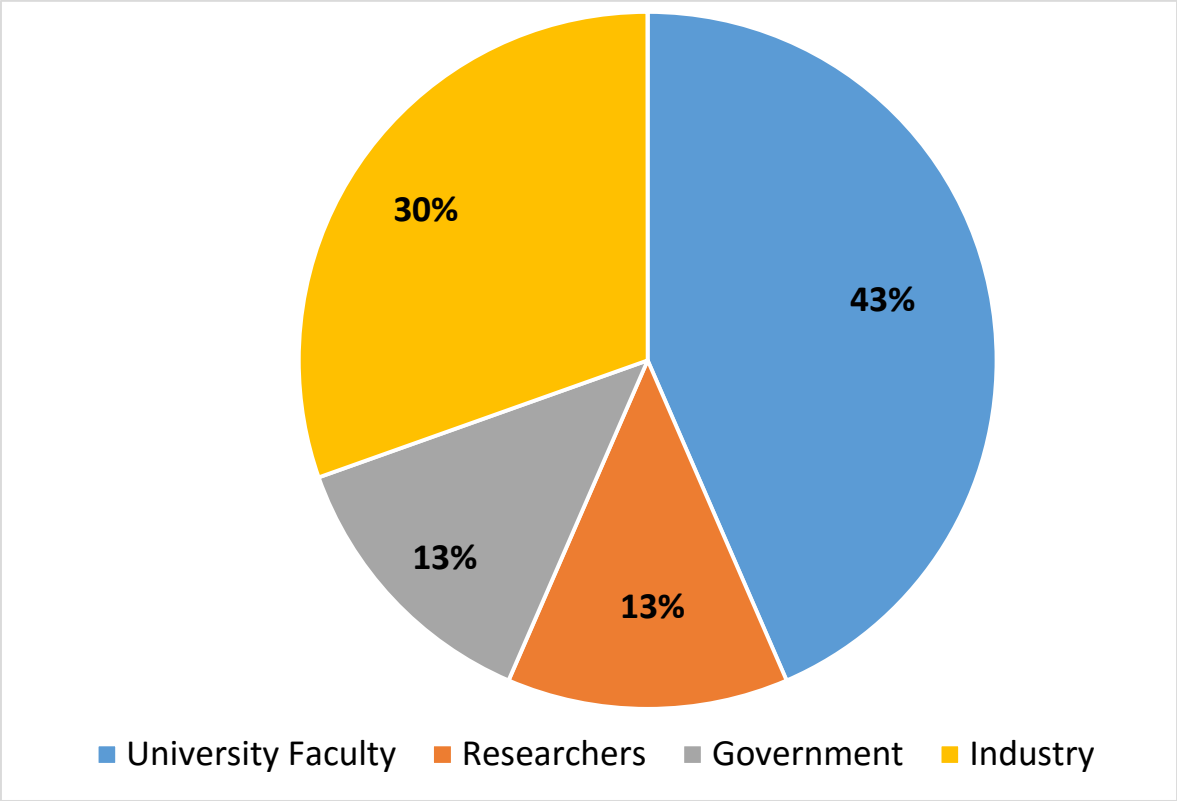


Figure 8: Distribution of INES Ph.D. Program Graduates with CEE Background in Employment Sectors (n = 23)

5. <u>Unnecessary duplication</u>.

a. **Show a four-year history of enrollments and degrees awarded in similar programs offered at other UNC institutions.**

There are only two other institutions of higher education (one public and one private) in North Carolina that offer similar Ph.D. in Civil Engineering programs – Duke University and North Carolina State University (NCSU). These two existing Ph.D. programs in Civil Engineering have excellent reputations with nationally known faculty, and a history of producing professionals that have made an impact in North Carolina, nationally, and internationally. Furthermore, these are mature and well-established programs. It is unlikely that their enrollment or funding will be affected significantly by the proposed CE Ph.D. program. The enrollment and graduation data of these two Ph.D. programs are summarized in Tables 6 and 7 below.

Table 6: Enrollment Data and Ph.D. Degrees Conferred at North Carolina State University at Raleigh, NC

Institution: **North Carolina State University at Raleigh, NC (Public)**

Program Title: **Ph.D. in Civil Engineering**

	2010-11	2011-12	2012-13	2013-14
Enrollment	95	111	110	110
Degrees-awarded	14	19	19	19

Source: NCSU OIRP (http://oirp.ncsu.edu/ir/) accessed in June 2015

Table 7: Enrollment Data and Ph.D. Degrees Conferred at Duke University at Durham, NC (Private), NC

Institution: **Duke University at Durham, NC (Private)**

Program Title: **Ph.D. in Civil and Environmental Engineering**

	2010-11	2011-12	2012-13	2013-14
Enrollment	50	49	52	50
Degrees-awarded	8	6	6	11

Source: Duke U. (http://gradschool.duke.edu/about/statistics) accessed in July 2015

- **North Carolina State University at Raleigh, NC (Public)** – Ph.D. in Civil Engineering granted its first degree in 1962 and currently confers about 19 CE Ph.D. degrees per year. It is located about 180 miles from UNC Charlotte. Mode of delivery: traditional (face-to-face) in class instruction.
- **Duke University at Durham, NC (Private)** – Ph.D. Civil and Environmental Engineering established in 1964 and currently confers about 11 CEE Ph.D. degrees per year. It is located about 130 miles from UNC Charlotte. Mode of delivery: traditional (face-to-face) in class instruction.

b. Identify opportunities for collaboration with institutions offering related degrees and discuss what steps have been or will be taken to actively pursue those opportunities where appropriate and advantageous.

During the National Civil Engineering Department Heads meeting held on May 18 - 20, 2015 at Blacksburg, VA, Prof. John Daniels (Chair, CEE at UNC Charlotte) met and discussed with Prof. Rudolf (Rudi) Seracino (Associate Head for Undergraduate Programs at the Department of Civil, Construction, and Environmental Engineering [CCEE], NCSU) our civil engineering program, research facilities at EPIC, and the request to plan the Ph.D. in Civil Engineering program. During September 2015, Drs. Brett Tempest and Youngjin Park traveled to Raleigh to meet NCSU personnel involved in large scale structural testing. The capabilities of the structural testing facilities at NCSU are complementary to UNC Charlotte. And there are common issues, namely safety for students, faculty and staff. Our researchers maintain open communication to ensure best practices at both institutions and to ensure that as UNC System institutions, we are responsive to state needs. Dr. Daniels has also informed Dr. Mort Barlaz, Head of CCEE at NCSU about this proposed plan during the summer of 2015.

UNC Charlotte has long collaborated with NCSU, and especially through the historical interinstitutional Ph.D. program, from which several of our current and emeritus faculty have graduated. This was a valuable program while UNC Charlotte was transitioning to a research intensive institution. Through this program, CEE faculty at UNC Charlotte demonstrated the ability to advise and successfully graduate Ph.D. students. A recent example of partnership between the Department of Civil, Construction, and Environmental Engineering at NCSU and the Department of Civil and Environmental Engineering at UNC Charlotte is given by the letter of collaboration for NSF funding, as attached in Appendix 2. In terms of current research, Prof. Nagui Rouphail, Director of Institute for Transportation Research and Education (ITRE) and Professor at NCSU, is collaborating with UNC Charlotte CEE faculty Prof. Wei Fan, one of our transportation engineering faculty, on an ongoing NCDOT research project titled “Developing a Systematic Approach to Improving Bottleneck Analysis in North Carolina.” Several other faculty members from our environmental engineering area including Professors Jy Wu, Jim Bowen, and Helene Hilger (emerita) have had partnerships with faculty members at NCSU.

Similarly, Dr. Daniels contacted Professor Mark Wiesner, Head of the Civil and Environmental Engineering Department at Duke University. He expresses confidence in his program as well the benefits that can accrue to our state with the increased intellectual vitality of an additional Ph.D.

program at UNC Charlotte. A letter from Duke University in support of UNC Charlotte's request to plan the CE Ph.D. program is attached (Appendix 2).

c. Present documentation that establishment of this program would not create unnecessary program duplication.

North Carolina has very few programs when compared to other states of similar size and population. It is below average in comparison to the U.S. average and below most states.

According to the United States Census Bureau, the population of North Carolina during 2014 is estimated equal at 9,953,687 (census.gov). It currently ranks 9th in the U.S. in terms of total population. About 27% of the North Carolina population has a bachelor's or higher degree. With Charlotte and Raleigh projected as the two of the fastest growing metropolitan areas in the U.S. because of attractive livable communities and amicable weather conditions, the population of NC is expected to grow further in the coming decades. Appropriately, the proposed Ph.D. program will be housed at UNC Charlotte while the only current public Ph.D. program offered in NC is at NCSU in Raleigh.

With this projected population growth in NC and the Charlotte metro area, and the demand from both students and employers, the number of CE Ph.D. programs per population and per population area for selected states in the United States are shown and compared with North Carolina in Table 8. Most of the selected states have a total population less than the state of North Carolina. A majority of the selected states have at least two CE Ph.D. programs, while six of them have three or more Ph.D. programs. The number of CE Ph.D. programs per population and per population areas is lowest for North Carolina amongst the selected states. The computed rate for North Carolina is also lower than for the United States (126 CE/CEE Ph.D. programs offered nationally, as per American Society of Engineering Education website).

Table 9 summarizes the number of CE Ph.D. programs per employed civilians and per professional and related occupations for the same states shown in Table 8. The rates related to employed civilians and per professional and related occupations are lower for North Carolina than any other state.

Table 8. CE/CEE Ph.D. Program by Population - North Carolina Compared to Selected States

State	Population (in 1,000s)	Population per Square Mile	# Ph.D. Programs	# of Ph.D. Programs per Million Population
	2010	2010	2014	2015
United States	**308,746**	**87.4**	**126**	**0.41**
Wyoming	564	5.8	1	1.77
New Hampshire	1,316	147.0	1	0.76
Idaho	1,568	19.0	1	0.64
New Mexico	2,059	17.0	2	0.97
Nevada	2,701	24.6	2	0.74
Utah	2,764	33.6	2	0.72
Kansas	2,853	34.9	2	0.70
Iowa	3,046	54.5	2	0.66
Oregon	3,831	39.9	2	0.52
Kentucky	4,339	109.9	2	0.46
South Carolina	4,625	153.9	2	0.43
Alabama	4,780	94.4	4	0.84
Colorado	5,029	48.5	3	0.60
Massachusetts	6,548	839.4	6	0.92
Virginia	8,001	202.6	4	0.50
North Carolina	9,535	196.1	2	0.21
Michigan	9,884	174.8	4	0.40

Table 10 summarizes metropolitan statistical areas similar or smaller in size than Charlotte, North Carolina. All of these metropolitan statistical areas have at least one CE Ph.D. program with the exception of Charlotte, North Carolina.

Table 9. CE/CEE Ph.D. Program per Employed Civilians and Professional and Related Occupations - North Carolina Compared to Selected States

State	Total Employed Civilians (in 1,000s)	Professional and Related Occupations (in 1,000s)	# Ph.D. Programs	# Ph.D. Programs per Million Employed Civilians	# Ph.D. Programs per Million Professional and Related Occupations
United States	**139,064**	**30,805**	**126**	0.91	4.09
Wyoming	278	52	1	3.60	19.23
Idaho	691	125	1	1.45	8.00
New Hampshire	702	177	1	1.42	5.65
New Mexico	843	203	2	2.37	9.85
Nevada	1,131	183	2	1.77	10.93
Utah	1,271	264	2	1.57	7.58
Kansas	1,385	308	2	1.44	6.49
Iowa	1,571	309	2	1.27	6.47
Oregon	1,780	390	2	1.12	5.13
Kentucky	1,844	396	2	1.08	5.05
South Carolina	1,899	393	2	1.05	5.09
Alabama	1,952	408	4	2.05	9.80
Colorado	2,482	623	3	1.21	4.82
Massachusetts	3,194	875	6	1.88	6.86
Virginia	3,800	968	4	1.05	4.13
North Carolina	4,094	958	2	0.49	2.09
Michigan	4,232	1006	4	0.95	3.98

Table 10. Regional Populations Compared to CE/CEE Ph.D. Programs – Charlotte Region Compared to Selected Urban Areas

Metropolitan statistical area	Population 2010	# Ph.D. Programs	# of Ph.D. Programs per Million Population
Huntsville, AL	417,593	1	2.39
El Paso, TX	800,647	1	1.25
Salt Lake City, UT	1,124,197	1	0.89
Birmingham-Hoover, AL	1,128,047	1	0.89
Raleigh-Cary, NC	1,130,490	2	1.77
Buffalo-Niagara Falls, NY	1,135,509	1	0.88
Oklahoma City, OK	1,252,987	1	0.80
Virginia Beach-Norfolk-Newport News, VA-NC	1,671,683	1	0.60
Austin-Round Rock-San Marcos, TX	1,716,289	1	0.58
Indianapolis-Carmel, IN	1,756,241	1	0.57
Charlotte-Gastonia-Rock Hill, NC-SC	1,758,038	0	0.00
Las Vegas-Paradise, NV	1,951,269	1	0.51
Portland-Vancouver-Hillsboro, OR-WA	2,226,009	1	0.45

The two similar Ph.D. programs in North Carolina (at NCSU and Duke University) have been conferring degrees since the early 1960's.

By way comparison, the CEE Department at Duke University has 18 tenured and tenure-track faculty, 2 professors of practice, and 1 instructor (total equivalent to 21 faculty). With this size on average, annually they confer about 14, 9 and 10 BS, MS and Ph.D. degrees, respectively, per year in Civil Engineering. The CEE Department at Duke is ranked #37 among civil engineering graduate programs by U.S. News & World Report 2015 and #40 among CEE doctoral programs by the National Research Council (NAS, 2011). In FY 2014 the total of new research awards in this Department was $8.57 million.

The Department of Civil, Construction, and Environmental Engineering (CCEE) at North Carolina State University has 49 faculty, 768 undergraduate students, and 339 graduate students. On average, they confer about 125, 90 and 18 BS, MS and Ph.D. degrees, respectively, per year in Civil Engineering. The CCEE Department at NCSU is ranked #31 among civil engineering graduate programs by U.S. News & World Report 2015 and #12 among CEE doctoral programs by the National Research Council (NAS, 2011). This Department in FY 2014 reported $17.6 million in research expenditures.

By comparison, the CEE Department at UNC Charlotte has 22 faculty, and this reflects recent growth. As recent as five years ago, the CEE Department had 18 faculty, or approximately 1/3 the size of NCSU. The CEE Department at UNC Charlotte has 419 undergraduate students and 79 graduate students. Research expenditures in 2015 were $1.8 million, with $4.2 million in new awards. In comparison to the civil engineering research programs at Duke and NCSU, a higher percentage of research activity at UNC Charlotte is funded by private sector / industry sources.

Both NCSU and Duke University produce doctoral graduates whose employment objectives are focused on faculty positions at national and international research universities. We anticipate that our doctoral graduates will be employed by a wide range of employers including industry,

academic institutions, community colleges, and research and development institutes/agencies. There is demand from both students and employers. The tables above indicate that having a CE Ph.D. program at UNC Charlotte would benefit the state as well as the Charlotte region.

6. **Enrollment. Estimate the total number of students that would be enrolled in the program during the first year of operation and in each delivery mode (campus, online, site – add lines as needed):**

Delivery Mode_campus__ Full-Time __6 - 8_____ Part-Time ___None_____

Estimate the total number of students that would be enrolled in the program during the fourth year of operation and in each delivery mode (campus, online, site – add lines as needed):

Delivery Mode_campus__ Full-Time __24 - 28_____ Part-Time ___2 - 4_____

a. **Enrollment data from similar programs in UNC, the state, or country**.

The enrollment data from similar programs in the UNC system and North Carolina are provided in section 5 (a) of this proposal. Please refer to Tables 6 & 7 for enrollment data in NC State University (similar program in UNC system) and Duke University (the only other similar Ph.D. program in the state), respectively.

Enrollment and award data from some UNC Charlotte peer universities across the US in similar Ph.D. degree programs are presented below in Table 11. Among our peer universities, the steady-state enrollment data range from a high of 74 to a low 9 students. The mean enrollment data among our peer universities is 31 students.

Table 11: Enrollment and Award Data in CE/CEE Ph.D. Degree Programs from Selected Peer Universities across the U.S.

Florida International University	**Year**	**2011-12**	**2012-13**	**2013-14**	**2014-15**
	# Enrolled	54	61	71	74
	# Awarded	7	9	8	11
University of Colorado at Denver	**Year**	**2011-12**	**2012-13**	**2013-14**	**2014-15**
	# Enrolled	28	28	19	15
	# Awarded	2	7	5	9
University of Louisville	**Year**	**2009-10**	**2010-11**	**2011-12**	**2012-13**
	# Enrolled	20	30	39	27
	# Awarded	1	1	2	0
University of Massachusetts at Lowell	**Year**	**2009-10**	**2010-11**	**2011-12**	**2012-13**
	# Enrolled	2	6	9	9
	# Awarded	1	0	0	0
University of Nevada at Las Vegas	**Year**	**2011 -12**	**2012-13**	**2013-14**	**2014-15**
	# Enrolled	34	40	42	31
	# Awarded	2	2	3	9

b. Conclusions:

The proposed plan is to admit between 6 – 8 students per year including up to 4 part-time students by year 4. Several technology intensive energy and allied companies (such as Duke Energy, EPRI, AREVA, CB&I, AECOM) are located in Charlotte region. It is estimated that a few of the full time engineers will be interested to enroll as part-time Ph.D. students in Civil Engineering. However, the candidates enrolled in the program during its first year will be required to maintain full-time residency. Considering an average of 4 years for a full-time student with a master's degree in Civil Engineering to complete the Ph.D. program, the expected steady-state enrollment will be an average of approximately 24 - 28 students. In ten years this number will approach 50, similar to the trajectory of the INES Ph.D. program. It is estimated that at any one point, there will be about 8-10 ongoing dissertations. The numbers of enrolled Ph.D. students per CE faculty member at Duke and NCSU are 2.33 and 2.29, respectively. Since our teaching load is comparably high and our research infrastructure and state/endowed support is relatively less compared to NCSU and Duke, and in consideration our continuing engagement in INES Ph.D. program, the number of enrolled CE Ph.D. students is expected to be about 1 per CE faculty member.

According to the ASEE, 2014 data, there are 126 CE/CEE Ph.D. programs in the U.S. The enrollment numbers in these programs average between 45 – 50 students per program. Many large programs such Georgia Tech, University of Illinois Urbana-Champaign, University of Texas at Austin, Virginia Tech and NC State University have enrollment figures exceeding double the national average (example NCSU has 110 enrolled students in 2014). Based on our projection of expected enrollment of 1 student per CE faculty, and with 22 full-time research faculty, our enrollment data would average about 22 students. This projected enrollment data matches reasonably well with the state-state enrollment data analysis from CE/CEE Ph.D. degree programs of some peer universities across the U.S. (Table 6). The average enrollment data among these peer universities is 30 - 31 students.

7. <u>Resources</u>. Will any of the resources listed below be required to deliver this program? (If yes, please briefly explain in the space below each item, state the estimated new dollars required at steady state after four years, and state the source of the new funding and resources required.)

a. New Faculty: Yes_____ No __X___

b. Faculty Program Coordination: Yes _____ No __X___

c. Additional Library Resources: Yes _____ No __X___

d. Additional Facilities and Equipment: Yes _____ No __X___

e. Additional Other Program Support: Yes _____ No _X____
(for example, additional administrative staff, new Master's program graduate student assistantships, etc.)

‘

SUMMARY OF ESTIMATED ADDITIONAL COSTS FOR PROPOSED PROGRAM

INSTITUTION	***UNC Charlotte***
Degree(s) to be Granted	***Ph.D. in Civil Engineering***
Differential tuition requested per student per academic year	***$0***

PROJECTED ENROLLMENT

	Year 1	Year 2	Year 3	Year 4
Projected Full Time Student (1.0 FTE)	8	15	21	28
Projected Part Time Student (0.5 FTE)		1	2	3
Projected annual FTE Students	8	15.5	22	29.5
Projected annual differential tuition	**$ 0**	**$ 0**	**$ 0**	**$ 0**

PROPOSED BUDGET OF ADDITIONAL COST

	Year 1	Year 2	Year 3	Year 4
Six (6) Teaching Assistantships (TAs) @ $14,000/9-month	$84,000	$84,000	$84,000	$84,000
*In-state tuition, fees and health insurance @$9,278/year (for both TAs and externally funded RAs)	$37,112	$64,946	$92,780	$111,336
*Out of state tuition, fees and health insurance @$22,448/year (for both TAs and externally funded RAs)	$89,792	$179,584	$246,928	$359,168
Total Additional Costs**	**$ 210,904**	**$ 328,530**	**$ 423,708**	**$ 554,504**
*Number of students based on Projected Full Time Students	4 in state 4 out-of-state	7 in state 8 out-of-state	10 in state 11 out-of-state	12 in state 16 out-of-state

****Full Tuition waiver required for all students enrolled in the program in form of The Graduate Assistant Support Plan (GASP), not included in the total additional costs**

8. <u>Curriculum leverage.</u> Will the proposed program require development of any new courses? If yes, briefly explain.

No development of any new courses required for the proposed program. All the required and elective courses are already offered.

9. <u>Funding Sources</u>. Does the program require enrollment growth funding in order to be implemented and sustained? If so, can the campus implement and sustain the program should enrollment growth funding be unavailable? Letters of commitment should be provided.

No, funding predicated on enrollment growth in the Civil Engineering Ph.D. program is not required for the program to be implemented and sustained.

9a. For graduate programs only:

Does the program require a tuition differential or program specific fee in order to be implemented and sustained?

No.

i. If yes, state the amount of tuition differential or fee being considered, and give a brief justification.

The proposal requests annual support as noted above, but not through a tuition differential or fee. In either case, the program can be delivered through external resources, as evidenced by recent faculty research productivity.

ii. Can the campus implement and sustain the program if the tuition differential or program fee is not approved? Letters of commitment from the Chancellor and/or Chief Academic Officer should be provided.

There is no tuition differential requested.

10. <u>For doctoral programs only</u>:

a. Describe the research and scholarly infrastructure in place (including faculty) to support the proposed program.

<u>Faculty</u>

The Civil and Environmental Engineering Department at UNC Charlotte is composed of four main civil engineering areas: environmental and water resources, structures, geoenvironmental/geotechnical, and transportation. The CEE Department presently has a total of 22 research active faculty, broken down in the four areas as follows.

- Environmental and water resources: 6
- Structures: 7
- Geoenvironmental/geotechnical: 6
- Transportation: <u>3</u>

  Total **22**

No new faculty hires are needed to implement the proposed CE Ph.D. program. The program would facilitate increased research productivity and external funding acquisition with the present faculty workforce. However, as the program grows over the years, more tenure-track faculty would likely be hired to meet the additional research and teaching loads and provide the needed technical expertise in the evolving program. All the primary infrastructure (testing and modeling laboratories, computing resources and software, classrooms, and office space) is in place to implement the proposed CE Ph.D. program. The existing INES Ph.D. program provides evidence of our present capabilities and capacity; 7-12 additional doctoral students per year could be advised by our existing faculty and be accommodated by our research/scholarly infrastructure. The excellent testing and modeling labs, computational resources (hardware and software), and unique off-campus facilities are described below.

Infrastructure

Structural and Materials Facilities

High-Bay Structures Lab

The EPIC Building houses the High-Bay Structures Lab, a three-story, 7500 square-foot space for testing full-scale or model structures and foundations under large static or quasi-dynamic loads. This facility is one of only ten such laboratories in the U.S. The Lab features interior and exterior strong-floor foundations; two 32ft-tall, 1.2 million pound capacity strong walls in an L-shaped plan; three geotechnical test pits (12ft square x 5ft deep, 12ft square x 10ft deep, and 10ft in diameter x 10ft deep); two free-standing structural steel reactions frames (one spanning over the geotechnical test pits); two tandem/independent 30-ton overhead cranes that run the length of the lab; and a second-level mezzanine with control room and observation area. Numerous actuators and jacks, pumps and hoses, supporting hydraulic equipment, data acquisition systems, sensors/instrumentation, and a wealth of heavy-lifting equipment and tools are available for use in the lab. The High-Bay Lab is also supported by a fabrication/machine shop, an exterior courtyard, and numerous nearby rooms for specialized testing.

ISERRT Center

The Infrastructure Security and Emergency Responder Research and Training (ISERRT) Center's mission is to make positive contributions to the security and resilience of infrastructure, personnel, and related assets through basic and applied research, education, and training. ISERRT Center personnel developed and operate two open-arena blast/impact/ballistics/fire testing facilities, the ISERRT Facility in Gastonia NC and the military-grade ISERRT-M Facility in Maxton NC.

The Physical Security Lab supports modeling efforts, field testing of structures, and testing of structures and components conducted at the ISERRT or ISERRT-M Facilities. Further, the Lab is the "learning community" base for all students involved in physical security research.

Other structural and materials facilities are listed below.

- *Experimental Structural Dynamics and Health Monitoring Lab*
- *Construction Materials Development Lab*
- *Structural Materials Testing Lab*

- *Visualization Lab*

Geoenvironmental/Geotechnical Facilities

Advanced Geomaterial Testing Lab

The advanced geomaterial testing lab several geotechnical testing devices aimed at the advanced characterization of geomaterials under complex loading. This lab features a GDS combined Advanced Dynamic Cyclic Simple Shear (AdvDCSS) which is one of only four in the world. This device is a testing system that can be used for dynamic cyclic simple shear and dynamic cyclic triaxial testing used to study the dynamic properties and liquefaction susceptibility of geomaterials under cyclic loading that simulates actual earthquake loading. This device is also equipped to measure dynamic properties of geomaterial under different suction pressures and unsaturated conditions. This lab also houses Geocomp advanced cyclic triaxial system that allows study of liquefaction of sands and industrial byproducts, as well as the determination of engineering properties and characterization for complex projects such as tunnels, earth dams, deep excavations, etc. Additional to these two main testing devices in this lab, we have a resonant column device and a direct simple shear.

Geo-centrifuge Lab:

The geo-centrifuge laboratory has a footprint of approximately 600 sq.ft and it houses two geo-centrifuges. The larger centrifuge is a 10-ft-diameter centrifuge with a swing basket that can contain samples up to $1ft^3$ in volume and 250 lbs mass that can be subjected a G level of ≤ 200 G. This centrifuge is used for graduate courses in geotechnical and geoenvironmental engineering and for carrying out research pertaining to hydraulic properties of waste materials. The smaller centrifuge is of the size of a washing machine and is exclusively for testing soil and waste samples for unsaturated hydraulic properties. It can accommodate, up to 6 samples having volume ≤ 1 L and it can subject the samples to a maximum gravity loading of 4,000 G. This centrifuge is used for research as well as for a graduate level course that covers properties of soils and waste.

Unsaturated geomaterial testing Lab

The unsaturated geomaterial testing lab houses several devices to measure the unsaturated properties of soils and coal combustion byproducts. Housed in this lab are several devices to measure soil water characteristics curve including 6 Soilmoisture 2-1/4 in diameter tempe cells (0

– 2 bars); Soilmoisture pressure plate extractors (1 bar and 5 bars); Soilmoisture volumetric pressure plate extractor with the Hysteresis attachments; Decagon WP4 Dewpoint Potentiameter (0 – 3000 bars). In addition to these bench top and lab scale devices are several decagon field tensiometers for field measurement.

Other geotechnical and geo-environmental laboratories include:

- *Field and In situ Testing Lab*
- *Geosynthetic Materials Testing and Performance Lab*
- *Pavement Materials Performance Lab*
- *Soil and Rock Dynamics Experimentation Lab*

Transportation Facilities

The EPIC Building houses two transportation labs, one focusing on transportation modeling and simulation (*Transportation Modeling and Simulation Lab)* and the other focusing on intelligent transportation systems, traffic operations and optimization (*ITS Tool)*. Both the labs are equipped with state-of-the-art computers which have traffic simulation software (Synchro/SimTraffic and VISSIM), transportation planning software (TransCAD), geometric design software, and geo-spatial data processing and analysis software. They are also equipped with surveying equipment, traffic signal controllers, a sign retro-reflectometer, and devices such as video cameras, Bluetooth detectors, global positioning systems (GPS), and Jamar counters to collect traffic counts and analyze transportation system performance. These devices are used to conduct engineering as well as observation studies using the real world transportation network as its lab. Furthermore, a 100-feet test rail track (prototype) was constructed outside the EPIC building to research and evaluate innovative track construction, design strategies and operation of trains.

Computational Resources (Hardware and Software)

The CEE Department, College, and University develop and maintain several computational resources, such as: research compute clusters with hundreds of cores, dedicated computers/workstations for data acquisition in the labs and field, computer labs for graduate/undergraduate classes and research, and a wealth of individual computers for faculty, staff, and graduate student offices.

Numerous commercial and in-house computer programs support faculty and graduate student research, design, and instruction.

Graduate Courses

All graduate courses required for the proposed CE Ph.D. curriculum are existing courses in the CEE Department.

b. Describe the method of financing the proposed new program (including extramural research funding and other sources) and indicate the extent to which additional state funding may be required.

Implementing the proposed CE Ph.D. program would necessitate the acquisition of additional external funding (federal, state, and private) by the CEE faculty already in the CEE Department. Due to the new doctoral degree option, the overall doctoral student body would grow (CE Ph.D. students plus INES Ph.D. students), necessitating faculty to write more successful proposals to acquire the additional external funding needed to support doctoral research assistantships. As usual, the funding would support the other research expenses of the project, such as: materials and supplies, release time for faculty, lab fees, etc. However, the added time required of the existing faculty to advise the projected additional 7-12 doctoral students and write the additional proposals to fund them could be offset by 6 teaching assistantships per 9 months with 6 full tuition waivers. The notion is to have the capacity to support 6 new deserving CE Ph.D. students as TAs their first year, followed by RA support (from external funding) their remaining 3-4 years in the program; existing TA moneys, fellowships, and external research funding would round out first-year support for the other projected students in the program.

c. State the number, amount, and source of proposed graduate student stipends and related tuition benefits that will be required to initiate the program.

A summary of the required graduate student stipends and related tuition benefits are outlined below.

Year 1:

- Teaching Assistantships (TAs)
    - Number of grad student TA stipends: 6

- Amount of individual TA stipend: $14,000/9-month (total: $84,000)
- Source of TA stipends: state funding
- Tuition benefits for students receiving TA stipend: 6 full tuition remissions
- Source of TA tuition benefits: state funding

- Research Assistantships (RAs)
  - Number of grad student RA stipends: 2
  - Amount of individual RA stipend: $18k/year (total: $36,000)
  - Source of RA stipends: external funding
  - Tuition benefits for students receiving RA stipend: 2 full tuition remissions
  - Source of RA tuition benefits: state funding

Subsequent years:

- Teaching Assistantships (TAs)
  - Number of grad student TA stipends: 6/year
  - Amount of individual TA stipend: $14,000/year (total: $84,000/year)
  - Source of TA stipends: state funding
  - Tuition benefits for students receiving TA stipend: 6 full tuition remissions per year
  - Source of TA tuition benefits: state funding
- Research Assistantships (RAs)
  - Number of grad student RA stipends: add 4-6/year for the next three years (total RA stipends for Year 2: 6-8; Year 3: 10-14; Year 4: 14-20; Year 5 and beyond: 14-20)
  - Amount of individual RA stipend: $18k/year
  - Source of RA stipends: external funding
  - Tuition benefits for students receiving RA stipend: add 4-6 full tuition remissions per year for the next three years (total RA tuition remissions for Year 2: 6-8; Year 3: 10-14; Year 4: 14-20; Year 5 and beyond: 14-20)
  - Source of RA tuition benefits: state funding

Note that continued student support by stipend and tuition remission, regardless of the funding source, is contingent on the student taking the required course credits per semester (6 minimum), meeting progression requirements (3.2/4.0 minimum), and making adequate progress on his/her research, as deemed by the student's doctoral committee.

11. Contact. List the names, titles, e-mail addresses and telephone numbers of the person(s) responsible for planning the proposed program.

Primary Contact

- John L. Daniels, Professor of Civil and Environmental Engineering, jodaniel@uncc.edu, 704-687-1219

UNC Charlotte Faculty

- Vincent O. Ogunro, Associate Professor of Civil and Environmental Engineering, vogunro@uncc.edu , 704-687-1230
- Srinivas Pulugurtha, Professor of Civil and Environmental Engineering, sspulugurtha@uncc.edu , 704-687-1233

This request for authorization to plan a new program has been reviewed and approved by the appropriate campus committees and authorities.

Chancellor: Phil. J Nelson Date: 1/22/17

Chancellor (Joint Partner Campus): _____ Date: _____

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APPENDICES

APPENDIX 1. Documentation of Student Demand.

APPENDIX 2. Relevant Letters of Support

APPENDIX 3. Uniform Articulation Agreement between UNC Baccalaureate Engineering Programs and NC Community College System Associate in Engineering Programs

APPENDIX 4. Peer and National Comparisons by Academic Analytics, LLC and Market Analysis Hanover Research, Inc.

APPENDIX 1

Documentation of Student Demand: Representative communication

- Eimar Sandoval-Vallejo's Rescission of Admission Offer for lack of CE Ph.D. at UNC Charlotte
- Edgardo Ruiz's Letter indicating Acceptance of Admission Offer at another University because CE Ph.D. is not offered at UNC Charlotte
- Fahad Alsaqer, UNC Charlotte Student, will not apply to UNC Charlotte because we do not offer CE Ph.D. (his scholarship providers required Ph.D. degree in Civil Engineering)

Facultad de Ingeniería
Escuela de Ingeniería Civil y Geomática

Universidad del Valle

Santiago de Cali, August 1/2012

Dr. Miguel A. Pando
Associate Professor
Department of Civil and Environmental Engineering
University of North Carolina at Charlotte
9201 University City Blvd,
Charlotte, NC

RE: Final decision about institution for Ph.D.

Dear Professor:

As my mentor and my former advisor for my MS in Civil Engineering at the University of Puerto Rico at Mayaguez, I was really eager to pursue my Ph.D. under your supervision. As you know I am currently a faculty member in the School of Civil Engineering and Geomatics at Universidad del Valle in Cali, Colombia. As a professor, I have the opportunity to receive total or partial funding for tuition, and to receive my salary to cover my living expenses during doctoral studies. Because of that, different instances at the university must review one proposal including the topic, the advisor and the institution where the studies will be conducted. I inquired about the possibility of receiving this funding to obtain my doctoral degree at UNC Charlotte under your supervision. However, my university indicated that they want to send faculty abroad to obtain a Ph.D. in civil engineering, so it is in line with the scope of my teaching and research when I resume my position in the School of Civil Engineering and Geomatics.

This is very unfortunate, but as much as I understand the strengths and benefits of having an interdisciplinary Ph.D. as the one your mentioned (INES program), I hope you understand the reasons behind my institutions' decision to only fund Ph.D. degrees aligned with the scope and name of my department.

I hope we can continue to collaborate upon my return from my doctoral studies. I will continue to be in touch and keep you informed of my plans.

Sincerely,

Eimar Andrés Sandoval-Vallejo,
M.S. in Civil Engineering
Assistant Professor, School of Civil Engineering and Geomatics
Universidad del Valle
Calle 13 # 100-00
Cali, Colombia
Tel: 572-3392086
Email: eimar.sandoval@correounivalle.edu.co

From: "Ruiz, Edgardo ERDC-RDE-GSL-MS" <Edgardo.Ruiz@erdc.dren.mil>
Date: October 13, 2015 at 11:53:46 AM EDT
To: "Pando, Miguel" <mpando@uncc.edu>
Subject: Visit to UNC Charlotte

Dear Dr. Pando,

It was very nice seeing you on July 22, 2015 and have the opportunity to see your university and the facilities of your department. I was very impressed with the university and the facilities in EPIC. As you know after my MS in Civil Engineering under your supervision at the University of Puerto Rico at Mayaguez (UPRM) I joined the US Army Engineer Research and Development Center (ERDC) as a research civil engineer in the Structural Engineering Branch. Annually, ERDC provides funding for the Long-Term Training (LTT) Program. The LTT program is a great benefit that we have as ERDC employees in which we are sent to pursue Ph.D. degrees in our respective fields. The program pays for all expenses for 1-yr at the university of our choice. As you can imagine this is a very popular program, therefore a there is an application and selection process. To apply for the LTT program a proposal is submitted for evaluation in which it must be outlined the selected university, advisor, field of study and degree. As you may recall I went through the process of applying for LTT and had contacted you about pursuing my Ph.D. at UNCC with you as my advisor. We had even identified various potential research areas. However, I should point out that given the scope of our work a Ph.D. in civil engineering was preferred. I would have loved to pursue my Ph.D. at UNC Charlotte but the INES program, although attractive, would not be able to grant a Ph.D. in Civil Engineering and was therefore removed as a consideration under the guidance of my leadership. Therefore I have started my Ph.D. in civil engineering at Mississippi State University.

I understand your department is in the process of proposing a Ph.D. in Civil Engineering. If this program would have been in place when I applied for LTT, I have no doubt that I would have conducted my Ph.D. studies at UNCC. If the program is approved please let me know so I can advertise it among my colleagues (many are also alumni from UPRM including some that did their MSCE degrees under your supervision).

Next time I am in the area I hope to visit you again.

Regards,

Edgardo Ruiz, MSCE, PE
Research Civil Engineer
US Army Engineer Research and Development Center
Structural Engineering Branch

UNC CHARLOTTE

Ogunro, Tobi <vogunro@uncc.edu>

Re: Ph.D. Program (Fahad Alsaqer)

1 message

Ogunro, Tobi <vogunro@uncc.edu> Thu, Oct 15, 2015 at 10:48 AM
To: "Gergely, Janos" <jgergely@uncc.edu>
Cc: John Daniels <jodaniel@uncc.edu>, Miguel Pando <mpando@uncc.edu>

Thanks Janos,

I will include this in the appendix.
Thanks again.

Vincent

On Thu, Oct 15, 2015 at 10:36 AM, Gergely, Janos <jgergely@uncc.edu> wrote:

FYI... again, reinforcing our need for a CE PhD program!
jg

---------- Forwarded message ----------
From: **Alsaqer, Fahad** <falsaqer@uncc.edu>
Date: Wed, Oct 14, 2015 at 9:14 PM
Subject: Ph.D. Program (Fahad Alsaqer)
To: Janos Gergely <jgergely@uncc.edu>

Dear,
Dr. Janos Gergely

Thank you very much for explaining me the graduate programs of the Department of Civil and Environmental Engineering at UNCC. After carefully reading my scholarship provider guidelines for a Ph.D. scholarship, I found out that the Ph.D. program must be stated as a *Ph.D. in Civil Engineering* rather than a *Ph.D. in Infrastructure and Environmental Systems*. As a result, I can not enroll in the Ph.D. program UNCC now offering, unless the program name changed. I enjoyed meeting you and I only wish that circumstances allowed me to continue being one of your students.

Thanks,

Fahad Alsaqer

APPENDIX 2

Relevant Letters of Support

- CEE Department, Duke University's Support for a Ph.D. in Civil Engineering at UNC Charlotte
- Duke Energy and EPIC Board's Support for a Ph.D. in Civil Engineering at UNC Charlotte
- AECOM's Support for a Ph.D. in Civil Engineering at UNC Charlotte
- EPIC Support for a Ph.D. in Civil Engineering at UNC Charlotte
- GEOPIER Support for a Ph.D. in Civil Engineering at UNC Charlotte

Example Letter Documenting Proposed Collaboration with NC State

- Letter of Support, provided from UNC Charlotte CEE Department to NC State's CCE Department

MARK R. WIESNER
DIRECTOR, CENTER FOR THE ENVIRONMENTAL IMPLICATIONS OF NANOTECHNOLOGY
JAMES L. MERIAM PROFESSOR OF CIVIL & ENVIRONMENTAL ENGINEERING
PRATT SCHOOL OF ENGINEERING
NICHOLAS SCHOOL OF THE ENVIRONMENT

John L. Daniels

Professor and Chair

Department of Civil and Environmental Engineering

The University of North Carolina at Charlotte

Charlotte, NC 28223

RE: Support for Request for Authorization to Plan a New Degree Program, Ph.D. in Civil Engineering

Dear Professor Daniels (John),

I enjoyed our conversation on Monday, July 27, 2015, during which we discussed your efforts to seek authorization to plan for a Civil Engineering Ph.D. program at The University of North Carolina Charlotte. As we discussed, Duke University also has a Civil Engineering Ph.D. program. I see no duplication between our program and that which you propose for a variety of reasons, some of which are included below.

- There are currently only two Civil Engineering Ph.D. programs in North Carolina, neither of which are located in Charlotte.
- Adding a Ph.D. program at Charlotte helps to increase the intellectual vitality of the region, creating more opportunities to collaborate on state, national, and international initiatives as well as externally funded grants and contracts.
- The majority of our students focus on environmental engineering, while those who specialize in civil engineering tend to have a computational, material science, or risk/reliability focus; this is in contrast to your stated focus on experimental civil

DUKE UNIVERSITY □ CENTER FOR THE ENVIRONMENTAL IMPLICATIONS OF NANOTECHNOLOGY
BOX 90287 □ 120 HUDSON HALL-ENGINEERING BUILDING
DURHAM, NC 27708-0287
PHONE: +1 919-660-5292 □ FAX:+1 919-660-5459 □ E-MAIL: wiesner@duke.edu

Duke
UNIVERSITY

CEINT
Center for the Environmental
Implications of NanoTechnology

engineering research, e.g., large scale structural testing in your new high bay, soil/structure interaction, and so forth.

- The majority of our Ph.D. students pursue careers in academia as faculty, with a smaller fraction pursuing careers in government or non-government organizations; in contrast with your focus on industry in general and the energy sector in particular.

In short, I fully support your efforts to secure a Civil Engineering Ph.D. program at The University of North Carolina Charlotte.

Yours sincerely

Mark R. Wiesner, Ph.D., P.E.
Chair, Department of Civil and Environmental Engineering
Director, Center for Environmental Implications of Nanotechnology (CEINT)
James L. Meriam Professor of Civil & Environmental Engineering

Dhiaa M. Jamil
President, Regulated Generation
and Transmission

Duke Energy
DEC48G | 550 South Tryon Street
Charlotte, NC 28202

Mailing Address:
PO Box 1321
Charlotte, NC 28201

o: 704.382.2200
f: 980.373.9846
dhiaa.jamil@duke-energy.com

January 4, 2016

Dr. John L. Daniels, P.E.
Professor and Chair
Department of Civil and Environmental Engineering
The University of North Carolina at Charlotte
Charlotte, NC 28223

RE: EPIC External Advisory Board Support for a Ph.D. in Civil Engineering at UNC Charlotte

Dear Dr. Daniels,

During our most recent EPIC board meeting, I learned that the Department of Civil and Environmental Engineering is seeking authorization to plan and eventually establish a Ph.D. in Civil Engineering. As a discipline, civil engineering is vital to the energy industry's workforce development and research capacity needs.

With more than 250 regional energy corporations located in Charlotte, there is ample need for discipline-specific specialization in the three core areas of engineering, i.e., mechanical, electrical, and civil. UNC Charlotte is able to meet our needs in mechanical and electrical engineering, however civil engineering remains incomplete without a Ph.D. program.

It is no secret that the utility industry is facing a workforce shortage, with the majority of employees aged 55 or older. Given the increased complexity of energy infrastructure (e.g., transmission lines, grid security, plant infrastructure, etc.), we will need graduates at all degree levels, including the Ph.D.

In short, many energy companies are potential employers of your graduates as well as collaborators and consumers of your research. EPIC's External Advisory Board consists of the following companies who support the EPIC program: Duke Energy, Akoustis, Inc., STEAG Energy Services, AREVA, ATKINS, SEWW Energy, EPRI, Westinghouse, Pillsbury Law, Allied Technical Resources, Siemens Energy, SAS Institute, EnergyUnited and Piedmont Natural Gas. UNCC needs innovative minds and solutions to tackle the challenges. To that end, if the EPIC program is to fully reach its potential, then a Civil Engineering Ph.D. program at The University of North Carolina Charlotte is required.

Sincerely,

Dhiaa Jamil, Executive VP
Chair – EPIC External Advisory Board
Duke Energy Corporation
P. O. Box 1321 – Mail Code DEC48G
Charlotte, NC 28201

AECOM

February 26, 2016

Dr. John L. Daniels, P.E.
Professor and Chair
Department of Civil and Environmental Engineering
The University of North Carolina at Charlotte
Charlotte, NC 28223

RE: AECOM's Support for a Ph.D. in Civil Engineering at UNC Charlotte

Dear Dr. Daniels,

During our recent meeting to recruit students, I learned that the Department of Civil and Environmental Engineering is seeking authorization to plan and eventually establish a Ph.D. in Civil Engineering. Such authorization fills a rather obvious need, given that your college already has Ph.D. program in Electrical and Mechanical Engineering. As a discipline, Civil Engineering is vital to the engineering industry's workforce development and research capacity needs. This is especially true to Charlotte engineering companies that continue to grow due to the quality clients in the southeast. To develop the best workforce and be responsive to our industry, you must educate students at all levels (BS, MS, and PhD) and do it with the best faculty. This requires that you offer a complete set of programs, including the Ph.D. in Civil Engineering.

A Ph.D. is not just useful for a career in academia. AECOM is ranked number one among global design firms, and we need the expertise at all levels. While appropriately fewer in number as compared to BS and MS, we routinely hire employees with Ph.Ds in Charlotte and across the country in Civil Engineering. For example Dr. Kula Kulasingam, who now serves as a senior lead geotechnical engineer here in Charlotte, is one of our top engineers in the company. Engineering design firms need employees at all educational levels, especially given the increased complexity and forecasted growth in civil engineering projects.

As you know, AECOM acquired URS Corporation, which was one of the founding members of the Energy Production and Infrastructure Center (EPIC). Our firm encouraged the allocation of $76 million in state funding to build the EPIC building to ensure that you have the facilities necessary to conduct research and train future engineers. You now have this building and it is time to fully leverage it with a civil engineering Ph.D. program.

In summary, my firm and I fully support your plans to offer a Ph.D. in civil engineering. The state of North Carolina benefits significantly from Charlotte, and Charlotte needs this program to complete its programmatic offerings, thereby increasing access to both local industry and the community.

Sincerely,

Richard S. Keagy, PE, LEED AP
Vice President, Mid Southeast Area
Power & Industrial/Oil & Gas Business Unit Leader
AECOM Technology Services
Rich.keagy@aecom.com
Ph: 980-230-7680

UNC CHARLOTTE

The WILLIAM STATES LEE COLLEGE *of* ENGINEERING

Energy Production and Infrastructure Center (EPIC)

9201 University City Boulevard, Charlotte, NC 28223-0001
t/ 704.687.1669 f/ 704.687.1819 www.epic.uncc.edu

December 11, 2015

Dr. John L. Daniels, P.E.
Professor and Chair
Department of Civil and Environmental Engineering
The University of North Carolina at Charlotte
Charlotte, NC 28223

RE: EPIC Support for a PhD in Civil Engineering at UNC Charlotte

Dear Dr. Daniels,

I am aware that the Department of Civil and Environmental Engineering is seeking authorization to plan and establish a PhD in Civil Engineering. I encourage you to continue that pursuit, and with this letter please accept our (EPIC's) support of your efforts.

The creation of EPIC was driven by the energy industry who saw a need for advanced education and research capabilities in the energy arena. When the concept of EPIC was first discussed, several key objectives were expressed immediately. One of them was to provide a system of programs, people, and facilities that would support work, at an advanced level on infrastructure issues; that is, in civil engineering. In terms of developing the energy workforce and expanding energy research capacity, there is no discipline more important than civil engineering.

Please know that EPIC pledges our full support to a PhD program in Civil Engineering in terms of staff, facilities, and resources. Let me know how I can help.

Sincerely,

Johan Enslin, PhD, FIEEE, PrEng
Director, Energy Production & Infrastructure Center
Duke Energy Distinguished Chair in Power Engineering Systems
9201 University City Blvd.
EPIC 1226
Charlotte, NC 28223

GEOPIER®
Tensar

May 11, 2016

Dr. John L. Daniels, P.E.
Professor and Chair
Department of Civil and Environmental Engineering
The University of North Carolina at Charlotte
Charlotte, NC 28223

RE: Geopier Foundation's Support for a Ph.D. in Civil Engineering at UNC Charlotte

Dear Dr. Daniels,

I understand from my participation in the advisory board that the Department of Civil and Environmental Engineering is seeking authorization to plan and eventually establish a Ph.D. in Civil Engineering. We enthusiastically support this plan and are thus providing you with this letter of explaining why.

- Our company, Geopier Foundations, invents, develops, engineers, and markets specialty geotechnical foundation systems for the support of commercial buildings, transportation structures, and industrial facilities. Ten years ago, we relocated our company from Virginia to the greater Charlotte area to gain access to engineering talent that is available and produced locally. As such, we rely on a strong and robust academic community to attract and train great engineers. We strongly believe that the Civil Engineering program at UNC Charlotte would be enhanced if it were able to confer doctoral degrees. This enhancement serves to draw in higher level applicants for all degree programs that then translate into better equipped graduates. These graduates then enhance the value of Charlotte and the State of North Carolina to the professional community.

- Geopier recruits Civil Engineers that graduate with both Masters of Science and Doctoral degrees. We have found that this mix of engineers serves us well in the development of our intellectual properties. We would actively recruit from UNC Charlotte's graduating doctoral students should UNC Charlotte confer doctoral degrees in Civil Engineering.

- As our firm develops its intellectual property, we are constantly faced with the need to form collaborative relationships with our academic colleagues. In the past we have worked with and funded projects at Virginia Tech, the University of Wisconsin, Iowa State University, the University of Kansas, BYU, Arizona State University, the University of Utah, and others. We are actively engaged in academic conferences and state of the art developments. We seek additional collaborators and greatly value the access afforded by the UNC Charlotte campus to our headquarters offices. Should UNC Charlotte develop a Ph.D. program, we would actively seek to engage the University in collaborative research projects. We would further envision that these projects would further benefit NC State University researchers who would likely be brought in to work on projects better addressed by NC State researchers.

- As this year's president of the Geo Institute of ASCE, I am in a unique position to have a view of the issues surrounding our profession both in academe and in industry. Our Civil Engineering profession begs for innovation, collaboration, and technology development. As a leader in the industry, I firmly believe that the establishment of the UNC Charlotte doctoral program will

allow UNC Charlotte to flourish in an increasingly tech-centered world. Without such a program will relegate the University within North Carolina's largest city to serving yesterday's problems. We industry leaders have a responsibility to form a vision of tomorrow's needs and to establish organizations equipped to fulfill these needs.

- A Civil Engineering Ph.D. program at UNC Charlotte will serve to increase the value of the entire UNC system to the residents of the State of North Carolina. As we enhance our ability to serve tomorrow's needs, the value of the entire University system will increase and the total research funding that will be addressable by all Civil Engineering programs within the State will increase. We all know that "a rising tide floats all boats.'

In summary, my firm and I fully support your plans to offer a Ph.D. in civil engineering. The state of North Carolina benefits significantly from Charlotte, and Charlotte needs this program to complete its programmatic offerings, thereby increasing access to both local industry and the community.

Sincerely,

Kord Wissmann, Ph.D., PE, D.GE
President
Geopier Foundations
130 Harbour Place Drive, Suite 280
Davidson NC 28036 USA

UNC CHARLOTTE

The WILLIAM STATES LEE COLLEGE *of* ENGINEERING

9201 University City Boulevard
3252 EPIC
Charlotte, NC 28223-0001

Department of Civil and
Environmental Engineering

704/687-1219
FAX: 704/ 687-0957

December 2, 2015

RE: Collaboration with North Carolina State University for NSF 15-607, IUSE / Professional Formation of Engineers: REvolutionizing engineering and computer science Departments (RED)

Dr. Morton A. Barlaz, P.E.
Professor and Head
Department of Civil, Construction, and Environmental Engineering
North Carolina State University
PO Box 7908
Raleigh, NC 27695-7908

Dear Dr. Barlaz,

Thank you for describing the proposal that you are submitting to the NSF to revolutionize the manner in which we educate civil engineering undergraduate students. I very much concur with your premise and approach. As such I appreciate your offer to include faculty from UNC Charlotte in meetings and workshops to discuss teaching methods and the results of the project's research. I will identify and sponsor at least two faculty from my department to participate in the workshops that are conducted over the course of the project.

As I am sure that you are aware, UNC Charlotte has an NSF –RED in Computer Science (Award Number: 1519160), and the results thus far have been remarkable. My previous service as a program officer at the NSF has convinced me of the value of transforming undergraduate education in a range of institutional profiles and settings. The focus at UNC Charlotte has been on re-orienting the learning process to intentionally connect with peers, the profession, and the community. My department's participation in your proposed project will facilitate broader and deeper systemic change across two different colleges (College of Engineering and College of Computing and Informatics). Please let me know as soon as your project is awarded so that we can identify the appropriate faculty members and work through logistical details.

Sincerely,

Dr. John L. Daniels, P.E.
Professor and Chair
Department of Civil and Environmental Engineering

APPENDIX 3

Uniform Articulation Agreement between UNC Baccalaureate Engineering Programs and NC Community College System Associate in Engineering Programs

- Memorandum of Approval by the State Board of Community Colleges and the UNC Board of Governors
- List of Participating Programs in NC CCS Associate in Engineering Programs

NORTH CAROLINA COMMUNITY COLLEGE SYSTEM
R. Scott Ralls, Ph.D.
President

March 4, 2015

MEMORANDUM

TO: Presidents
Chief Academic Officers

FROM: Wesley E. Beddard, Associate Vice President
Programs

SUBJECT: State Board of Community College and UNC Board of Governors February Action
Uniform Articulation Agreement between UNC Baccalaureate Engineering Programs and NC Community College System Associate in Engineering Programs

The State Board of Community Colleges and The UNC Board of Governors approved the attached *Uniform Articulation Agreement between the University of North Carolina Baccalaureate Engineering Programs and the North Carolina Community College System Associate in Engineering Programs* in February. This approval includes a new Associate in Engineering (AE) college transfer degree curriculum standard for the North Carolina Community College System. (See appendix E)

The Uniform Articulation Agreement was a joint project of the NC Community College System and the University of North Carolina engineering programs. It applies to all NC community colleges that are approved to offer the AE degree program and to those constituent institutions of the UNC that offer the Bachelor of Science Engineering programs.

The Associate in Engineering program is designed to meet the prerequisites requirements of the University of North Carolina engineering programs. In order to receive approval to offer the AE, the community college must provide a program of study which is in compliance with the AE curriculum standard and certification of the following:

- Master's credentialed faculty for each course provided under the AE
- Adequate facilities/resources to provide the AE
- Evidence of sufficient student demand

Please see the attached section 11 of the Curriculum Procedures Reference Manual for detailed information concerning the community college approval process for the AE.

We are appreciative of the community college and UNC engineering program representatives that worked so diligently on this agreement which will promote educational advancement opportunities for AE degree completers moving between the NC community colleges and the constituent institutions of The University of North Carolina in order to complete Bachelor of Science in Engineering degrees.

If you have any questions concerning the Uniform Articulation Agreement, please contact Wesley Beddard at (919) 807-7098 or beddardw@nccommunitycolleges.edu.

WB/jf
Attachments
c: Dr. Lisa M. Chapman Ms. Elizabeth Self CC15-010
Ms. Jennifer Frazelle Program Coordinators Email

List of North Carolina community colleges approved by State Board to offer the Associate in Engineering degree

1	Asheville Buncombe Technical Community College
2	Blue Ridge Community College
3	Brunswick Community College
4	Catawba Valley Community College
5	Central Carolina Community College
6	Central Piedmont Community College
7	Coastal Carolina Community College
8	College of The Albemarle
9	Craven Community College
10	Durham Technical Community College
11	Fayetteville Technical Community College
12	Forsyth Technical Community College
13	Gaston College
14	Guilford Technical Community College
15	Halifax Community College
16	Johnston Community College
17	Mitchell Community College
18	Nash Community College
19	Pitt Community College
20	Richmond Community College
21	Sandhills Community College
22	Tri-County Community College
23	Wake Technical Community College
24	Wilkes Community College

APPENDIX 4

Department Reports by Academic Analytics, LLC and Hanover Research

- Peer Institution Identification and Comparison by Academic Analytics, LLC
- Department Gauge and National Comparison by Academic Analytics, LLC
- Civil Engineering Ph.D. Analysis by Hanover Research, Inc.

University of North Carolina Charlotte

Release: AAD2014.05.565 Logout

Department Peer Identification Tool

Department Selection

Department: Civil and Environmental Engineering, Department of

Discipline: Civil Engineering (154 Departments)

Manual Peer Selection

Switch To Institution Criteria

Peers

Adelphi University
Air Force Institute of Technology
Alabama A&M University
Albany Medical College
Albert Einstein College of Medicine of Yeshiva University
Alfred University
Alliant International University
American University
Andrews University
Antioch University New England
Arizona State University
Arkansas State University
Ave Maria University

>>
<<

Selected Peers

Florida International University
Old Dominion University
Portland State University
University of Colorado Denver
University of Louisville
University of Massachusetts Lowell
University of Nevada, Las Vegas
University of New Mexico, The

Variable Selection

Click the variables and use the arrow buttons to select and un-select the variables to include in the report.

Available Variables

Articles - Journal Publications per Author
Articles - Journal Publications per Faculty Member
Articles - Number of Faculty With a Journal Publication
Articles - Percentage of Faculty With Journal Publication
Articles - Total Journal Publications
Citations - Citations per Faculty Member
Citations - Citations per Publication
Citations - Number of Faculty With Citation
Citations - Percentage Authors With Citation
Citations - Percentage of Faculty With Citation
Citations - Total Citations
ConfProceedings - Conference Proceedings per Author
ConfProceedings - Conference Proceedings per Faculty Member
ConfProceedings - Total Conference Proceedings

>>
<<

Selected Variables

Articles - Journal Publications per Author
Articles - Journal Publications per Faculty Member
Articles - Number of Faculty With a Journal Publication
Articles - Percentage of Faculty With Journal Publication
Articles - Total Journal Publications
Citations - Citations per Faculty Member
Citations - Citations per Publication
Citations - Number of Faculty With Citation
Citations - Percentage Authors With Citation
Citations - Percentage of Faculty With Citation
Citations - Total Citations
ConfProceedings - Conference Proceedings per Author
ConfProceedings - Conference Proceedings per Faculty Member
ConfProceedings - Total Conference Proceedings

Number of schools above selection to compare: 1

Number of schools below selection to compare: 1

Run Report

Download Data

Schools and Proximity

Peer Institution	Variables in Proximity
Portland State University	27
University of Toledo, The	27
University of Colorado Denver	27
University of Texas Arlington	27
Old Dominion University	27
University of New Mexico, The	27
Florida International University	27
University of Wisconsin - Milwaukee	27
University of Nevada, Las Vegas	27
University of Massachusetts Lowell	27
University of Texas at San Antonio, The	27
University of North Carolina Charlotte	27
University of Rhode Island	27
University of Louisville	27
Western Michigan University	27

Articles Variables

InstitutionName	DepartmentName	No. Fac	Journal Publications per Author
Portland State University	Civil and Environmental Engineering, Department of	16	12.78
University of Toledo, The	Civil Engineering, Department of	9	10.57
University of Colorado Denver	Civil Engineering, Department of	14	9.92
University of Texas Arlington	Civil Engineering, Department of	19	9.50
Old Dominion University	Civil and Environmental Engineering, Department of	12	8.44
University of New Mexico, The	Civil Engineering, Department of	17	8.41
Florida International University	Civil and Environmental Engineering, Department of	18	8.18
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	7.33
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	6.28
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	6.17
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	6.07
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	5.56
University of Rhode Island	Civil and Environmental Engineering, Department of	13	5.00
University of Louisville	Civil and Environmental Engineering, Department of	10	3.67
Western Michigan University	Civil and Construction Engineering, Department of	8	3.50

InstitutionName	DepartmentName	No. Fac	Journal Publications per Faculty Member
University of Texas Arlington	Civil Engineering, Department of	19	9.00
University of Colorado Denver	Civil Engineering, Department of	14	8.50
University of New Mexico, The	Civil Engineering, Department of	17	8.41
University of Toledo, The	Civil Engineering, Department of	9	8.22
Florida International University	Civil and Environmental Engineering, Department of	18	7.72
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	7.33
Portland State University	Civil and Environmental Engineering, Department of	16	7.19
Old Dominion University	Civil and Environmental Engineering, Department of	12	6.33

University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	5.95
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	5.31
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	4.68
Western Michigan University	Civil and Construction Engineering, Department of	8	3.50
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	3.36
University of Rhode Island	Civil and Environmental Engineering, Department of	13	3.08
University of Louisville	Civil and Environmental Engineering, Department of	10	2.20

InstitutionName	DepartmentName	No. Fac	Number of Faculty With a Journal Publication
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	18.00
University of Texas Arlington	Civil Engineering, Department of	19	18.00
Florida International University	Civil and Environmental Engineering, Department of	18	17.00
University of New Mexico, The	Civil Engineering, Department of	17	17.00
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	16.00
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	14.00
University of Colorado Denver	Civil Engineering, Department of	14	12.00
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	12.00
Old Dominion University	Civil and Environmental Engineering, Department of	12	9.00
Portland State University	Civil and Environmental Engineering, Department of	16	9.00
University of Rhode Island	Civil and Environmental Engineering, Department of	13	8.00
Western Michigan University	Civil and Construction Engineering, Department of	8	8.00
University of Toledo, The	Civil Engineering, Department of	9	7.00
University of Louisville	Civil and Environmental Engineering, Department of	10	6.00
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	6.00

InstitutionName	DepartmentName	No. Fac	Percentage of Faculty With Journal Publication
University of New Mexico, The	Civil Engineering, Department of	17	1.00
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	1.00
Western Michigan University	Civil and Construction Engineering, Department of	8	1.00
University of Texas Arlington	Civil Engineering, Department of	19	0.95
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	0.95
Florida International University	Civil and Environmental Engineering, Department of	18	0.94
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	0.88
University of Colorado Denver	Civil Engineering, Department of	14	0.86
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	0.84
University of Toledo, The	Civil Engineering, Department of	9	0.78
Old Dominion University	Civil and Environmental Engineering, Department of	12	0.75
University of Rhode Island	Civil and Environmental Engineering, Department of	13	0.62
University of Louisville	Civil and Environmental Engineering, Department of	10	0.60
	Civil and Environmental Engineering,		

Portland State University	Department of	16	0.56
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	0.55

InstitutionName	DepartmentName	No. Fac	Total Journal Publications
University of Texas Arlington	Civil Engineering, Department of	19	171.00
University of New Mexico, The	Civil Engineering, Department of	17	143.00
Florida International University	Civil and Environmental Engineering, Department of	18	139.00
University of Colorado Denver	Civil Engineering, Department of	14	119.00
Portland State University	Civil and Environmental Engineering, Department of	16	115.00
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	113.00
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	89.00
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	88.00
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	85.00
Old Dominion University	Civil and Environmental Engineering, Department of	12	76.00
University of Toledo, The	Civil Engineering, Department of	9	74.00
University of Rhode Island	Civil and Environmental Engineering, Department of	13	40.00
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	37.00
Western Michigan University	Civil and Construction Engineering, Department of	8	28.00
University of Louisville	Civil and Environmental Engineering, Department of	10	22.00

Citations Variables

InstitutionName	DepartmentName	No. Fac	Citations per Faculty Member
Portland State University	Civil and Environmental Engineering, Department of	16	89.44
Old Dominion University	Civil and Environmental Engineering, Department of	12	71.42
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	66.68
University of Texas Arlington	Civil Engineering, Department of	19	63.11
University of Toledo, The	Civil Engineering, Department of	9	42.22
University of Colorado Denver	Civil Engineering, Department of	14	41.29
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	39.83
University of New Mexico, The	Civil Engineering, Department of	17	37.35
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	29.00
Florida International University	Civil and Environmental Engineering, Department of	18	28.94
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	21.00
University of Rhode Island	Civil and Environmental Engineering, Department of	13	17.92
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	16.89
University of Louisville	Civil and Environmental Engineering, Department of	10	12.40
Western Michigan University	Civil and Construction Engineering, Department of	8	11.63

InstitutionName	DepartmentName	No. Fac	Citations per Publication
Portland State University	Civil and Environmental Engineering, Department of	16	10.01
	Civil and Environmental Engineering,		

Old Dominion University	Department of	12	9.85
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	9.53
University of Texas Arlington	Civil Engineering, Department of	19	5.68
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	5.25
University of Rhode Island	Civil and Environmental Engineering, Department of	13	5.07
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	4.78
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	4.55
University of Toledo, The	Civil Engineering, Department of	9	4.27
University of Louisville	Civil and Environmental Engineering, Department of	10	4.13
University of Colorado Denver	Civil Engineering, Department of	14	3.78
University of New Mexico, The	Civil Engineering, Department of	17	3.69
Florida International University	Civil and Environmental Engineering, Department of	18	3.28
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	2.97
Western Michigan University	Civil and Construction Engineering, Department of	8	2.82

InstitutionName	DepartmentName	No. Fac	Number of Faculty With Citation
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	17.00
University of New Mexico, The	Civil Engineering, Department of	17	17.00
University of Texas Arlington	Civil Engineering, Department of	19	16.00
Florida International University	Civil and Environmental Engineering, Department of	18	15.00
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	14.00
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	13.00
University of Colorado Denver	Civil Engineering, Department of	14	12.00
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	11.00
Portland State University	Civil and Environmental Engineering, Department of	16	10.00
Old Dominion University	Civil and Environmental Engineering, Department of	12	8.00
University of Rhode Island	Civil and Environmental Engineering, Department of	13	7.00
University of Toledo, The	Civil Engineering, Department of	9	7.00
Western Michigan University	Civil and Construction Engineering, Department of	8	7.00
University of Louisville	Civil and Environmental Engineering, Department of	10	6.00
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	6.00

InstitutionName	DepartmentName	No. Fac	Percentage Authors With Citation
University of New Mexico, The	Civil Engineering, Department of	17	1.00
Portland State University	Civil and Environmental Engineering, Department of	16	1.00
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	1.00
University of Colorado Denver	Civil Engineering, Department of	14	1.00
University of Louisville	Civil and Environmental Engineering, Department of	10	1.00
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	1.00
University of Toledo, The	Civil Engineering, Department of	9	1.00

University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	0.94
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	0.92
Old Dominion University	Civil and Environmental Engineering, Department of	12	0.89
University of Texas Arlington	Civil Engineering, Department of	19	0.89
University of Rhode Island	Civil and Environmental Engineering, Department of	13	0.88
Western Michigan University	Civil and Construction Engineering, Department of	8	0.88
Florida International University	Civil and Environmental Engineering, Department of	18	0.88
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	0.76

InstitutionName	DepartmentName	No. Fac	Percentage of Faculty With Citation
University of New Mexico, The	Civil Engineering, Department of	17	1.00
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	0.92
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	0.89
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	0.88
Western Michigan University	Civil and Construction Engineering, Department of	8	0.88
University of Colorado Denver	Civil Engineering, Department of	14	0.86
University of Texas Arlington	Civil Engineering, Department of	19	0.84
Florida International University	Civil and Environmental Engineering, Department of	18	0.83
University of Toledo, The	Civil Engineering, Department of	9	0.78
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	0.68
Old Dominion University	Civil and Environmental Engineering, Department of	12	0.67
Portland State University	Civil and Environmental Engineering, Department of	16	0.63
University of Louisville	Civil and Environmental Engineering, Department of	10	0.60
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	0.55
University of Rhode Island	Civil and Environmental Engineering, Department of	13	0.54

InstitutionName	DepartmentName	No. Fac	Total Citations
Portland State University	Civil and Environmental Engineering, Department of	16	1431.00
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	1267.00
University of Texas Arlington	Civil Engineering, Department of	19	1199.00
Old Dominion University	Civil and Environmental Engineering, Department of	12	857.00
University of New Mexico, The	Civil Engineering, Department of	17	635.00
University of Colorado Denver	Civil Engineering, Department of	14	578.00
Florida International University	Civil and Environmental Engineering, Department of	18	521.00
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	478.00
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	464.00
University of Toledo, The	Civil Engineering, Department of	9	380.00
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	321.00
University of Rhode Island	Civil and Environmental Engineering, Department of	13	233.00
University of Massachusetts Lowell	Civil and Environmental Engineering,	11	231.00

	Department of		
University of Louisville	Civil and Environmental Engineering, Department of	10	124.00
Western Michigan University	Civil and Construction Engineering, Department of	8	93.00

ConfProceedings Variables

InstitutionName	DepartmentName	No. Fac	Conference Proceedings per Author
University of Texas Arlington	Civil Engineering, Department of	19	9.33
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	5.25
Portland State University	Civil and Environmental Engineering, Department of	16	4.25
University of New Mexico, The	Civil Engineering, Department of	17	4.10
Western Michigan University	Civil and Construction Engineering, Department of	8	3.40
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	3.40
University of Rhode Island	Civil and Environmental Engineering, Department of	13	3.33
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	3.00
Florida International University	Civil and Environmental Engineering, Department of	18	2.67
Old Dominion University	Civil and Environmental Engineering, Department of	12	2.57
University of Colorado Denver	Civil Engineering, Department of	14	2.56
University of Toledo, The	Civil Engineering, Department of	9	2.33
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	2.00
University of Louisville	Civil and Environmental Engineering, Department of	10	1.50
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	1.25

InstitutionName	DepartmentName	No. Fac	Conference Proceedings per Faculty Member
University of Texas Arlington	Civil Engineering, Department of	19	4.42
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	3.32
University of New Mexico, The	Civil Engineering, Department of	17	2.41
Western Michigan University	Civil and Construction Engineering, Department of	8	2.13
University of Colorado Denver	Civil Engineering, Department of	14	1.64
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	1.58
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	1.55
Old Dominion University	Civil and Environmental Engineering, Department of	12	1.50
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	1.38
Florida International University	Civil and Environmental Engineering, Department of	18	1.33
Portland State University	Civil and Environmental Engineering, Department of	16	1.06
University of Toledo, The	Civil Engineering, Department of	9	0.78
University of Rhode Island	Civil and Environmental Engineering, Department of	13	0.77
University of Louisville	Civil and Environmental Engineering, Department of	10	0.60
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	0.42

InstitutionName	DepartmentName	No. Fac	Number of Faculty With a Conference Proceeding
	Civil and Environmental Engineering,		

University of North Carolina Charlotte	Department of	19	12.00
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	11.00
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	10.00
University of New Mexico, The	Civil Engineering, Department of	17	10.00
Florida International University	Civil and Environmental Engineering, Department of	18	9.00
University of Texas Arlington	Civil Engineering, Department of	19	9.00
University of Colorado Denver	Civil Engineering, Department of	14	9.00
Old Dominion University	Civil and Environmental Engineering, Department of	12	7.00
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	5.00
Western Michigan University	Civil and Construction Engineering, Department of	8	5.00
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	4.00
Portland State University	Civil and Environmental Engineering, Department of	16	4.00
University of Louisville	Civil and Environmental Engineering, Department of	10	4.00
University of Rhode Island	Civil and Environmental Engineering, Department of	13	3.00
University of Toledo, The	Civil Engineering, Department of	9	3.00

InstitutionName	DepartmentName	No. Fac	Percentage of Faculty With a Conference Proceeding
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	0.69
University of Colorado Denver	Civil Engineering, Department of	14	0.64
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	0.63
Western Michigan University	Civil and Construction Engineering, Department of	8	0.63
University of New Mexico, The	Civil Engineering, Department of	17	0.59
Old Dominion University	Civil and Environmental Engineering, Department of	12	0.58
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	0.53
Florida International University	Civil and Environmental Engineering, Department of	18	0.50
University of Texas Arlington	Civil Engineering, Department of	19	0.47
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	0.45
University of Louisville	Civil and Environmental Engineering, Department of	10	0.40
University of Toledo, The	Civil Engineering, Department of	9	0.33
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	0.33
Portland State University	Civil and Environmental Engineering, Department of	16	0.25
University of Rhode Island	Civil and Environmental Engineering, Department of	13	0.23

InstitutionName	DepartmentName	No. Fac	Total Conference Proceedings
University of Texas Arlington	Civil Engineering, Department of	19	84.00
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	63.00
University of New Mexico, The	Civil Engineering, Department of	17	41.00
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	30.00
Florida International University	Civil and Environmental Engineering, Department of	18	24.00
University of Colorado Denver	Civil Engineering, Department of	14	23.00

University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	22.00
Old Dominion University	Civil and Environmental Engineering, Department of	12	18.00
Western Michigan University	Civil and Construction Engineering, Department of	8	17.00
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	17.00
Portland State University	Civil and Environmental Engineering, Department of	16	17.00
University of Rhode Island	Civil and Environmental Engineering, Department of	13	10.00
University of Toledo, The	Civil Engineering, Department of	9	7.00
University of Louisville	Civil and Environmental Engineering, Department of	10	6.00
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	5.00

Grants Variables

InstitutionName	DepartmentName	No. Fac	Dollars per Grant
University of New Mexico, The	Civil Engineering, Department of	17	156181.36
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	121165.00
University of Toledo, The	Civil Engineering, Department of	9	121088.59
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	113451.75
University of Texas Arlington	Civil Engineering, Department of	19	107424.33
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	91513.00
Portland State University	Civil and Environmental Engineering, Department of	16	83902.88
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	73298.17
University of Louisville	Civil and Environmental Engineering, Department of	10	63225.75
University of Rhode Island	Civil and Environmental Engineering, Department of	13	60521.40
University of Colorado Denver	Civil Engineering, Department of	14	52221.00
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	46718.00
Old Dominion University	Civil and Environmental Engineering, Department of	12	43606.25
Florida International University	Civil and Environmental Engineering, Department of	18	41620.00
Western Michigan University	Civil and Construction Engineering, Department of	8	0.00

InstitutionName	DepartmentName	No. Fac	Grant Dollars per Faculty Member
University of Toledo, The	Civil Engineering, Department of	9	228722.89
University of New Mexico, The	Civil Engineering, Department of	17	128619.94
University of Texas Arlington	Civil Engineering, Department of	19	101770.42
University of Rhode Island	Civil and Environmental Engineering, Department of	13	46554.92
Portland State University	Civil and Environmental Engineering, Department of	16	41951.44
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	33045.00
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	30504.33
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	27486.81
University of Louisville	Civil and Environmental Engineering, Department of	10	25290.30
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	23884.58
Florida International University	Civil and Environmental Engineering,	18	23122.22

	Department of		
University of Colorado Denver	Civil Engineering, Department of	14	18650.36
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	17211.89
Old Dominion University	Civil and Environmental Engineering, Department of	12	14535.42
Western Michigan University	Civil and Construction Engineering, Department of	8	0.00

InstitutionName	DepartmentName	No. Fac	Grants per Faculty Member
University of Toledo, The	Civil Engineering, Department of	9	1.89
University of Texas Arlington	Civil Engineering, Department of	19	0.95
University of New Mexico, The	Civil Engineering, Department of	17	0.82
University of Rhode Island	Civil and Environmental Engineering, Department of	13	0.77
Florida International University	Civil and Environmental Engineering, Department of	18	0.56
Portland State University	Civil and Environmental Engineering, Department of	16	0.50
University of Louisville	Civil and Environmental Engineering, Department of	10	0.40
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	0.38
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	0.37
University of Colorado Denver	Civil Engineering, Department of	14	0.36
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	0.33
Old Dominion University	Civil and Environmental Engineering, Department of	12	0.33
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	0.27
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	0.21
Western Michigan University	Civil and Construction Engineering, Department of	8	0.00

InstitutionName	DepartmentName	No. Fac	Number of Faculty Members With Grant
University of Texas Arlington	Civil Engineering, Department of	19	10.00
University of New Mexico, The	Civil Engineering, Department of	17	6.00
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	6.00
University of Rhode Island	Civil and Environmental Engineering, Department of	13	5.00
Portland State University	Civil and Environmental Engineering, Department of	16	5.00
Florida International University	Civil and Environmental Engineering, Department of	18	4.00
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	4.00
University of Toledo, The	Civil Engineering, Department of	9	4.00
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	4.00
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	3.00
Old Dominion University	Civil and Environmental Engineering, Department of	12	3.00
University of Colorado Denver	Civil Engineering, Department of	14	2.00
University of Louisville	Civil and Environmental Engineering, Department of	10	2.00
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	1.00
Western Michigan University	Civil and Construction Engineering, Department of	8	0.00

			Percentage of Faculty With

InstitutionName	DepartmentName	No. Fac	Grant
University of Texas Arlington	Civil Engineering, Department of	19	0.53
University of Toledo, The	Civil Engineering, Department of	9	0.44
University of Rhode Island	Civil and Environmental Engineering, Department of	13	0.38
University of New Mexico, The	Civil Engineering, Department of	17	0.35
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	0.33
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	0.32
Portland State University	Civil and Environmental Engineering, Department of	16	0.31
Old Dominion University	Civil and Environmental Engineering, Department of	12	0.25
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	0.25
Florida International University	Civil and Environmental Engineering, Department of	18	0.22
University of Louisville	Civil and Environmental Engineering, Department of	10	0.20
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	0.16
University of Colorado Denver	Civil Engineering, Department of	14	0.14
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	0.09
Western Michigan University	Civil and Construction Engineering, Department of	8	0.00

InstitutionName	DepartmentName	No. Fac	Total Grant Dollars
University of New Mexico, The	Civil Engineering, Department of	17	2186539.00
University of Toledo, The	Civil Engineering, Department of	9	2058506.00
University of Texas Arlington	Civil Engineering, Department of	19	1933638.00
Portland State University	Civil and Environmental Engineering, Department of	16	671223.00
University of Rhode Island	Civil and Environmental Engineering, Department of	13	605214.00
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	453807.00
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	439789.00
Florida International University	Civil and Environmental Engineering, Department of	18	416200.00
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	366052.00
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	363495.00
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	327026.00
University of Colorado Denver	Civil Engineering, Department of	14	261105.00
University of Louisville	Civil and Environmental Engineering, Department of	10	252903.00
Old Dominion University	Civil and Environmental Engineering, Department of	12	174425.00
Western Michigan University	Civil and Construction Engineering, Department of	8	0.00

InstitutionName	DepartmentName	No. Fac	Total Number of Grants
University of Texas Arlington	Civil Engineering, Department of	19	18.00
University of Toledo, The	Civil Engineering, Department of	9	17.00
University of New Mexico, The	Civil Engineering, Department of	17	14.00
Florida International University	Civil and Environmental Engineering, Department of	18	10.00
University of Rhode Island	Civil and Environmental Engineering, Department of	13	10.00

Portland State University	Civil and Environmental Engineering, Department of	16	8.00
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	7.00
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	6.00
University of Colorado Denver	Civil Engineering, Department of	14	5.00
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	4.00
University of Louisville	Civil and Environmental Engineering, Department of	10	4.00
Old Dominion University	Civil and Environmental Engineering, Department of	12	4.00
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	4.00
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	3.00
Western Michigan University	Civil and Construction Engineering, Department of	8	0.00

Honors Variables

InstitutionName	DepartmentName	No. Fac	Awards per Faculty Member
University of Louisville	Civil and Environmental Engineering, Department of	10	0.80
Portland State University	Civil and Environmental Engineering, Department of	16	0.56
University of New Mexico, The	Civil Engineering, Department of	17	0.47
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	0.32
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	0.31
Florida International University	Civil and Environmental Engineering, Department of	18	0.28
Old Dominion University	Civil and Environmental Engineering, Department of	12	0.25
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	0.25
University of Texas Arlington	Civil Engineering, Department of	19	0.16
University of Rhode Island	Civil and Environmental Engineering, Department of	13	0.15
University of Colorado Denver	Civil Engineering, Department of	14	0.14
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	0.11
University of Toledo, The	Civil Engineering, Department of	9	0.11
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	0.09
Western Michigan University	Civil and Construction Engineering, Department of	8	0.00

InstitutionName	DepartmentName	No. Fac	Number of Faculty Members With Award
University of New Mexico, The	Civil Engineering, Department of	17	6.00
Portland State University	Civil and Environmental Engineering, Department of	16	6.00
Florida International University	Civil and Environmental Engineering, Department of	18	5.00
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	4.00
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	4.00
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	3.00
University of Texas Arlington	Civil Engineering, Department of	19	3.00
University of Colorado Denver	Civil Engineering, Department of	14	2.00
University of Louisville	Civil and Environmental Engineering, Department of	10	2.00
Old Dominion University	Civil and Environmental Engineering,	12	2.00

	Department of		
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	2.00
University of Rhode Island	Civil and Environmental Engineering, Department of	13	1.00
University of Toledo, The	Civil Engineering, Department of	9	1.00
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	1.00
Western Michigan University	Civil and Construction Engineering, Department of	8	0.00

InstitutionName	DepartmentName	No. Fac	Percentage of Faculty With Award
Portland State University	Civil and Environmental Engineering, Department of	16	0.38
University of New Mexico, The	Civil Engineering, Department of	17	0.35
Florida International University	Civil and Environmental Engineering, Department of	18	0.28
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	0.25
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	0.25
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	0.21
University of Louisville	Civil and Environmental Engineering, Department of	10	0.20
Old Dominion University	Civil and Environmental Engineering, Department of	12	0.17
University of Texas Arlington	Civil Engineering, Department of	19	0.16
University of Colorado Denver	Civil Engineering, Department of	14	0.14
University of Toledo, The	Civil Engineering, Department of	9	0.11
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	0.11
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	0.09
University of Rhode Island	Civil and Environmental Engineering, Department of	13	0.08
Western Michigan University	Civil and Construction Engineering, Department of	8	0.00

InstitutionName	DepartmentName	No. Fac	Total Awards
Portland State University	Civil and Environmental Engineering, Department of	16	9.00
University of New Mexico, The	Civil Engineering, Department of	17	8.00
University of Louisville	Civil and Environmental Engineering, Department of	10	8.00
University of Nevada, Las Vegas	Civil and Environmental Engineering and Construction , Department of	19	6.00
University of Texas at San Antonio, The	Civil and Environmental Engineering, Department of	16	5.00
Florida International University	Civil and Environmental Engineering, Department of	18	5.00
University of Wisconsin - Milwaukee	Civil Engineering and Mechanics, Department of	12	3.00
Old Dominion University	Civil and Environmental Engineering, Department of	12	3.00
University of Texas Arlington	Civil Engineering, Department of	19	3.00
University of Colorado Denver	Civil Engineering, Department of	14	2.00
University of North Carolina Charlotte	Civil and Environmental Engineering, Department of	19	2.00
University of Rhode Island	Civil and Environmental Engineering, Department of	13	2.00
University of Toledo, The	Civil Engineering, Department of	9	1.00
University of Massachusetts Lowell	Civil and Environmental Engineering, Department of	11	1.00
Western Michigan University	Civil and Construction Engineering, Department of	8	0.00

Academic Analytics Department Profile

Civil Engineering: Civil Engineering

Based On Fall 2014 Data

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Quintile Analysis 19

Box Plots 20

Research Market Share 21

Appendix 24

Note: Academic Analytics has a 1 year delay built into the release of its compiled databases. The information represented in this report is based on data from various date ranges up to the Fall of 2014 as illustrated in the table below.

Academic Analytics 2014 Data Coverage

Faculty:	**Academic Year 2014 - 2015**
Journal Articles:	**2011 - 2014**
Citations*:	**2010 - 2014**
Conference Proceedings:	**2011 - 2014**
Books:	**2005 - 2014**
Grants:	**2010 - 2014**
Awards:	**No Limit**

*For articles published five years ago, five years have elapsed during which citations may have accrued (for the 2014 database, an article published in 2010 could have been cited in 2010, 2011, 2012, 2013, and 2014). An article published in 2011 could have been cited in 2011, 2012, 2013, or 2014 (four years of citations). An article published in 2012 could have been cited for 3 years (2012, 2013, or 2014); and so on. In sum, we have five years of citations to articles that are 5 years old, 4 years of citations to articles that are 4 years old, 3 years of citations to articles that are 3 years old, etc.

Faculty List:

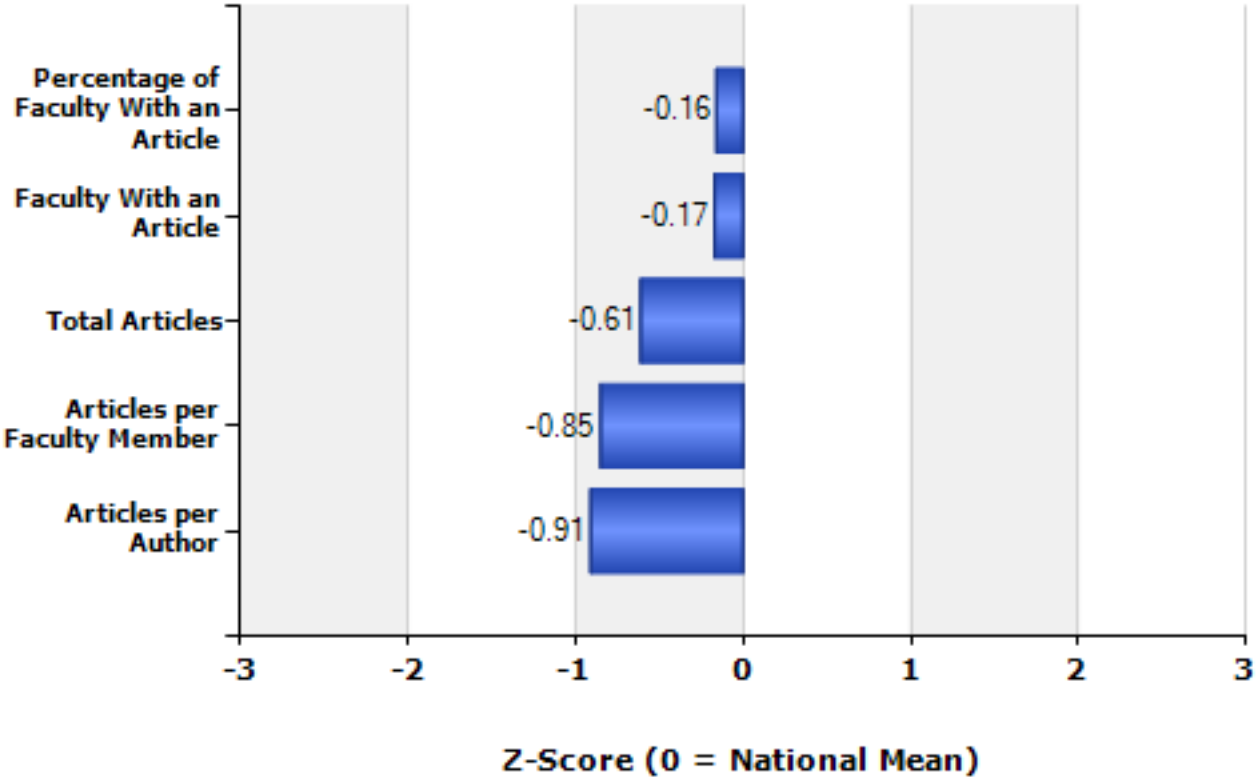
Full Name	Faculty Rank	Tenure Status	FacultyType	Administrative Position	Hire Date	Terminal Degree	Terminal Degree Year	Terminal Degree Institution
Wu, Jy S	Professor	Tenured	Regular		08/25/1980	PHD	1980	Rutgers University-Univ Coll
Daniels, John L	Professor	Tenured	Regular	Department Chair / Head AC	01/01/2001	PHD	2001	University of MA-Lowell
Weggel, David Carl	Professor	Tenured	Regular		08/16/2002	PHD	1997	University of TX-Austin
Janardhanam, Rajaram	Professor	Tenured	Regular		08/25/1980	PHD	1981	Virginia Tech
Bowen, James D	Associate Professor	Tenured	Regular		12/15/1995	PHD	1990	MIT
Tempest, Brett Quentin	Assistant Professor	TenureTrack	Regular		08/16/2010	PHD	2010	UNC Charlotte
Young, David T	Professor	Tenured	Regular		08/18/1985	PHD	1985	Virginia Tech
Ogunro, Vincent Oloruntobi	Associate Professor	Tenured	Regular		01/01/2001	PHD	1997	Nat'l Inst Applied Scien Lyon
Kane, Martin R	Associate Professor	Tenured	Regular		08/01/1995	PHD	1995	Michigan State University
Amburgey, James E	Associate Professor	Tenured	Regular		08/17/2005	PHD	2002	Georgia Institute of Tech
Gergely, Ioan	Associate Professor	Tenured	Regular		08/17/1998	PHD	1998	University of UT
Warren, Kimberly Anne	Associate Professor	Tenured	Regular		08/17/2005	PHD	2003	North Carolina State Univ
Chen, Shen-En	Professor	Tenured	Regular		08/17/2005	PHD	1996	West Virginia University
Pulugurtha, Srinivas Subrahmanyam	Professor	Tenured	Regular		08/17/2005	PHD	1998	University of NV-Las Vegas
Pando, Miguel A	Associate Professor	Tenured	Regular		08/16/2010	PHD	2003	Virginia Tech
Whelan, Matthew James	Assistant Professor	TenureTrack	Regular		08/16/2010	PHD	2009	Clarkson University
Khire, Milind Vishnu	Professor	Tenured	Regular		12/02/2013	PHD	1995	University of WI-Madison
Keen, Olya S	Assistant Professor	TenureTrack	Regular		01/01/2013	PHD	2012	University of CO-Boulder
Fan, Wei	Associate Professor	TenureTrack	Regular		08/15/2013	PHD	2004	University of TX-Austin

Department Gauge

Civil and Environmental Engineering, Department of | Civil Engineering (154 Departments)

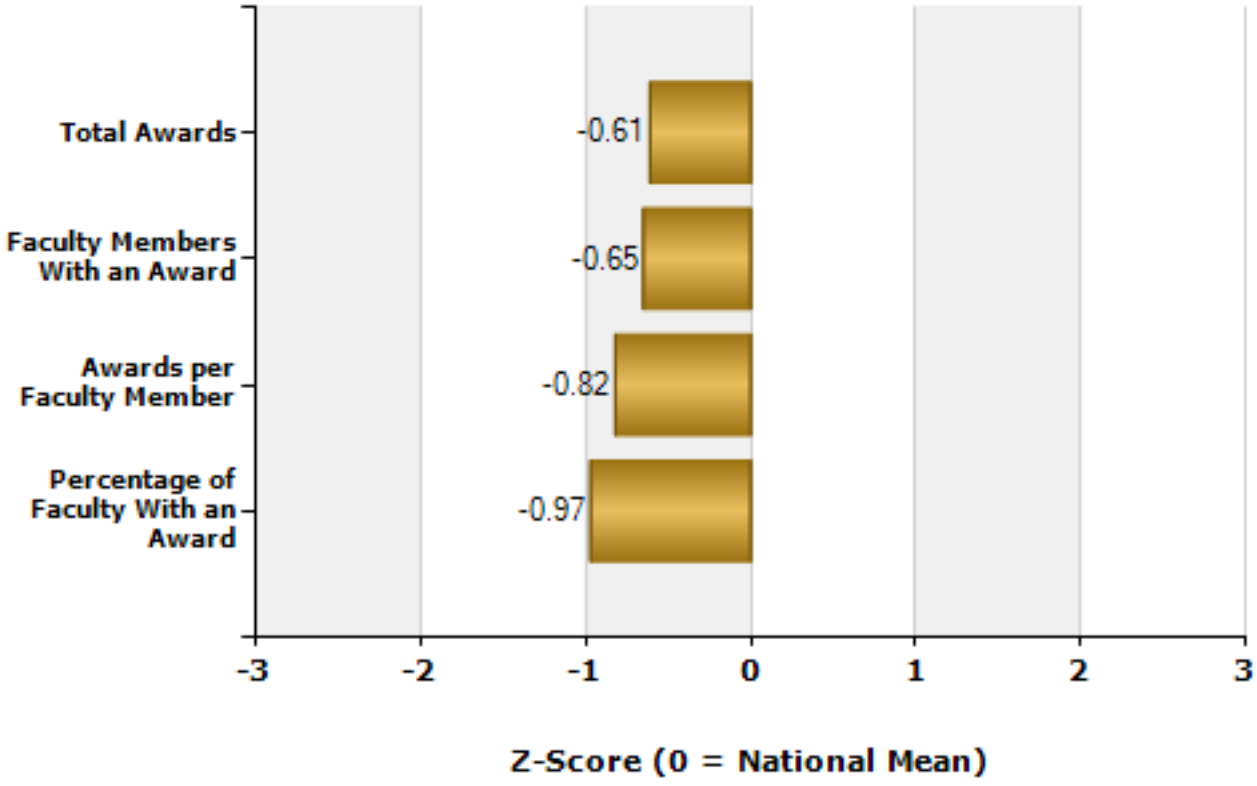
Department Gauge - Articles

University of North Carolina Charlotte | Civil and Environmental Engineering, Department of



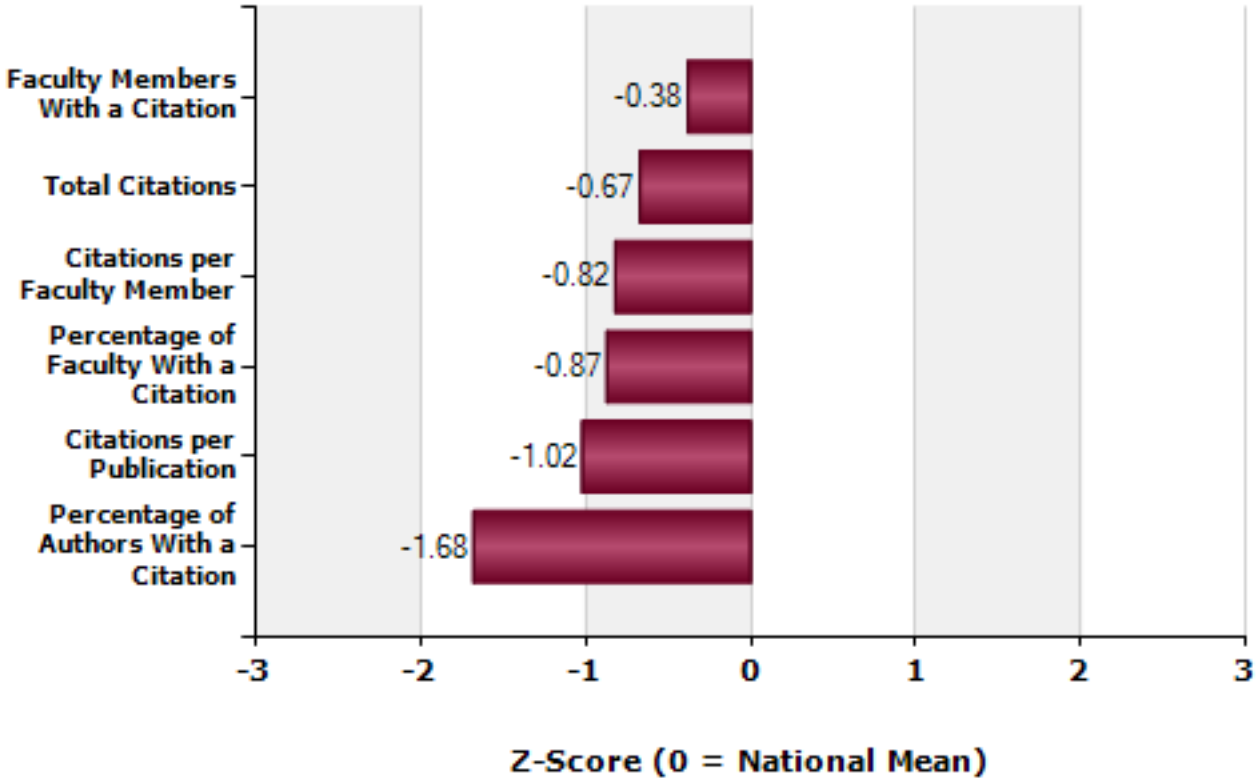
Department Gauge - Awards

University of North Carolina Charlotte | Civil and Environmental Engineering, Department of



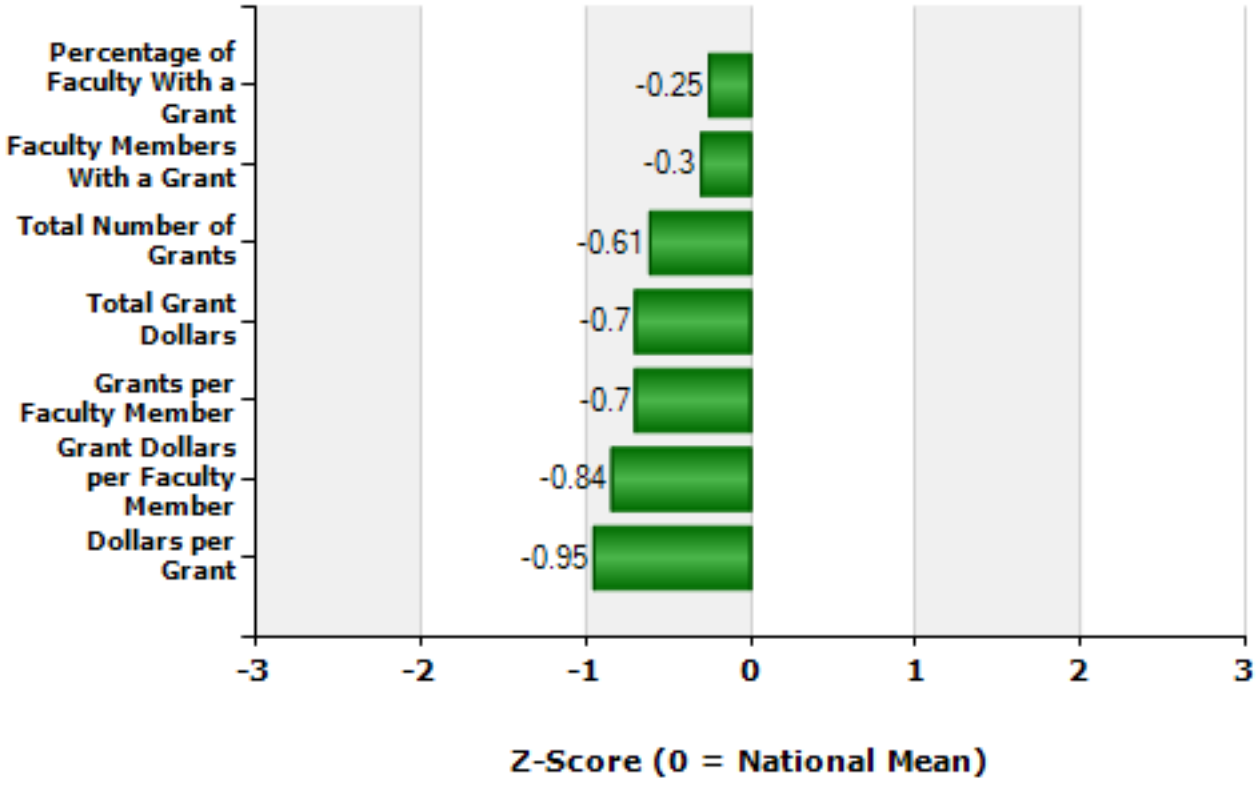
Department Gauge - Citations

University of North Carolina Charlotte | Civil and Environmental Engineering, Department of



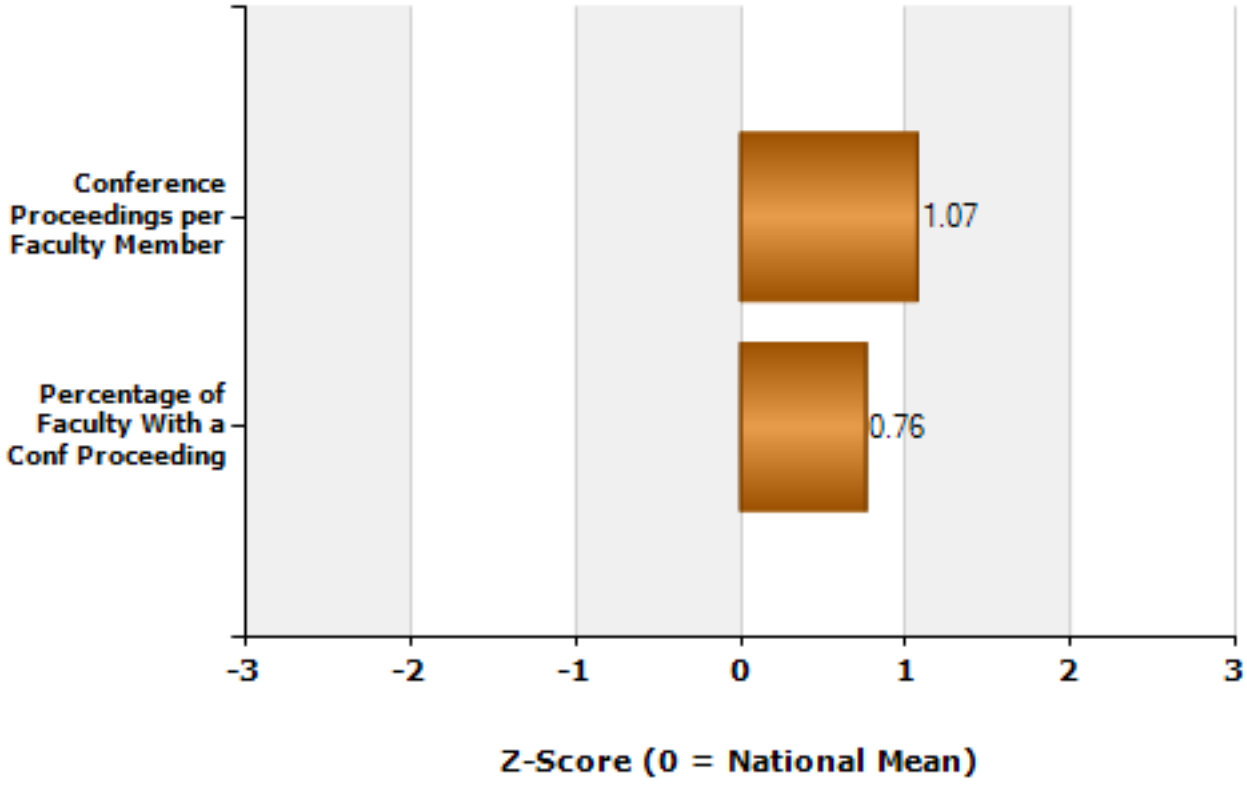
Department Gauge - Grants

University of North Carolina Charlotte | Civil and Environmental Engineering, Department of



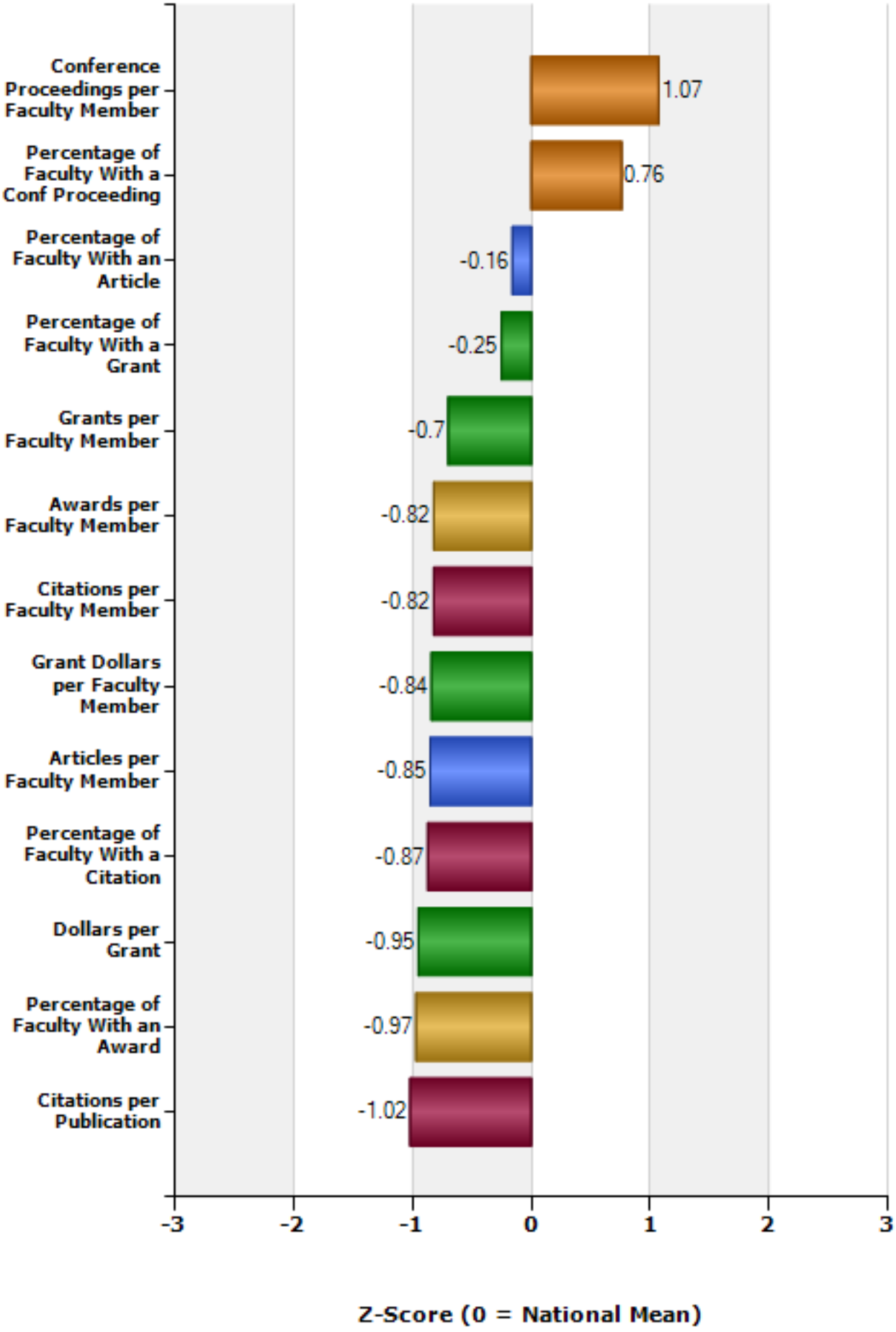
Department Gauge - Conference Proceedings

University of North Carolina Charlotte | Civil and Environmental Engineering, Department of



Department Gauge - Index Variables

University of North Carolina Charlotte | Civil and Environmental Engineering, Department of

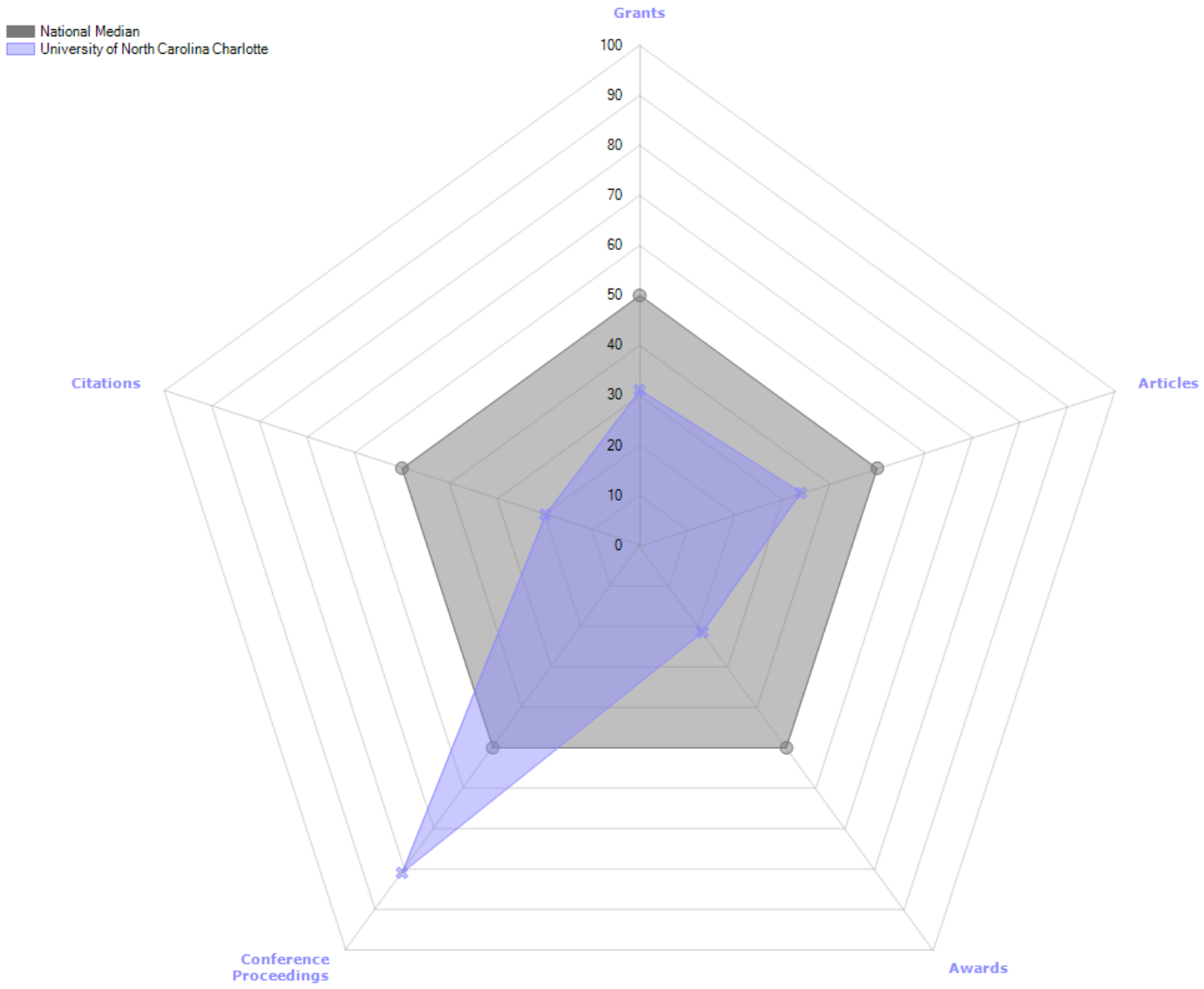


Productivity Radar

Civil and Environmental Engineering, Department of | Civil Engineering (154 Departments) (154 Departments)

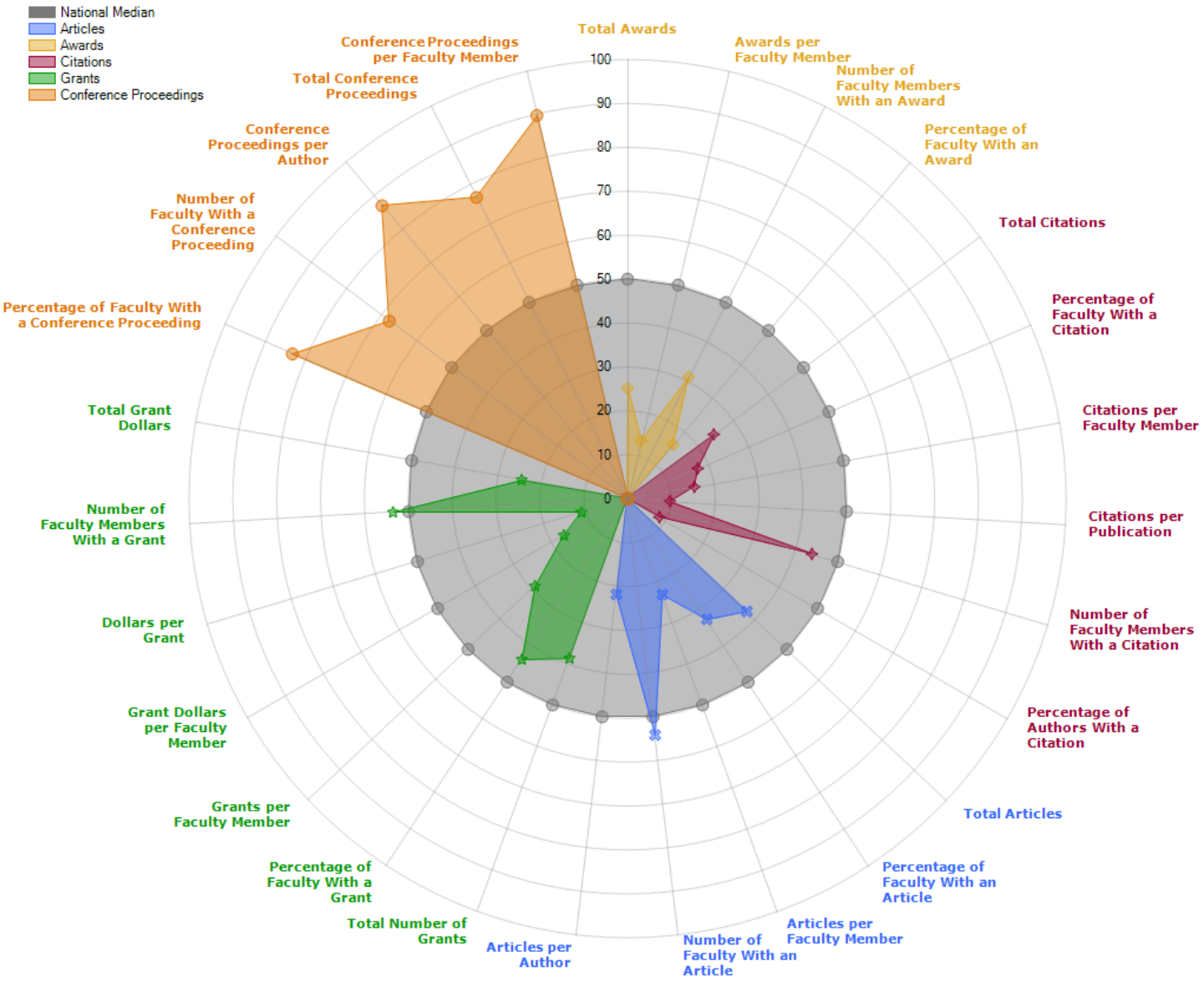
Department Radar - All Variables Summary

University of North Carolina Charlotte | Civil and Environmental Engineering, Department of



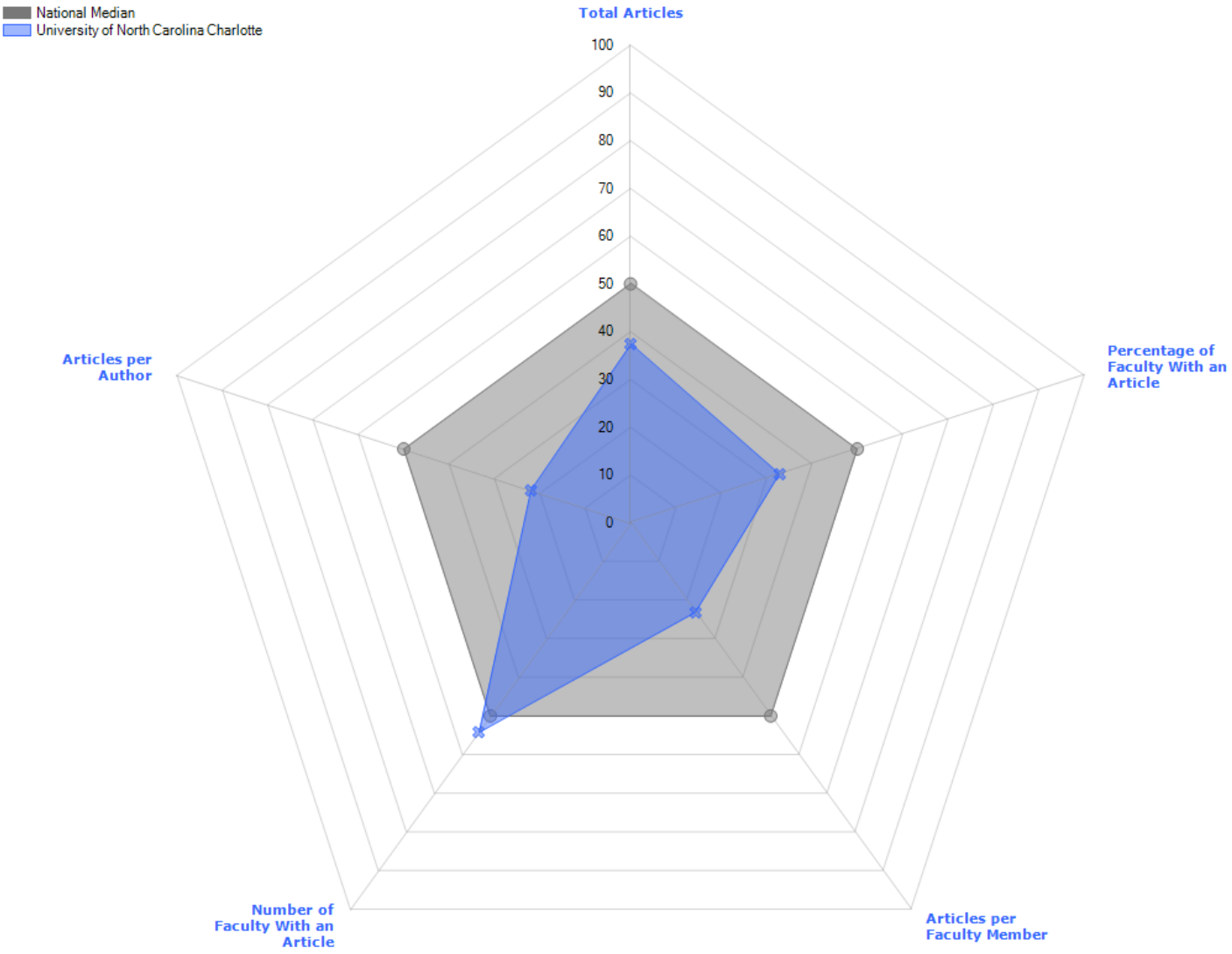
Department Radar - All Variables

University of North Carolina Charlotte | Civil and Environmental Engineering, Department of



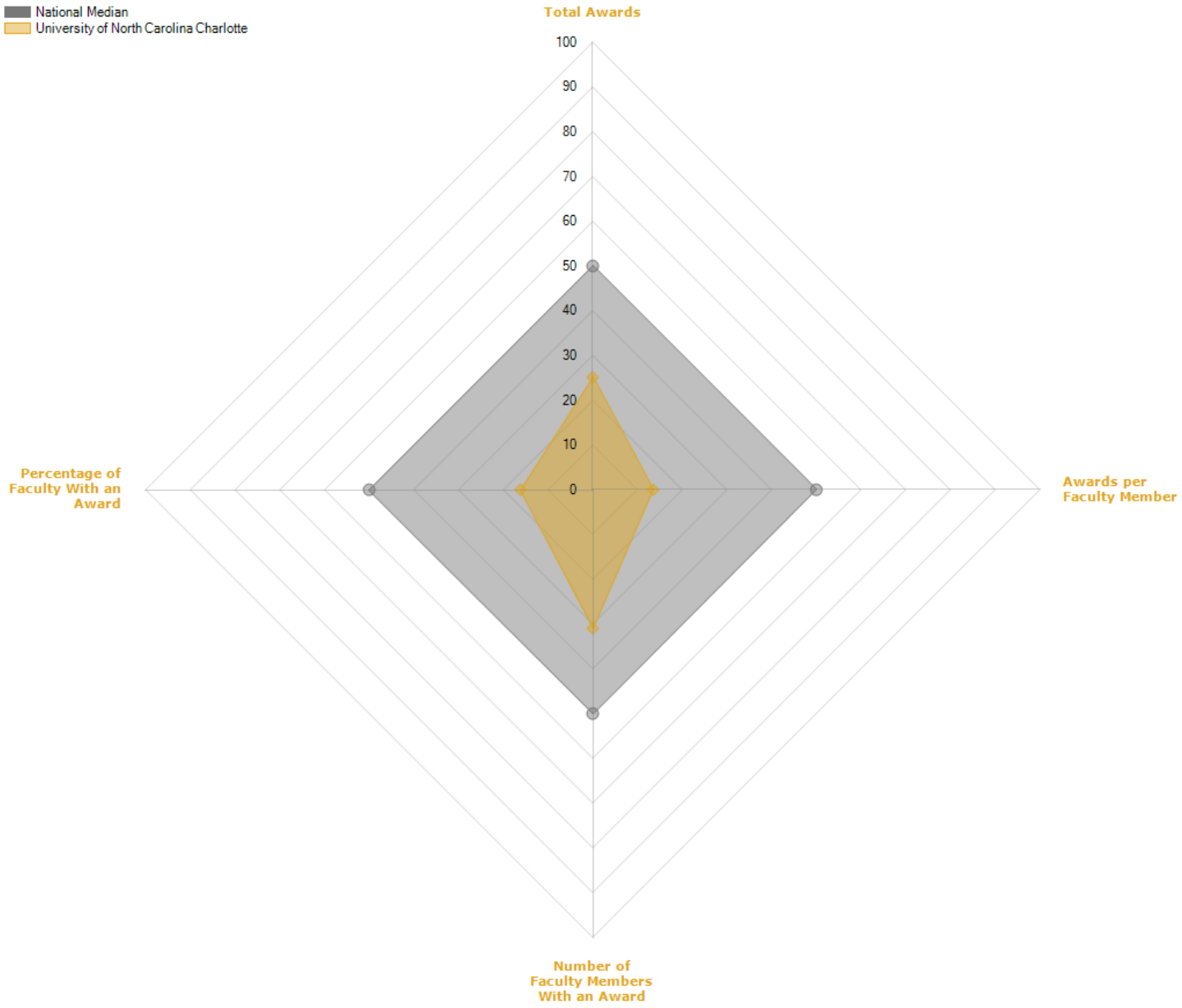
Department Radar - Articles

University of North Carolina Charlotte | Civil and Environmental Engineering, Department of



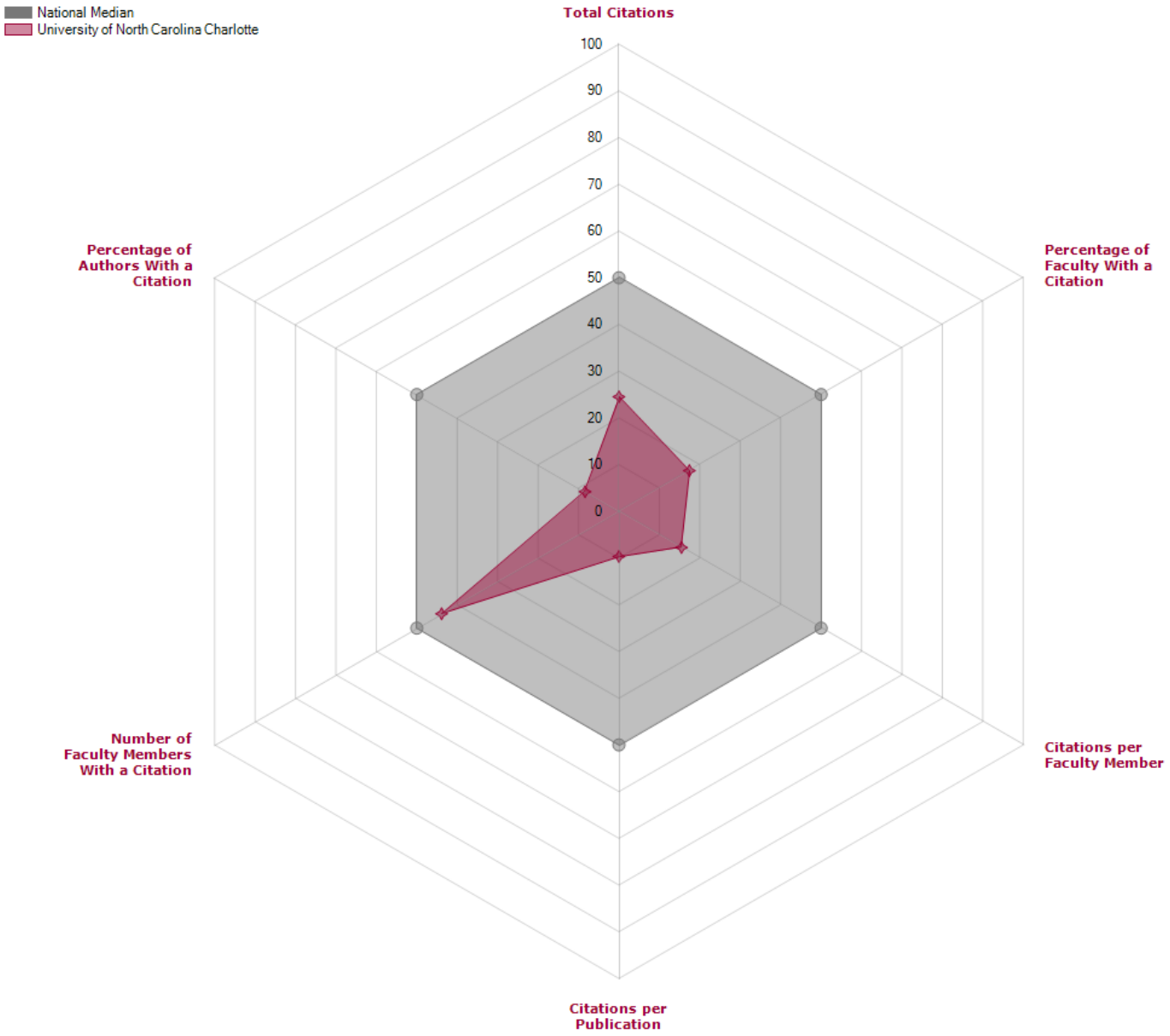
Department Radar - Awards

University of North Carolina Charlotte | Civil and Environmental Engineering, Department of



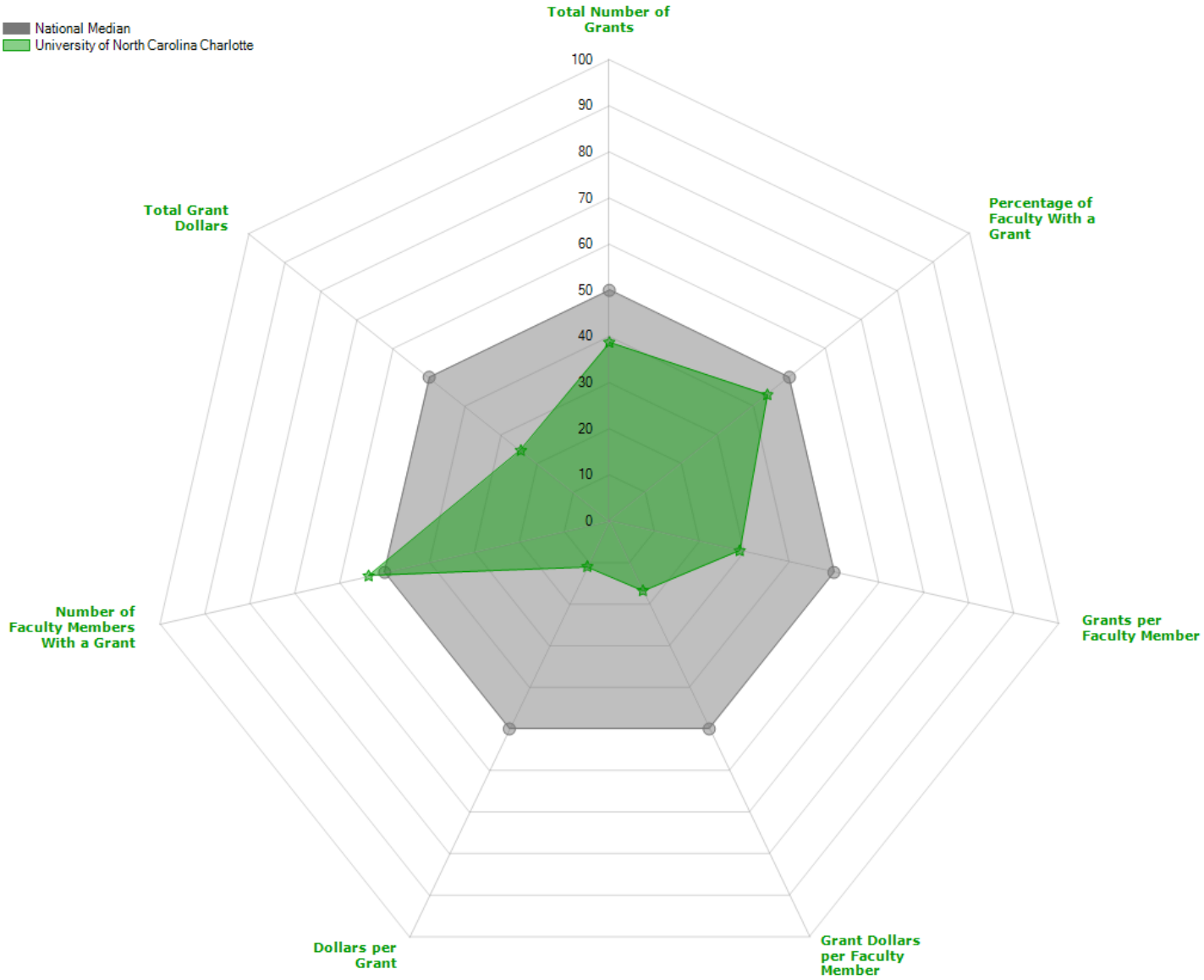
Department Radar - Citations

University of North Carolina Charlotte | Civil and Environmental Engineering, Department of



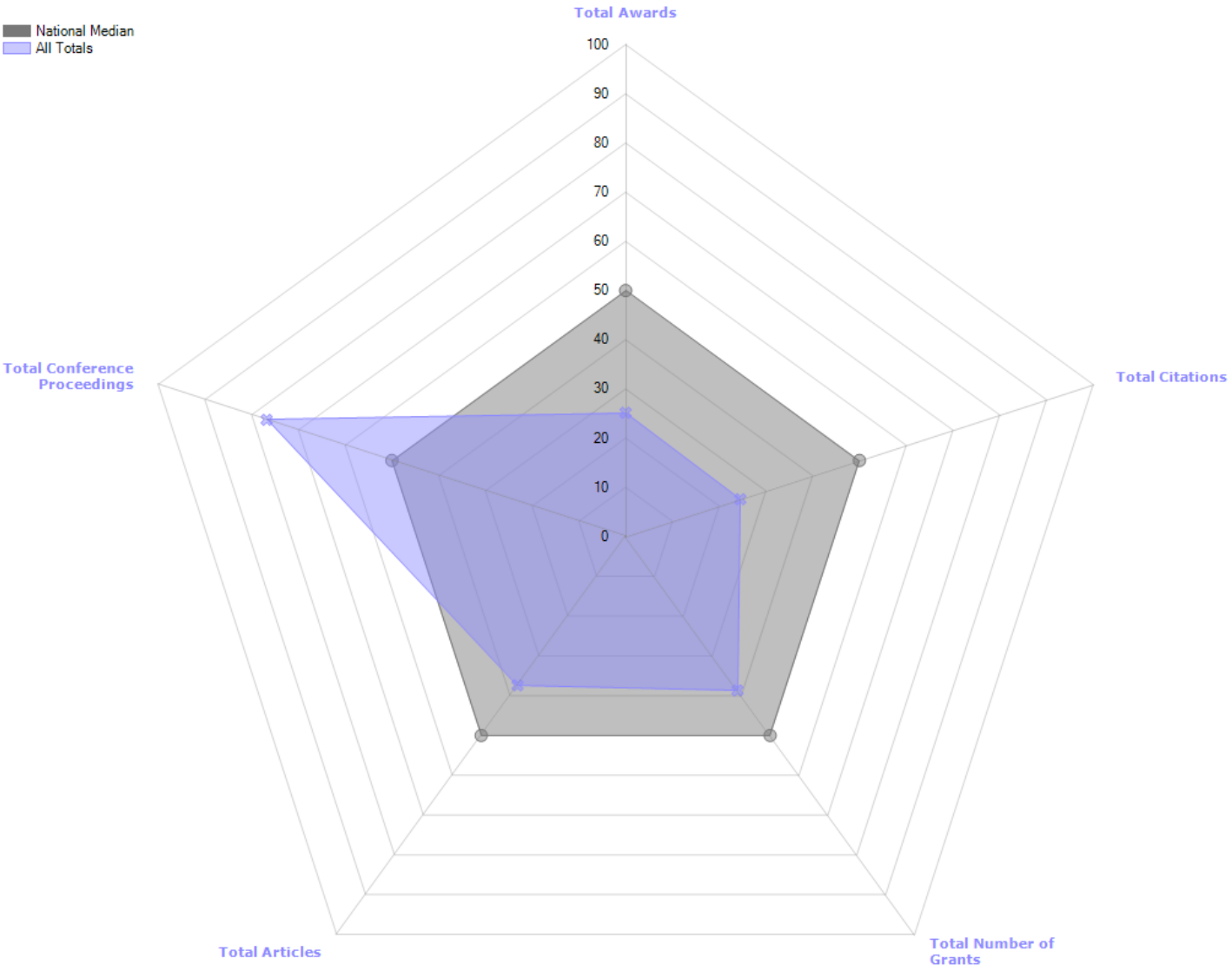
Department Radar - Grants

University of North Carolina Charlotte | Civil and Environmental Engineering, Department of



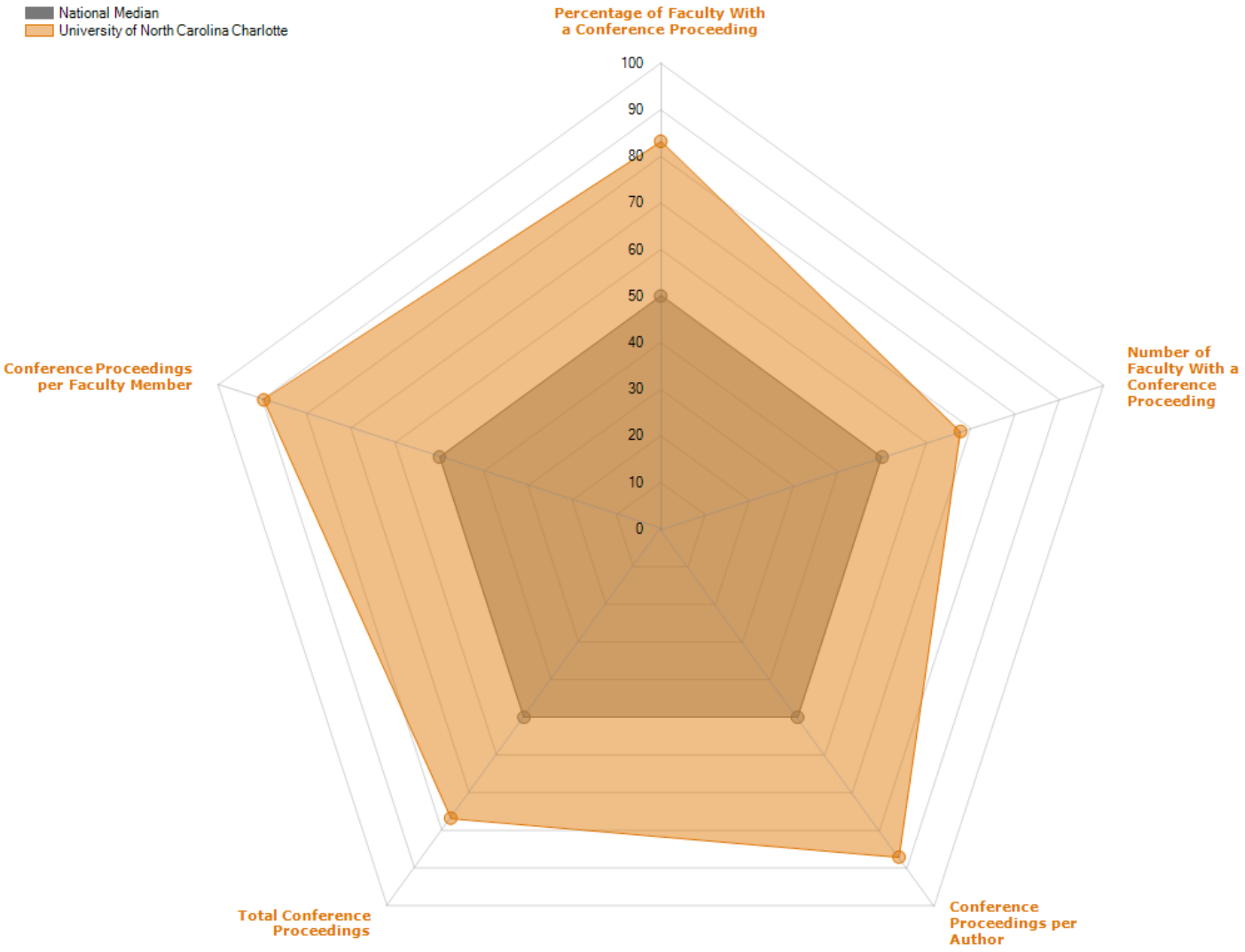
Department Radar - Totals

University of North Carolina Charlotte | Civil and Environmental Engineering, Department of



Department Radar - Conference Proceedings

University of North Carolina Charlotte | Civil and Environmental Engineering, Department of



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Department Faculty

Department: Civil and Environmental Engineering, Departm

Discipline: Civil Engineering (154 Departments)

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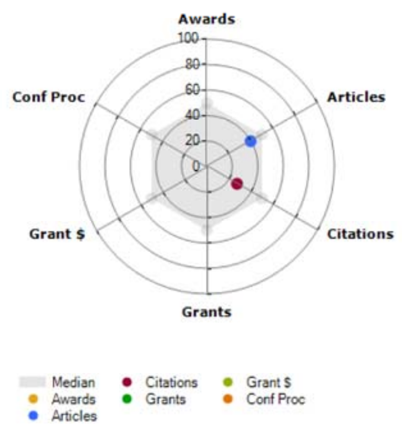
Department Faculty Xqlyhuvlw|#ri#Qruwk#Fdurolqd#Fkduorwwh##Flylo#dqg#Hqylurqphqwdo#Hqjlqhhulqj/#Ghsduwphqw#ri



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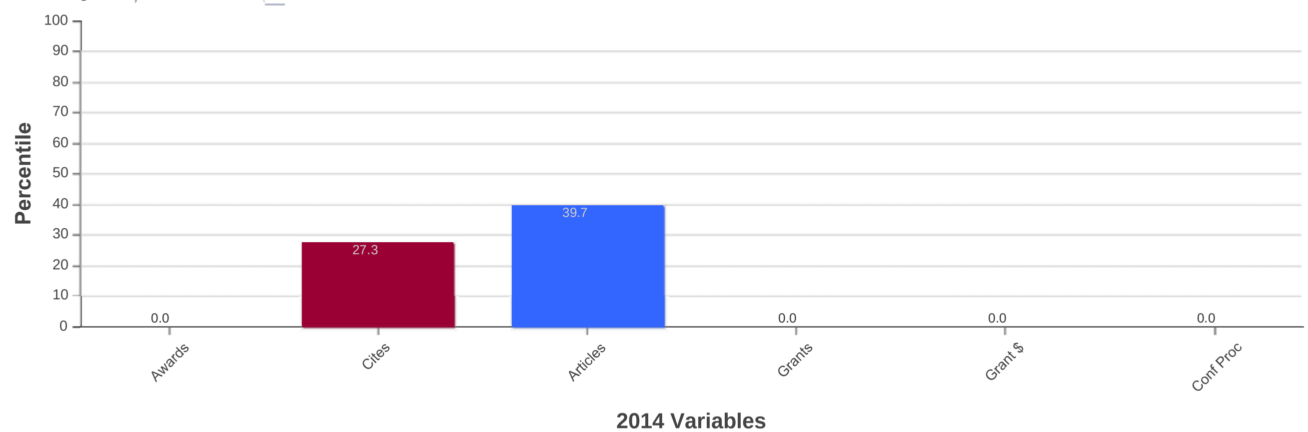

Details - Click here to view Details

ACADEMIC ANALYTICS

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Department Quintile Analysis

Important Notice About Departmental Comparison

Department: Civil and Environmental Engineering, Departm

Discipline: Civil Engineering (154 Departments)

Download Data

Discipline Quintiles

Calculated by Faculty Rank CHANGE

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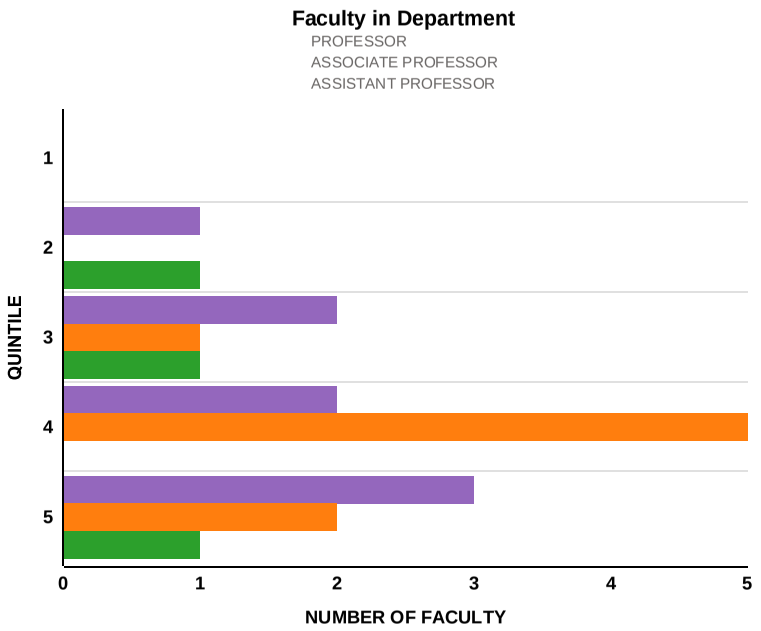
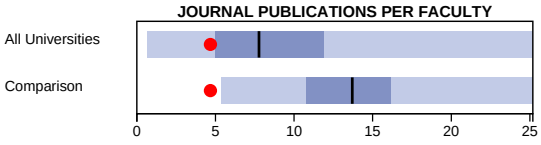
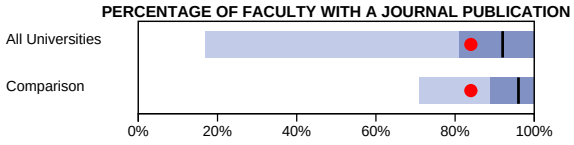
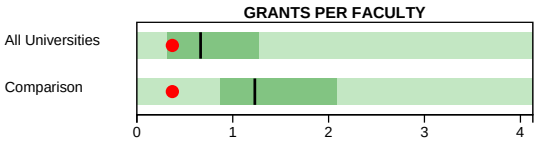
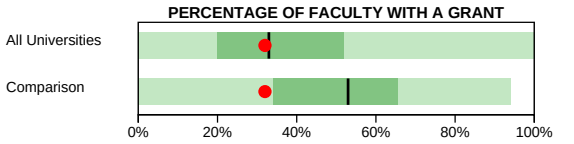
Rank	Quintile	# Faculty	Citations	Articles	Awards	Conf Proc	Grants	Annual Grant Dollars
	4	5<8	736166	6414<	41;7	7179	617<	'7;7/8;6194
	5	5<7	463136	4;149	31<;	61<<	4167	'4:5/69;1<7
Surihvvru	6	5<7	84158	<195	31:8	516<	3193	':9/969187
	7	5<7	49168	7197	31;7	4189	3175	'7:/733169
	8	5<3	41;4	4138	316;	3173	313:	';/5641<9
	4	4::	663149	5717;	31<5	7145	6176	'66:/5941<3
	5	4:9	;:1;5	451;<	3178	5168	416<	'45</5;319;
Dvvrfldwh Surihvvru	6	4:9	66155	;168	315:	5153	3195	'7</33;163
	7	4:9	<1:3	619;	315:	4159	3164	'66/68;143
	8	4:7	31:8	3185	3147	314:	3136	'5/6:9165
	4	476	58:148	4:188	3176	6173	41:5	'488/99:1<7
	5	475	;6164	43147	314;	615<	319;	'97/877179
Dvvlvwdqw Surihvvru	6	475	781;;	:19;	3139	41:6	3164	'58/9<3144
	7	475	53165	7198	3137	41:8	3147	'43/;57156
	8	474	61:5	419<	3136	31:<	3137	'5/:<4178

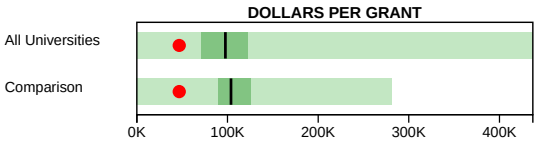


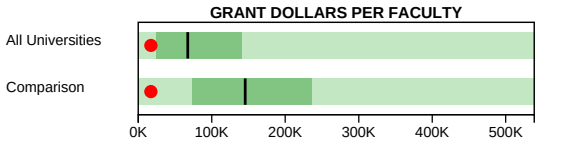


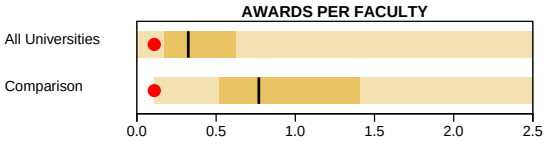


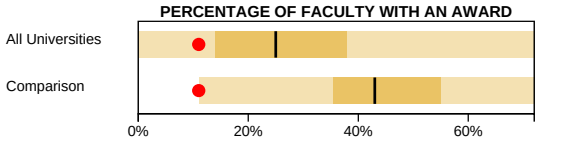


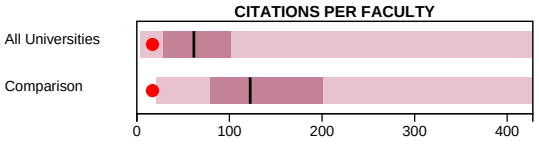


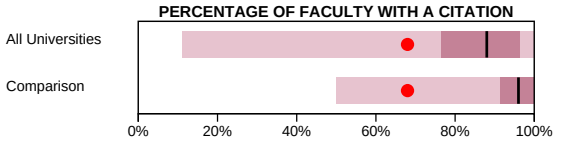


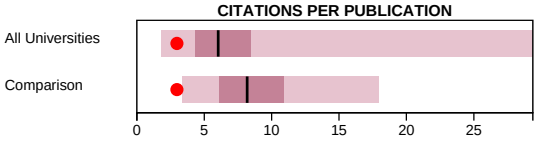












Grants Market Share

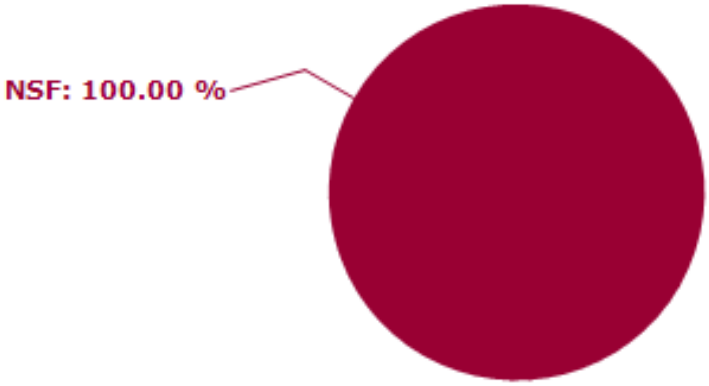
Civil and Environmental Engineering, Department of | Civil Engineering (154 Departments)

Department Percent of Available Grant Dollars Won

University of North Carolina Charlotte | Civil and Environmental Engineering, Department of

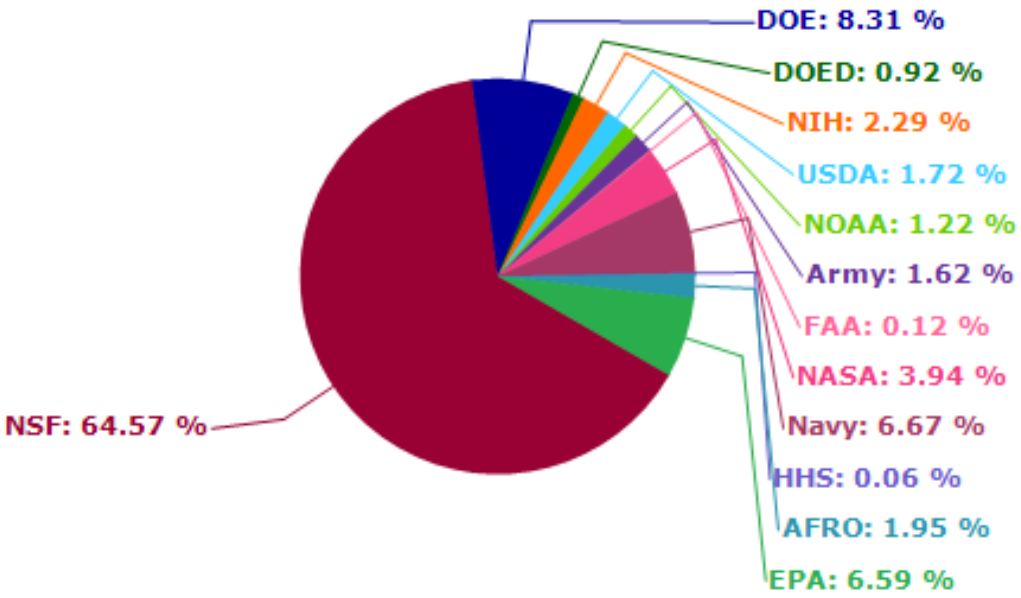
Agency	Percent of Available $ Won	Available $
Air Force Research Office	0.0%	$7,010,192
American Cancer Society	0.0%	$0
American Heart Association	0.0%	$0
Army Research Office	0.0%	$5,824,960
Department of Agriculture	0.0%	$6,159,672
Department Of Education	0.0%	$3,317,513
Department Of Energy	0.0%	$29,834,009
Dept. Health and Human Services	0.0%	$226,445
Environmental Protection Agency	0.0%	$23,671,526
Federal Aviation Administration	0.0%	$421,347
National Aeronautics and Space Administration	0.0%	$14,154,237
National Endowment For the Arts	0.0%	$0
National Endowment for the Humanities	0.0%	$0
National Institutes of Health	0.0%	$8,224,170
National Oceanic and Atmospheric Administration	0.0%	$4,388,635
National Science Foundation	0.1%	$231,788,044
Office of Naval Research	0.0%	$23,926,302

Department Funding



Agency	Total Grant $ Per Year
Air Force Research Office	0
American Cancer Society	0
American Heart Association	0
Army Research Office	0
Department of Agriculture	0
Department Of Education	0
Department Of Energy	0
Dept. Health and Human Services	0
Environmental Protection Agency	0
Federal Aviation Administration	0
National Aeronautics and Space Administration	0
National Endowment For the Arts	0
National Endowment for the Humanities	0
National Institutes of Health	0
National Oceanic and Atmospheric Administration	0
National Science Foundation	300,476
Office of Naval Research	0

Department Funding for AA Classification



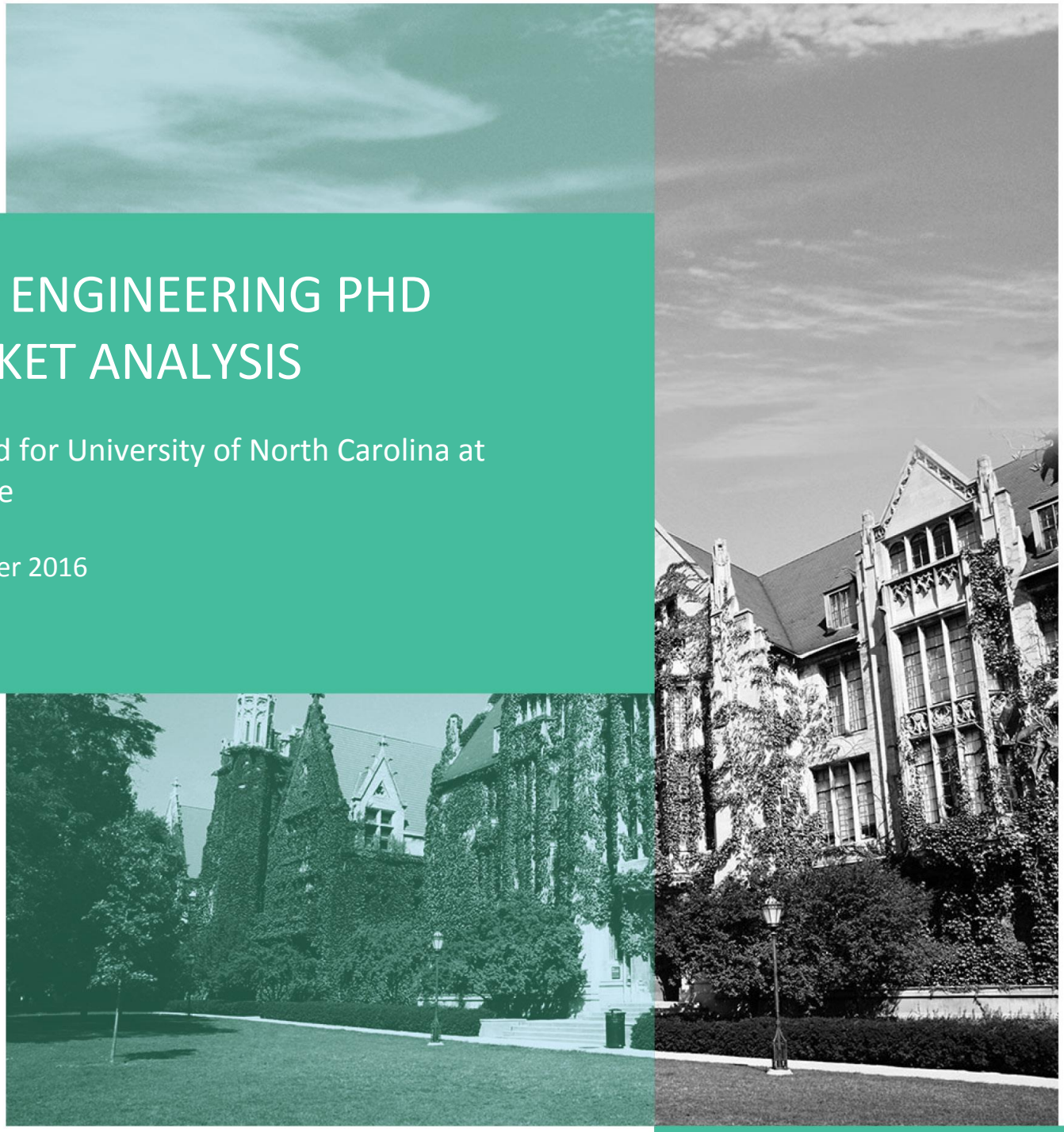
Agency	Total Grant $ Per Year
Air Force Research Office	7,010,192
American Cancer Society	0
American Heart Association	0
Army Research Office	5,824,960
Department of Agriculture	6,159,672
Department Of Education	3,317,513
Department Of Energy	29,834,009
Dept. Health and Human Services	226,445
Environmental Protection Agency	23,671,526
Federal Aviation Administration	421,347
National Aeronautics and Space Administration	14,154,237
National Endowment For the Arts	0
National Endowment for the Humanities	0
National Institutes of Health	8,224,170
National Oceanic and Atmospheric Administration	4,388,635
National Science Foundation	231,788,044
Office of Naval Research	23,926,302

Appendix A: Academic Discipline Weighting Schemes

Discipline Name	Awards	Books	Citations	Grants	Publications	Conference Proceedings
Accounting	5	14	40	0	41	0
Aerospace Engineering	10	0	30	30	18	12
Agricultural Economics	10	0	40	10	40	0
Agricultural/Biological Engineering and Bioengineering	20	0	25	30	25	0
Agriculture, various	10	0	40	10	40	0
Agronomy and Crop Science	10	0	35	20	35	0
American Studies	20	53	13	0	14	0
Anatomy	10	0	30	30	30	0
Ancient Studies	20	50	10	10	10	0
Animal Sciences	10	0	35	20	35	0
Anthropology	20	22	19	20	19	0
Applied Economics	10	10	35	10	35	0
Applied Mathematics	10	0	30	30	23	7
Applied Physics	20	0	25	30	19	6
Architecture	20	29	21	10	20	0
Architecture, Design, Planning, various	20	20	25	10	25	0
Area and Ethnic Studies, various	20	40	15	10	15	0
Art History and Criticism	20	57	12	0	11	0
Asian Languages	20	46	12	10	12	0
Asian Studies	20	54	13	0	13	0
Astronomy and Astrophysics	20	0	25	30	19	6
Atmospheric Sciences and Meteorology	10	0	30	30	30	0
Biochemistry	10	0	30	30	30	0
Bioinformatics and Computational Biology	10	0	30	30	30	0
Biological Sciences, various	10	0	30	30	30	0
Biology/Biological Sciences, General	10	0	30	30	30	0
Biomedical Engineering	10	0	30	30	22	8
Biomedical Sciences, General	10	0	30	30	30	0
Biomedical Sciences, various	10	0	30	30	30	0
Biophysics	20	0	25	30	25	0
Biostatistics	10	0	35	20	35	0
Botany/Plant Biology	10	0	30	30	30	0
Business Administration	10	17	37	0	36	0
Business, various	10	17	37	0	36	0
Cell Biology	10	0	30	30	30	0
Chemical Engineering	10	0	30	30	30	0
Chemical Sciences, various	20	0	25	30	25	0
Chemistry	10	0	30	30	30	0
Civil Engineering	10	0	30	30	21	9
Classics and Classical Languages	20	59	10	0	11	0
Clinical Psychology	10	8	31	20	31	0
Cognitive Science	10	0	30	30	30	0
Communication and Communication Studies	10	27	31	0	32	0
Communication Disorders and Sciences	10	5	33	20	32	0
Comparative Literature	20	56	12	0	12	0
Composition, Rhetoric and Writing	20	51	15	0	14	0
Computational Sciences	20	0	25	30	17	8
Computer and Information Sciences, various	10	0	35	20	20	15
Computer Engineering	10	0	30	30	16	14
Computer Science	10	0	30	30	16	14
Consumer and Human Sciences, various	10	5	38	10	37	0
Counseling Psychology	10	10	35	10	35	0
Counselor Education	10	19	35	0	36	0
Criminal Justice and Criminology	10	24	28	10	28	0
Curriculum and Instruction	10	29	26	10	25	0
Developmental Biology	10	0	30	30	30	0
Ecology	10	0	30	30	30	0
Economics, General	20	16	27	10	27	0
Education, General	10	32	24	10	24	0
Educational Evaluation and Research	10	15	32	10	33	0

Discipline Name	Awards	Books	Citations	Grants	Publications	Conference Proceedings
Educational Leadership and Administration	10	35	22	10	23	0
Educational Psychology	10	16	32	10	32	0
Electrical Engineering	10	0	30	30	16	14
Engineering Mechanics	10	0	30	30	20	10
Engineering, General	10	0	30	30	20	10
Engineering, various	10	0	30	30	20	10
English Language and Literature	20	58	11	0	11	0
Entomology	10	0	30	30	30	0
Environmental Engineering	10	0	30	30	22	8
Environmental Health Sciences	10	1	30	30	29	0
Environmental Sciences	10	0	30	30	30	0
Epidemiology	10	0	30	30	30	0
European Studies	20	43	13	10	14	0
Evolutionary Biology	10	0	30	30	30	0
Family and Human Sciences, various	10	6	32	20	32	0
Finance	10	16	37	0	37	0
Fisheries Science	10	0	35	20	35	0
Food Science	10	0	35	20	35	0
Forest Resources/Forestry	10	0	35	20	35	0
Foundations of Education	20	30	20	10	20	0
French Language and Literature	20	44	18	0	18	0
Gender Studies	20	31	20	10	19	0
Genetics	10	0	30	30	30	0
Geography	10	8	26	30	26	0
Geological and Mining Engineering	10	0	35	20	26	9
Geology/Earth Science, General	10	0	30	30	30	0
Geophysics	10	0	30	30	30	0
Germanic Languages and Literatures	20	43	19	0	18	0
Health Professions, various	10	4	33	20	33	0
Health, Physical Education, Recreation	10	5	43	0	42	0
Higher Education/Higher Education Administration	10	32	29	0	29	0
History	20	54	13	0	13	0
Horticulture	20	0	30	20	30	0
Human and Medical Genetics	10	0	30	30	30	0
Human Development and Family Studies, General	10	10	30	20	30	0
Humanities/Humanistic Studies, General	20	54	13	0	13	0
Immunology	10	0	30	30	30	0
Industrial Engineering	10	0	35	20	23	12
Information Science/Studies	10	0	35	20	20	15
Information Technology/Information Systems	10	0	35	20	20	15
International Affairs and Development	20	30	20	10	20	0
Italian Language and Literature	20	39	20	0	21	0
Health Promotion, Kinesiology, Exercise Science and Rehab	10	3	34	20	33	0
Languages, various	20	49	16	0	15	0
Linguistics	10	23	23	20	24	0
Management	10	17	37	0	36	0
Management Information Systems	10	10	35	10	27	8
Marine Sciences	10	0	30	30	30	0
Marketing	5	10	43	0	42	0
Mass Communications/Media Studies	10	27	31	0	32	0
Materials Engineering	10	0	30	30	22	8
Materials Science and Engineering	10	0	30	30	23	7
Mathematics	10	0	30	30	30	0
Mathematics Education	10	20	25	20	25	0
Mechanical Engineering	10	0	30	30	19	11
Medical Sciences, various	10	1	30	30	29	0
Microbiology	10	0	30	30	30	0
Molecular Biology	10	0	30	30	30	0
Molecular Genetics	10	0	30	30	30	0
Molecular Pharmacology	10	0	30	30	30	0
Music specialties	20	40	20	0	20	0
Music, General	20	44	18	0	18	0

Discipline Name	Awards	Books	Citations	Grants	Publications	Conference Proceedings
Natural Resources	10	0	35	20	35	0
Near and Middle Eastern Languages and Cultures	20	47	11	10	12	0
Neurobiology/Neuroscience	10	0	30	30	30	0
Nuclear Engineering	10	0	35	20	24	11
Nursing	10	4	33	20	33	0
Nutrition Sciences	10	1	29	30	30	0
Oceanography, Physical Sciences	10	0	30	30	30	0
Oncology and Cancer Biology	10	0	30	30	30	0
Operations Research	10	0	35	20	25	10
Oral Biology and Craniofacial Science	10	0	30	30	30	0
Pathology	10	0	30	30	30	0
Performing and Visual Arts, various	20	48	16	0	16	0
Pharmaceutical Sciences	10	0	30	30	30	0
Pharmacology	10	0	30	30	30	0
Pharmacy	10	1	35	20	34	0
Philosophy	20	41	19	0	20	0
Physics, General	20	0	25	30	20	5
Physiology, General	10	0	30	30	30	0
Plant Pathology	10	0	30	30	30	0
Plant Sciences	10	0	30	30	30	0
Political Science	20	32	19	10	19	0
Psychology, General	10	6	32	20	32	0
Psychology, various	10	6	32	20	32	0
Public Administration	10	23	29	10	28	0
Public Health	10	2	29	30	29	0
Public Policy	10	26	27	10	27	0
Religion/Religious Studies	20	57	11	0	12	0
School Psychology	10	15	33	10	32	0
Science Education	10	13	28	20	29	0
Slavic Languages and Literatures	20	48	11	10	11	0
Social Sciences, various	20	14	23	20	23	0
Social Work/Social Welfare	10	13	33	10	34	0
Sociology	20	22	24	10	24	0
Soil Science	10	0	35	20	35	0
Spanish Language and Literature	20	47	17	0	16	0
Special Education	10	15	23	30	22	0
Speech and Hearing Sciences	10	4	28	30	28	0
Statistics	10	0	30	30	30	0
Structural Biology	10	0	30	30	30	0
Systems Engineering	10	0	35	20	22	13
Teacher Education Specific Levels	10	34	23	10	23	0
Teacher Education Specific Subject Areas	10	25	27	10	28	0
Theatre Literature, History and Criticism	20	51	15	0	14	0
Theology/Theological Studies	10	70	10	0	10	0
Toxicology	10	0	30	30	30	0
Urban and Regional Planning	10	19	30	10	31	0
Veterinary Medical Sciences	10	2	34	20	34	0
Wildlife Science	10	0	35	20	35	0
Zoology	10	0	30	30	30	0
Law	18	19	22	22	19	0



CIVIL ENGINEERING PHD MARKET ANALYSIS

Prepared for University of North Carolina at Charlotte

September 2016

In the following report, Hanover Research assesses student and labor demand for civil engineering PhD programs. In addition, Hanover benchmarks exemplary, peer, and regional programs at public institutions and profiles two exemplary programs in North Carolina.

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EXECUTIVE SUMMARY AND KEY FINDINGS

INTRODUCTION

According to the American Society of Civil Engineers (ASCE), "infrastructure is the backbone of the U.S. economy and a necessary input to every economic output." However, in 2013 ASCE released a report card grading U.S. infrastructure as a "D+," underscoring the need for substantial improvements across nearly all types of infrastructure including roads, bridges, transit, electricity, waterways, ports, and airports.[1] Furthermore, ASCE notes that the United States needs to invest $1.4 trillion in infrastructure between 2016 and 2025 and $5.2 trillion by 2040; without such investments, the U.S. economy could lose almost $4 trillion and 2.5 million jobs by 2025 and $14.2 trillion and 5.8 million jobs by 2040 due to lost productivity.[2] As a result, future federal, state, and local investments to repair and enhance ailing infrastructure may drive demand for civil engineers.

In this report, Hanover Research examines student and labor market demand for graduate civil engineering degrees, particularly at the doctorate level, to assist the University of North Carolina-Charlotte (UNCC) in assessing the viability of such a program. In addition, Hanover provides an overview of the competitive landscape through benchmarking exemplary, peer, and regional programs. This report contains the following sections:

- **Section I: Student Demand** – analyzes 2011 to 2015 civil engineering doctorate and master's completions data compiled by the National Center for Education Statistics (NCES), along with enrollments data published by the National Science Foundation (NSF).
- **Section II**: **Labor Market Demand** – assesses current and future employment demand for civil engineers using labor projections data published by the U.S. Bureau of Labor Statistics and ONET. Job postings and educational attainment data are also included, along with North Carolina-specific employment trends.
- **Section III**: **Competitive Landscape** – provides an overview of trends among civil engineering PhD programs at exemplary, peer, and public institutions in North Carolina and similarly-sized southern states (South Carolina, Florida, and Virginia). Funding for civil engineering programs at higher education institutions is also discussed. Hanover also profiles Civil Engineering PhD programs at North Carolina State University and Duke University.

[1] "2013 Report Card for America's Infrastructure." ASCE. http://www.infrastructurereportcard.org/grades/

[2] "Failure to Act: Closing the Infrastructure Investment Gap for America's Economic Future." ASCE. P. 4. http://www.infrastructurereportcard.org/wp-content/uploads/2016/05/ASCE-Failure-to-Act-Report-for-Web-5.23.16.pdf

KEY FINDINGS

- **Student demand for civil engineering PhDs is increasing based on completions data.** On average, civil engineering completions grew by 8.2 percent per year nationally and 9.8 percent annually in North Carolina between 2011 and 2015. In comparison, demand for master's credentials declined in North Carolina, but remained stable nationwide.
- **International students represent a key audience for civil engineering graduate programs nationally and in North Carolina, due to rapid enrollment growth.** Between 2009 and 2014, foreign student enrollments increased by 11.5 percent overall, while domestic student enrollments declined by seven percent. In 2014 foreign students comprised almost half of civil engineering enrollments nationally and 42 percent of all enrollments in North Carolina.
- **Employer demand is growing for civil engineers nationally and in North Carolina.** Labor projections for civil engineers predict strong growth of 8.4 percent nationwide and 11 percent growth at the state level. Civil engineers are most heavily employed in the following industries/sectors (in order): architecture and engineering services, state and local governments, and construction at both geographic levels. Workforce gap analysis of degree completions versus average annual openings reveal sizeable national and state shortages in new civil engineering candidates.
- **Hanover found no substantial evidence indicating growing demand for faculty with backgrounds specifically in civil engineering, but demand may exist for faculty with engineering backgrounds in general.** Hanover assessed job postings data and student demand for general and civil engineering associate's degrees. While student demand for general engineering associate's degrees is increasing nationally and in North Carolina, demand declined for civil engineering degrees. However, civil engineers employed in education are most likely to work at public higher education institutions, suggesting high demand from these employers. Furthermore, labor projections for Engineering Teachers, Postsecondary forecast double-digit growth at both geographic levels.
- **PhD programs are widespread among all civil engineering graduate programs, and especially among those that are highly-ranked.** Sixty-six percent of institutions with civil engineering master's programs also offer PhD programs, and all of the top 20 institutions in graduate civil engineering offer such programs. Benchmarking reveals that PhD offerings are also common among public institutions located in states similar in size to North Carolina. However, institutions with and without PhD programs are represented in equal proportions among fastest growing civil engineering master's programs, suggesting that the addition of a PhD program may not directly boost student demand for master's degrees at an institution.
- **Student and employer demand may be growing for transportation specializations.** Historically, transportation represents the largest non-defense federal outlay area, and federal spending in this area has grown by 3.3 percent on average per year. Furthermore, recent national and state funding legislation has authorized increased spending on transportation. In addition, transportation was the most common concentration offering among benchmarked PhD in civil engineering programs.

- **PhD programs most likely require substantial start-up investments; however, institutions with such programs tend to receive more federal funding which may offset some costs.** Benchmarking reveals that PhD programs possess substantial investments in facilities and research. However, analysis of federal funding for civil engineering programs shows that PhD programs are not only more likely to receive grants, but also tend to receive larger awards. Furthermore, federal funding may be available to institutions seeking to expand their civil engineering facilities and research capabilities.

SECTION I: STUDENT DEMAND

To assess potential student demand for graduate civil engineering programs, Hanover analyzes recent completions and enrollments trends using data published by the National Center for Education Statistics' (NCES) Integrated Postsecondary Education Data (IPEDS) and the American Society for Engineering Education (ASEE), respectively.[3] When assessing regional trends, Hanover looks at southern state of similar size to North Carolina (similarly-sized states). Hanover primarily uses **Compound Annual Growth Rates** (CAGR) as its growth metric when evaluating student demand trends over time. More detailed information on Hanover's completions methodology is located in the Appendix.

COMPLETIONS TRENDS

Although student demand for civil engineering doctorates is rising, particularly regionally and in North Carolina, civil engineering master's degrees have a more negative outlook (Figures 1.1 and 1.2)**.** Nationally, doctorate completions had a strong CAGR of 8.2 percent over the last five years; however, master's completions grew more slowly with a CAGR of 2.8 percent. Meanwhile, doctorate completions grew at a rate of 13 percent overall for similarly-sized states and by 9.8 percent in North Carolina. Master's completions declined by 4.6 percent on average per year in North Carolina and by 1.8 percent in similar states.

Figure 1.1: Civil Engineering Master's Completions, 2011-2014

Geographic Level	2011	2012	2013	2014	2015	CAGR	AAC	STDEV
National	**4,549**	**5,000**	**5,009**	**5,187**	**5,089**	**2.8%**	**135**	**207**
Similarly-Sized Southern States	**547**	**607**	**608**	**637**	**509**	**-1.8%**	**-10**	**72**
➢ North Carolina	123	133	113	132	102	-4.6%	-5	20
➢ South Carolina	61	61	62	55	54	-3.0%	-2	3
➢ Virginia	142	143	149	146	131	-2.0%	-3	8
➢ Florida	221	270	284	304	222	0.1%	0	49

Note: Data include completions reported under 14.0801 Civil Engineering, General and 14.0899 Civil Engineering, Other.
Source: IPEDS

Figure 1.2: Civil Engineering Doctorate Completions, 2011-2014

Geographic Level	2011	2012	2013	2014	2015	CAGR	AAC	STDEV
National	**725**	**757**	**840**	**946**	**992**	**8.2%**	**67**	**29**
Similarly-Sized Southern States	**87**	**123**	**115**	**138**	**142**	**13.0%**	**14**	**17**
➢ North Carolina	22	25	24	31	32	9.8%	3	3
➢ South Carolina	5	17	14	28	20	41.4%	4	9
➢ Virginia	19	28	31	37	39	19.7%	5	3
➢ Florida	41	53	46	42	51	5.6%	3	8

Note: Data include completions reported under 14.0801 Civil Engineering, General and 14.0899 Civil Engineering, Other.
Note: Data include all doctorates, including research and other degrees. Source: IPEDS

[3] Unless otherwise noted, data for this section come from: "IPEDS Data Center." National Center for Education Statistics. http://nces.ed.gov/ipeds/datacenter/

Based on IPEDS data, 15 institutions in North Carolina and similarly-sized states reported doctorate completions between 2011 and 2015. However, Duke University and North Carolina State University at Raleigh are the only institutions offering such programs in North Carolina, indicating a potential need for additional programs in the state. Both of these programs are profiled later in this report.

Institutional-level master's and doctorate completions data for North Carolina are located in the Appendix. Total five-year completions and CAGR statistics for benchmarked doctorate programs are located in the companion spreadsheet.

While PhD programs are prevalent among institutions with civil engineering master's programs, institutions with and without PhD programs are equally represented among fastest growing master's programs (Figure 1.3)**.** Hanover compared institutions that reported master's completions with those that reported PhD completions in civil engineering to IPEDS between 2011 and 2015. 66.1 percent of all institutions (n=189) that reported master's in civil engineering completions also possess PhD programs. However, institutions with and without PhD programs are almost equally represented based on share among fastest growing master's programs. Hanover defined fastest growing master's programs as those with CAGRs equal to or above 3.0 percent. Roughly 42.4 percent of institutions with PhD programs were among fastest growing master's programs, versus 40.5 percent of institutions without PhD programs.

Figure 1.3: Prevalence of Civil Engineering Master's Programs with PhD Programs in General and Among Fastest Growing Master's Programs

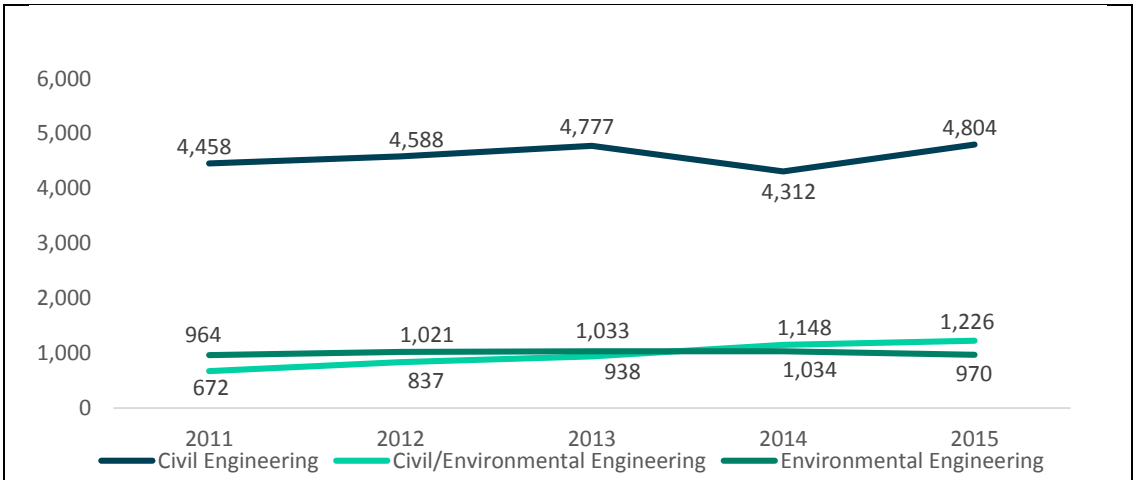
Institution Type	No. of Master's Programs	No. of Fastest Growing Programs	Percentage Share
With PhD	125	53	40.6%
Without PhD	64	26	42.4%

Source: IPEDS

ENROLLMENT TRENDS

Overall, doctoral enrollments in civil engineering fields increased slightly between 2011 and 2015, with a CAGR of almost two percent based on ASEE data (Figure 1.4)**.** In particular, demand for civil/environmental engineering experienced rapid growth during this timeframe with 16.2 percent average annual growth, exceeding enrollments in environmental engineering in 2014 and 2015. In comparison, master's enrollments remained stable for both civil and environmental engineering, but civil/environmental engineering exhibited high annual growth of 14.1 percent (Figure 1.5). Notably, civil engineering enrollment numbers exceed both civil/environmental and environmental engineering, suggesting consistently high demand for such degrees, despite stable growth and the existence of alternative civil and environmental engineering options.

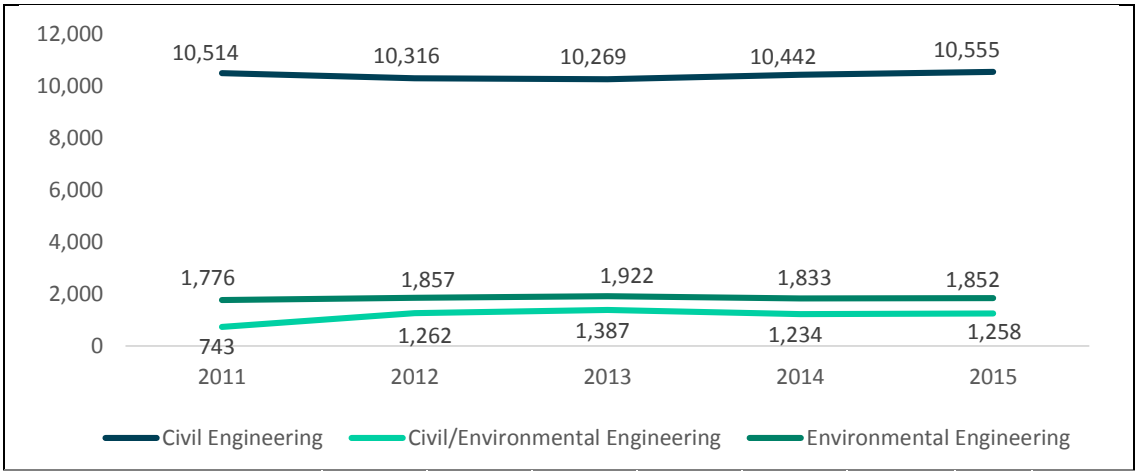
Figure 1.4: Doctorate Enrollments in Civil Engineering and Related Fields, 2011-2015



Field	2011	2012	2013	2014	2015	CAGR	AAC	STDEV
Civil Engineering	4,458	4,588	4,777	4,312	4,804	1.9%	87	347
Civil/Environmental Engineering	672	837	938	1,148	1,226	16.2%	139	52
Environmental Engineering	964	1,021	1,033	1,034	970	0.2%	2	43

Source: ASEE[4]

Figure 1.5: Master's Enrollments in Civil Engineering and Related Fields, 2011-2015



Field	2011	2012	2013	2014	2015	CAGR	AAC	STDEV
Civil Engineering	10,514	10,316	10,269	10,442	10,555	0.1%	10	145
Civil/Environmental Engineering	743	1,262	1,387	1,234	1,258	14.1%	129	246
Environmental Engineering	1.776	1.857	1,922	1,833	1,852	1.1%	19	66

Source: ASEE[5]

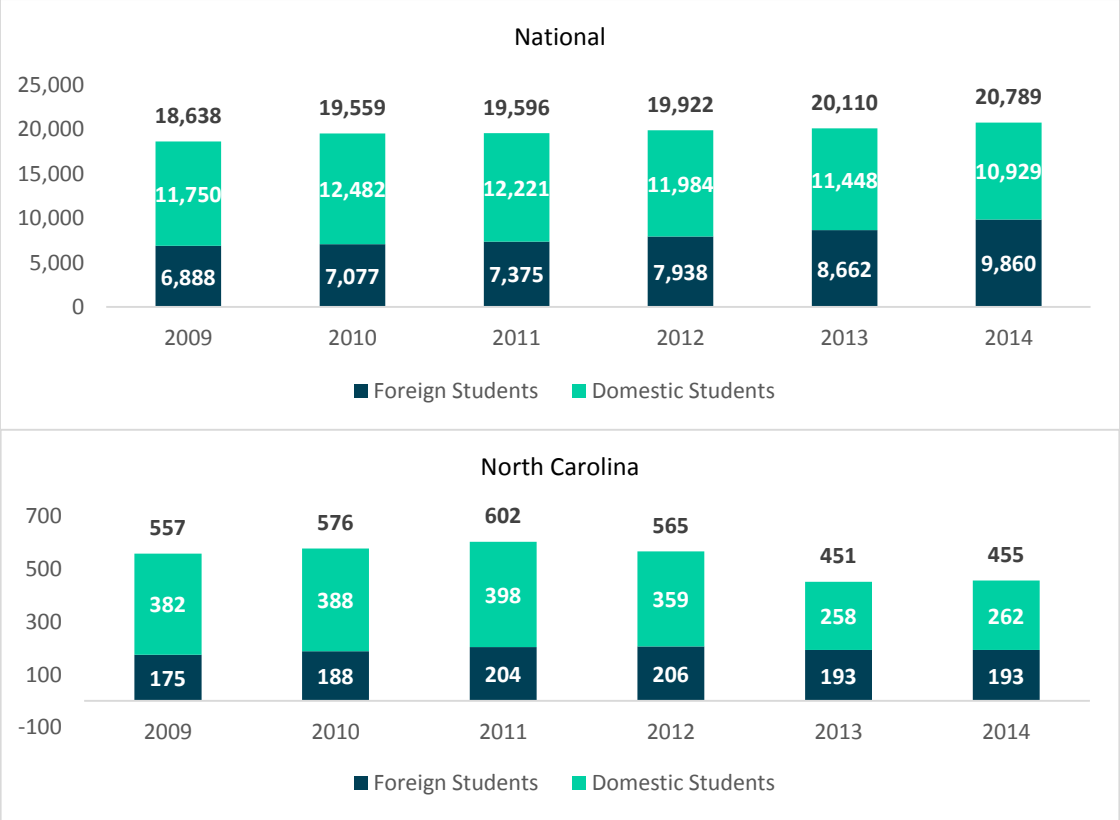
[4] Yoder, B. "Engineering by the Numbers." ASEE. P. 45. https://www.asee.org/papers-and-publications/publications/college-profiles/15EngineeringbytheNumbersPart1.pdf

[5] Ibid. P. 43.

FOREIGN AND DOMESTIC ENROLLMENTS

National Science Foundation (NSF) data reveal that foreign students represent a key and expanding demographic in civil engineering graduate education nationally and in North Carolina. NSF tracks annual graduate enrollments across science and engineering fields in general and for different demographics. Foreign student enrollments in civil engineering graduate education increased by 11.5 percent overall, while domestic enrollments declined by seven percent between 2009 and 2014 (Figure 1.6). In 2014 foreign students comprised almost half of civil engineering graduate enrollments nationally and 42 percent of all enrollments in North Carolina. Notably, domestic student enrollments in North Carolina declined by 31.4 percent between 2009 and 2014. As a result, a potential civil engineering doctorate program at UNCC should include foreign students in its program design and outreach.

Figure 1.6: Civil Engineering Graduate Enrollments by Citizenship and Geographic Area, 2009-2014



Note: Total enrollments are in bold. Numbers include graduate and doctorate students. Foreign student figures are based on temporary visa holders and domestic student figures are based on U.S. citizens. Data are for the fall of each year. 2014 is the most recent year for which data are publically available. Source: NSF[6]

[6] Data are from the Survey of Graduate Students and Postdoctorates in Science and Engineering. "Table 13. Graduate students in science, engineering, and health in all institutions, by field, citizenship, ethnicity, and race: 2009-2014." National Science Foundation. https://ncsesdata.nsf.gov/gradpostdoc/2014/html/GSS2014_DST_13.html

SECTION II: LABOR MARKET DEMAND

In this section, Hanover assesses the labor market for civil engineers using labor projections data from the Bureau of Labor Statistics (BLS) and ONET. In addition, Hanover conducts a job postings analysis using Indeed.com and provides an overview of specific trends in North Carolina using secondary sources. More information on Hanover's labor projections methodology is located in the Appendix.

LABOR PROJECTIONS

Over the next decade, jobs for civil engineers will exhibit faster than average growth of 8.4 percent and 11 percent nationwide and in North Carolina, respectively (Figure 2.1)**.** Other related occupations will also experience growth, namely Engineering Teachers, Postsecondary, which are projected have 13.2 percent growth nationally and 15.0 percent growth in North Carolina. In comparison, Architectural and Engineering Managers will experience below average growth of 2 percent nationally and 9 percent in North Carolina.

Figure 2.1: National Labor Projections for Civil Engineering Occupations, 2014-2024

(Numbers in Thousands)

Occupation	Employment		Change (2014-2024)		Annual Avg. Openings
	2014	2024	Number	Percent	
Total, All Occupations	**150,539.9**	**160,328.8**	**9,788.9**	**6.5%**	**4,650.7**
Civil Engineers	281.4	305.0	23.6	8.4%	10.7
Architectural and Engineering Managers	182.1	185.8	3.7	2%	6.0
Engineering Teachers, Postsecondary	46.0	52.0	6.0	13.2%	1.4

Source: BLS[7]

Figure 2.2: North Carolina Labor Projections for Civil Engineering Occupations, 2014-2024

Occupation	Employment		Change (2014-2024)		Annual Avg. Openings
	2014	2024	Number	Percent	
Civil Engineers	7,410	8,250	840	11%	300
Architectural and Engineering Managers	3,910	4,280	370	9%	160
Engineering Teachers, Postsecondary	1,330	1,530	200	15%	40

Note: Data are rounded to the tens place. Source: ONET[8]

[7] "Employment by detailed occupation." BLS. http://www.bls.gov/emp/ep_table_102.htm

[8] Hanover employs ONET data as 2014-2024 labor projections are not publically available on The Employment Security Commission of North Carolina's website. As a result, projections for all occupations are not available for 2014-2024. The average for all occupations for 2012-2022 was 12.0 percent. ONETOnline. http://www.onetonline.org/

Based on BLS data, civil engineers are predominantly employed in architectural, engineering, and related services, state and local governments, and construction.[9] Figure 2.3 provides a breakdown of the civil engineering employment numbers by sector and industry.

Figure 2.3: National Employment of Civil Engineers by Industry/Sector, May 2015

(n=275,210 across all industries)

Industry/Sector	No. Employed	Percentage
Architectural, Engineering, and Related Services	**144,460**	**52.5%**
Engineering Services	136,040	49.4%
All Government	**74,900**	**27.2%**
State Government	35,930	13.1%
Local Government	29,670	10.8%
Federal Government	9,400	3.45
Construction	**29,070**	**10.5%**
Construction of Buildings	18,560	6.7%
➢ Nonresidential Building Construction	17,430	6.3%
➢ Residential Building Construction	1,130	0.4%
Heavy and Civil Engineering Construction	7,430	2.7%
Highway, Street, and Bridge Construction	3,070	1.1%
Other Heavy and Civil Engineering Construction	2,060	0.7%
Utility System Construction	1,950	0.7%
Power and Communication Line and Related Structures Construction	730	0.2%
Land Subdivision	350	0.1%
Other Notable Industries/Sectors	**N/A**	**N/A**
Administrative and Support and Waste Management and Remediation	5,690	2.1%
Management, Scientific, and Technical Consulting Services	5,390	2.0%
Manufacturing	3,720	1.4%
Employment Services	3,720	1.4%
Utilities	2,160	0.8%
Education	1,670	0.6%
Mining	1,210	0.4%
Transportation Equipment Manufacturing	1,100	0.4%

Note: Only industries/sectors with top employment of civil engineers are shown. Percentages and numbers will not aggregate to 100 percent. Source: BLS[10]

[9] "Occupational Employment and Wages, May 2015: 17-2051: Civil Engineers." BLS. http://www.bls.gov/oes/current/oes172051.htm

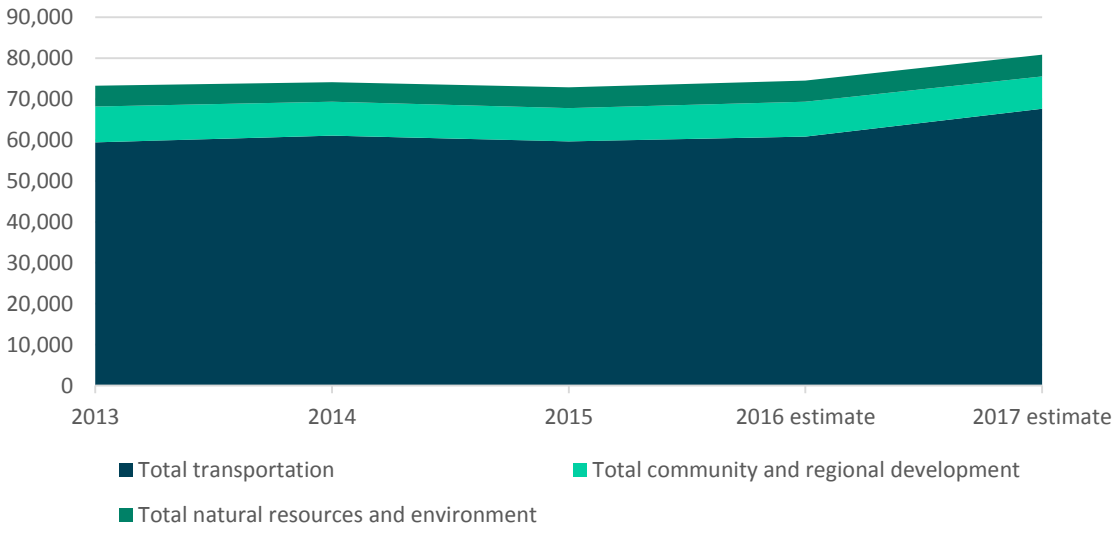
[10] "Occupational Employment Statistics Query System." BLS. http://data.bls.gov/oes/releasedate.do#oes.f.1

FEDERAL FUNDING TRENDS

To further determine which sectors of civil engineering may have growing employer demand, Hanover examines trends in infrastructure spending. To do so, Hanover compiled data on federal outlays for grants for major public physical capital investments published by the Office of Management and Budget (Figure 2.4). **Transportation received majority of infrastructure-related federal outlays over the last five years and is the largest area for non-defense federal outlays.** Furthermore, transportation outlays grew by an average of 3.3 percent per year based on 2016 and 2017 estimates. In particular, outlays for mass urban transportation have grown rapidly over the last five-years with a CAGR of 9.5 percent, while highways continue to receive the most funding in dollar terms. Such findings suggest high demand for civil engineers with backgrounds in transportation, especially in highways and mass transportation.

Figure 2.4: Composition of Federal Outlays for Grants for Major Public Physical Capital Investment, 2010-2017

(in millions of dollars)



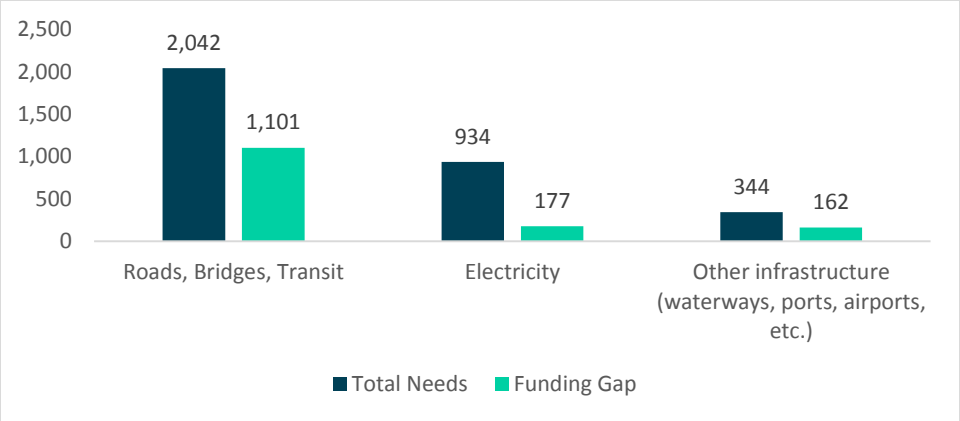
Category	2013	2014	2015	2016 estimate	2017 estimate	CAGR	AAC	STDEV
Total transportation	59,437	61,090	59,655	60,820	67,625	3.3%	2,047	2,987
➢ Highways	43,427	42,952	42,002	42,030	42,863	-0.3%	-141	660
➢ Urban mass transportation	12,286	14,633	14,199	15,011	17,637	9.5%	1,338	1,234
Total community and regional development	8,751	8,248	8,185	8,525	7,939	-2.4%	-203	371
Total natural resources and environment	5,072	4,817	5,065	5,212	5,303	1.1%	58	189

Source: Office of Management and Budget[11]

[11] "Historical Tables: Table 9.6-Composition of Outlays for Grants for Major Public Physical Capital Investment: 1941-2017." Office of Management and Budget. https://www.whitehouse.gov/omb/budget/Historicals

Despite large federal outlays, the American Society of Civil Engineers (ASCE) anticipates large gaps between funding levels and infrastructure needs, particularly in transportation. Between 2016 and 2025, roads, bridges, and transit will need more than $2.0 trillion in funding, but will receive only about half that amount (Figure 2.5). Due to high need for infrastructure rehabilitation and expansion, demand for civil engineers may increase, but lack of funding may preclude employers from actually hiring more civil engineers.

Figure 2.5: Projected Infrastructure Funding Gaps by Sector, 2016-2025



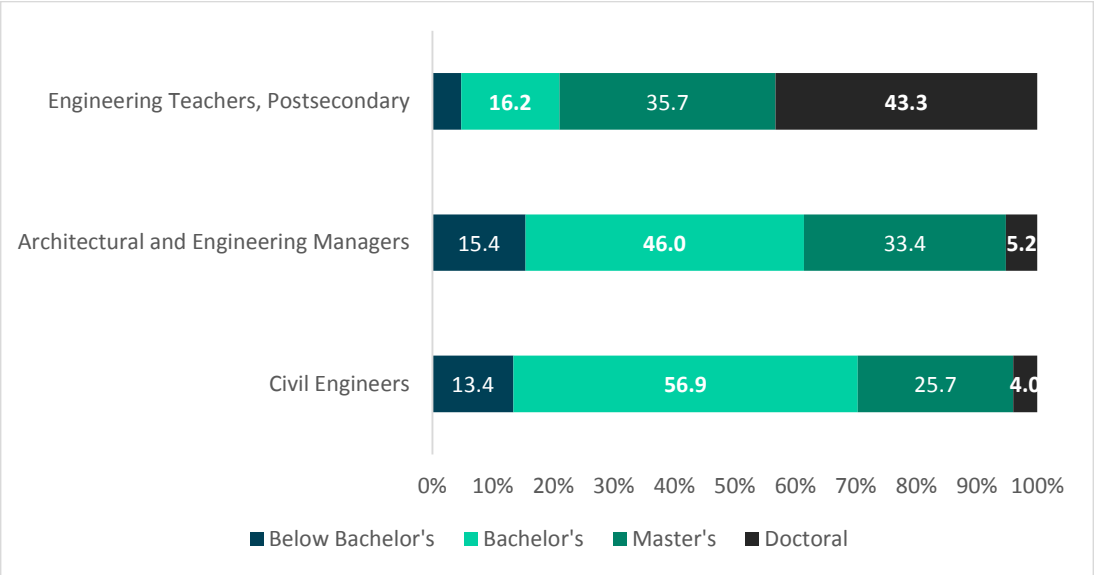
Source: ASCE[12]

EDUCATIONAL ATTAINMENT

A bachelor's degree is the standard educational requirement for entry-level jobs in civil engineering; **however, higher credentials may be needed for professional advancement or future employment** (Figure 2.6). Bachelor's graduates comprise the plurality of architectural and engineering managers and the majority of civil engineers. Yet, more than a quarter of workers in these occupations are master's-holders, revealing that such credentials may be needed for advancement or a competitive edge in these professions. Doctoral degrees seem to be most common among those employed as postsecondary teachers.

[12] [1] "Failure to Act: Closing the Infrastructure Investment Gap for America's Economic Future." Op. cit.
[2] Chart reproduced from: Harrison, D. "Civil Engineers Find Trillion-Dollar Infrastructure Funding Gap." *The Wall Street Journal.* May 10, 2016. http://blogs.wsj.com/economics/2016/05/10/civil-engineers-find-trillion-dollar-infrastructure-funding-gap/

Figure 2.6: Educational Attainment for Civil Engineering Professions
(Percentage of Workers Age 25 and Above)



Note: Labels are only shown for educational attainment levels accounting for more than five percent of workers. Source: BLS

Despite BLS data, the educational attainment standard for civil engineers may be changing to the master's degree. In 2014 the American Society of Civil Engineers (ASCE) adopted Policy Statement 465, which advocates raising the educational attainment level for civil engineers to the master's degree.[13] As a result, civil engineers seeking a competitive edge in the job market may increasingly seek doctoral education as a master's becomes the standard credential.

WORKFORCE SHORTAGE ANALYSIS

In this section, Hanover evaluates whether the number of civil engineering graduates is sufficient to meet employer demand. Hanover compares annual average openings for civil engineers with the number of civil engineering master's and doctorate completions. Note that Hanover omits openings for Engineering Teachers, Postsecondary and Architectural and Engineering Managers as these occupations may include individuals with a variety of degrees outside of civil engineering.

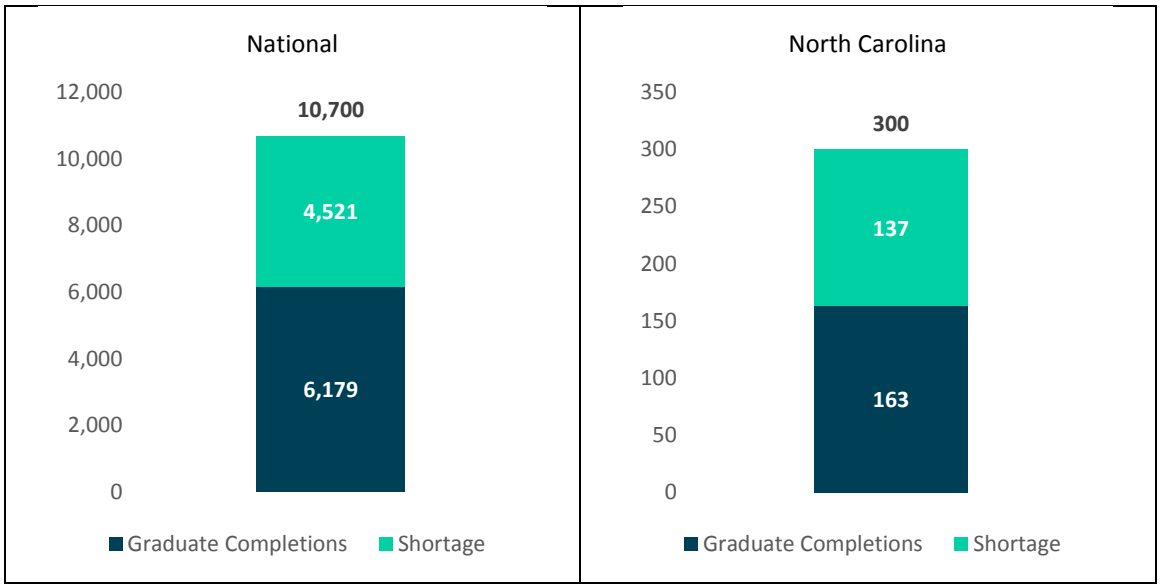
Based on a comparison of graduate degree completions and projected average annual openings, sizeable labor shortages exist both nationally and in North Carolina (Figure 2.7)**.** Assuming stable graduate and openings numbers, new graduates could only fill roughly half of all civil engineering openings (57.7 percent nationally and 54.3 percent in North Carolina). NCWorks data further support workforce shortages, revealing that there are only 0.41

[13] "Policy Statement 465-Academic Prerequisites for Licensure and Professional Practice." ASCE. http://www.asce.org/issues-and-advocacy/public-policy/policy-statement-465---academic-prerequisites-for-licensure-and-professional-practice/

candidates per job opening in civil engineering, using job postings data as of August 25, 2016.[14]

Figure 2.7: National and North Carolina Labor Shortages for Civil Engineering Occupations, 2014

(Based on Graduate Degree Completions and Average Annual Openings)



Note: Average annual openings are in bold. Source: BLS, ONET, and IPEDS[15]

JOB POSTINGS

General Trends for Civil Engineers

To analyze current employment trends for civil engineers, Hanover utilizes Indeed.com, an aggregator that compiles online job postings from hundreds of smaller job boards.[16] Indeed's Job Trends tool allows users to examine trends in the relative volume of total job postings over time (i.e., the percentage of job postings at any given time that contain the search term). Figure 2.8 displays trends in the percentage of job posts containing "civil engineer."

National job postings data reveal declining employer demand for civil engineers over the last five years. However, post volumes remain fairly high, with relevant job posts accounting for between 0.45 percent and 0.20 percent of all job posted nationwide.

[14] "Summary of Current Labor Market for Civil Engineers in North Carolina." NCWorks Online. https://www.ncworks.gov/vosnet/lmi/occ/occsummary.aspx?enc=e7AKr7bjUGRBEdrMte14UXg48NajrSFCp5i2DK+zH0Ap7IHAmvuMCkriiGtCZUm0SeiXSAnY164m0eF6c0f9w8AZt+3NpUnU1m54DO+lRBtw2LjhlvDPdl0zOq/yOiU9

[15] [1] ONET. Op. cit.
[2] "Employment by detailed occupation." BLS. Op. cit.
[3] IPEDS, Op. cit.

[16] "Job Search." Indeed.com. http://www.indeed.com/

Figure 2.8: Indeed.com Job Postings Trends for Civil Engineers, 2012-2016

Source: Indeed.com[17]

Hanover also utilized Indeed's job search function to conduct a search of online job postings for civil engineers. This approach provides a snapshot of employment trends at a given time (Figure 2.9). Nationally, employers posted more than 16,000 job announcements for civil engineers, including almost 500 posts in North Carolina, alone.

Figure 2.9: Number of Job Posts for Civil Engineers, Early September 2016

Geographic Level	Number of Job Posts
National	16,556
Similarly-Sized States	2,558
➢ North Carolina	494
➢ South Carolina	205
➢ Florida	1,046
➢ Virginia	813

Source: Indeed.com

Trends for Civil Engineering Faculty

Based on BLS data, the vast majority of civil engineers employed in education are at public colleges, universities, and professional schools (Figure 2.10). Consequently, demand for civil engineers will likely be higher at these types of institutions.

Figure 2.10 Number of Civil Engineers Employed in Education by Sector, May 2015

Industry/Sector	No. Employed	Percentage
All Education	**1,670**	**100%**
Colleges, Universities, and Professional Schools	1,480	88.6%
➢ Public	1,200	71.9%
➢ Private	270	16.2%

Source: BLS[18]

[17] "Job Trends." Indeed.com. http://www.indeed.com/jobtrends
[18] "Occupational Employment Statistics Query System." Op. cit.

To further investigate whether demand for civil engineering professors is growing, Hanover searched Indeed.com job postings for higher education institutions seeking civil engineering faculty. **As of early September 2016, 11 institutions had active job posts on Indeed.com for civil engineering faculty; however, none were by employers located in North Carolina or similarly-sized southern states.** Only one position nationwide was advertised by a community college (Contra Costa Community College District).[19] In addition, Hanover examined data on U.S. job postings in academia from AcademicKeys E-Flier. 31 positions were advertised for faculty and seven were for administrators nationwide from December 2015 through early September 2016.[20]

Hanover also gathered civil engineering and general engineering/pre-engineering associate's completions data to determine whether student demand is rising for such programs at community colleges (Figures 2.10 and 2.11, respectively). Completions growth or changes in the number of institutions offering such programs may indicate rising demand for engineering faculty. In addition to standard growth metrics, Hanover counted the number of institutions that consistently reported completions data for a program in 2012 and subsequent years.

Completions data reveal declining student demand for civil engineering associate's degrees, but increasing demand for general and pre-engineering degrees. As a result, **completions data do not support rising demand specifically for civil engineering faculty at community colleges; however, demand may be increasing for faculty for general and pre-engineering programs.**

Figure 2.10: Civil Engineering Associate's Completions, 2011-2015

Geographic Level	2011	2012	2013	2014	2015	CAGR	AAC	STDEV	New Programs
National	1,318	1,283	1,027	941	965	-7.5%	-88	104	19
Similarly-Sized States	173	127	146	91	97	-13.5%	-19	32	2
➢ North Carolina	77	61	59	32	45	-12.6%	-8	15	0
➢ South Carolina	54	37	38	36	25	-17.5%	-7	7	0
➢ Florida	27	18	36	16	15	-13.7%	-3	14	2
➢ Virginia	15	11	13	7	12	-5.4%	-1	4	0

Note: Includes completions reported under 14.0801 Civil Engineering, General; 14.0899 Civil Engineering, Other; 15.0201 Civil Engineering Technology/Technician; and 15.1304 Civil Drafting and Civil Engineering CAD/CADD. Source: IPEDS

[19] "Job Posts Search (Civil engineer and professor)." Indeed.com. http://www.indeed.com/jobs?q=Civil+engineer+and+professor&l=United+States&radius=75&start=10

[20] "Download E-Flier Back Copies." AcademicKeys. http://www.academickeys.com/all/eflier_backcopy.php

Figure 2.11: General/Pre-Engineering Associate's Completions, 2011-2015

Geographic Level	2011	2012	2013	2014	2015	CAGR	AAC	STDEV	New Programs
National	2,147	2,610	2,855	3,232	3,655	14.2%	377	82	62
Similarly-Sized States	334	399	437	451	498	10.5%	41	18	5
➢ North Carolina	17	42	58	80	97	54.6%	20	4	5
➢ Florida	7	4	4	2	0	-100.0%	-2	1	0
➢ Virginia	310	353	375	369	401	6.6%	23	18	0

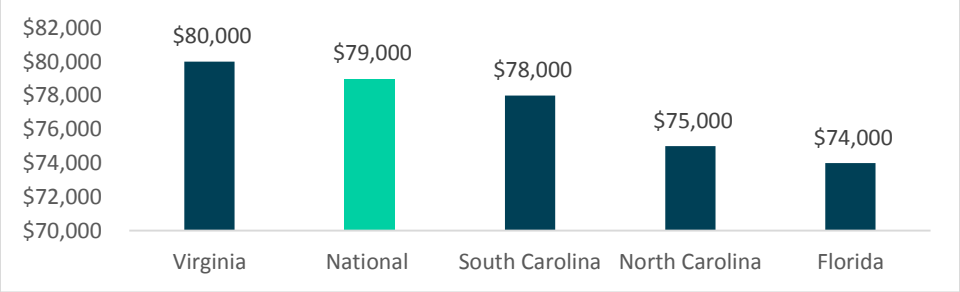
Note: South Carolina institutions reported no associate's completions in general and pre-engineering fields. Source: IPEDS

SALARY DATA

NCWorks estimates that median annual wage of civil engineers North Carolina in 2015 is $72,920.[21] However, Indeed.com job postings trends as of August 26, 2016 reveal that civil engineers in North Carolina may earn even higher salaries, with average earnings of $75,000. Yet, average salaries in North Carolina fall below the national average of $79,000 and are the second lowest among similarly-sized southern states (Figure 2.12).

Figure 2.12: Average Salaries for Civil Engineers

(Based on Indeed.com Job Posts)



Source: Indeed.com[22]

NORTH CAROLINA TRENDS

North Carolina's population is growing rapidly, which could place increased pressure on its infrastructure. In 2014 North Carolina became the ninth largest state in the country based on population, surpassing Michigan.[23] By 2030 the state's population is expected to grow to 12 million, making North Carolina the seventh most populated state in the nation.[24] Charlotte is also expected to experience high growth as North Carolina's largest city. Between 2013 and 2014, alone, the city gained 16,000 new inhabitants brining its population to 810,000.[25]

[21] NCWorks Online. Op. cit.
[22] "Salary Search." Indeed.com. http://www.indeed.com/salary
[23] "Facts and Figures." North Carolina Budget and Management. http://www.osbm.nc.gov/facts-figures
[24] Ibid.
[25] Ibid.

Furthermore, Mecklenburg county, in which Charlotte is located, is projected to experience 19.2 percent population growth between 2020 and 2030, reaching 1.14 million inhabitants.[26]

Although North Carolina's infrastructure quality and capacity generally exceeds the national average,[27] the state's rapid population growth has already prompted legislative action to rehabilitate, maintain, and expand its infrastructure. In March 2016, North Carolina passed a bill to borrow $2 billion to finance numerous infrastructure projects.[28] In addition, the state received a five percent funding increase in the 2015 federal highway bill.[29] Currently, lawmakers are debating how to allocate such funds; a revamp of I-95 is under consideration, particularly, as the state's roads continue to remain a major public concern due to congestion and wear.[30] Such legislative action could promote future employment of civil engineers.

While spending on infrastructure in North Carolina remains high across several indicators, it still fails to meet the state's needs; as a result, demand for civil engineers may increase, but funding gaps may prevent employers from hiring them. Based on U.S. Census data, North Carolina devoted 13.1 percent of state spending to infrastructure in 2013; the second highest percentage in the nation. Furthermore, North Carolina spending on roadways increased by 18.1 percent between 2003 and 2013, accounting for inflation. Even as the state's population has grown, spending per capita on transportation infrastructure has increased from $358 to $576 per capita. However, such increases are not enough to keep pace with the state's transportation needs.[31]

In fact, North Carolina's House Select Committee on Strategic Transportation Planning and Long-term Funding Solutions recently found that current funding levels meet only one-fifth of the needs of the state's transportation systems.[32] Moreover, capital spending on *all* infrastructure fell by 0.36 percent in the state between 2002 to 2013 and the share of infrastructure capital spending versus the state's Gross Domestic Product (GDP) has decreased by almost six percent on average per year between 2009 and 2013 (Figure 2.13).[33]

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[26] "County Population Growth: 2020-2030." North Carolina Budget and Management. https://ncosbm.s3.amazonaws.com/s3fs-public/demog/countygrowth_2030.html

[27] North Carolina received an infrastructure score of a "C" in 2013 from the ASCE, versus a "D+" for the nation as a whole. However, the ASCE still calls North Carolina's infrastructure "mediocre." See:
[1]"2013 North Carolina Report Card for Infrastructure." ASCE. http://www.infrastructurereportcard.org/north_carolina/north-carolina-overview/
[2] "Get to Know North Carolina's Mediocre Infrastructure." ASCE. http://www.infrastructurereportcard.org/asce-news/north-carolinas-infrastructure-needs/

[28] Collins, J. "NC Passes $2 Billion Bond for Infrastructure." *ABC News*. March 15, 2016.

[29] Ibid.

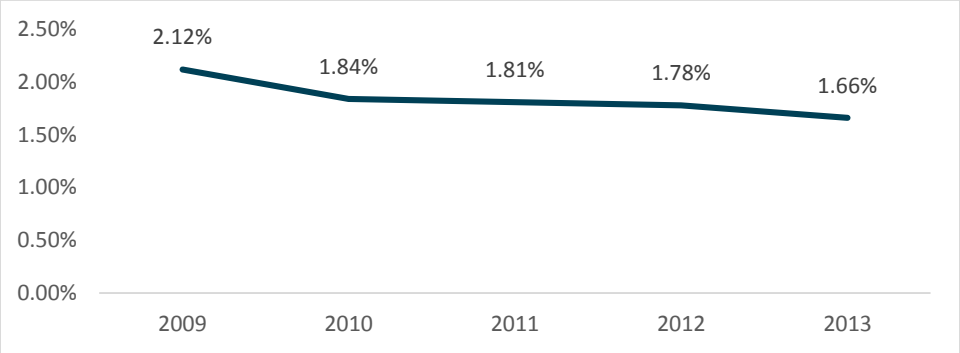
[30] Minnick, B. "Booming population puts strain on NC roads, infrastructure." *CBS North Carolina*. December 15, 2015. http://wncn.com/2015/12/15/booming-population-puts-strain-on-nc-roads-infrastructure/

[31] "North Carolina's spending on transportation grows, but needs remain." *Sun Journal.* March 14, 2015. http://www.newbernsj.com/20150314/north-carolinas-spending-on-transportation-grows-but-needs-remain/303149902

[32] Minnick, B. "Booming population puts strain on NC roads, infrastructure." *CBS North Carolina*. December 15, 2015. http://wncn.com/2015/12/15/booming-population-puts-strain-on-nc-roads-infrastructure/

[33] McNichol, E. "It's Time for States to Invest in Infrastructure." Center on Budget and Policy Priorities. *Policy Futures.* February 23, 2016. http://www.cbpp.org/research/state-budget-and-tax/its-time-for-states-to-invest-in-infrastructure

Figure 2.13: Infrastructure Capital Spending as Percent GDP in North Carolina, 2009-2013



Source: McNichol, E.[34]

As of May 2015, 6,730 civil engineers were employed in North Carolina, including 1,980 in the Charlotte-Concord-Gastonia, NC-SC metropolitan statistical area.[35] Figure 2.14 provides a breakdown of civil engineer employment by industry/sector. Similar to national trends, the top industries for civil engineers are architectural, engineering and related services; state and local governments, and construction.

Figure 2.14: North Carolina Civil Engineer Employment by Industry/Sector, May 2015 *(n=6,730)*

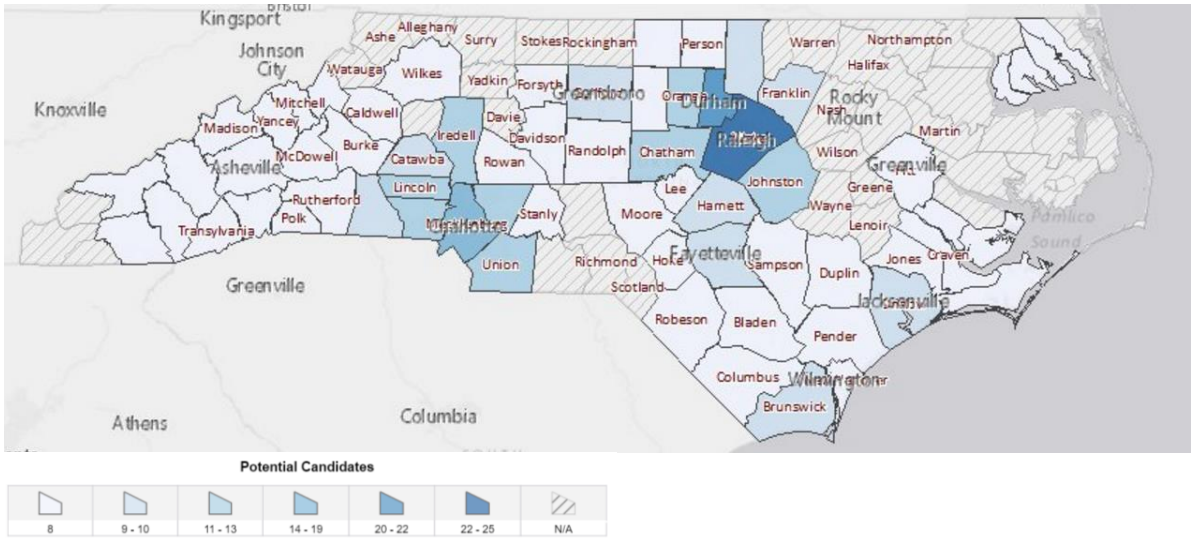
Industry/Sector	No. Employed	Percentage
Architectural, Engineering, and Related Services	**3,160**	**47.0%**
All Government	**2,170**	**32.2%**
State Government	1,450	21.5%
Local Government	600	8.9%
Federal Government	120	1.8%
Construction	**N/A**	**N/A**
Construction of Buildings	470	7.0%
➢ Nonresidential Building Construction	410	6.1%
➢ Residential Building Construction	60	0.9%
Other Notable Industries/Sectors	**N/A**	**N/A**
Management, Scientific, and Technical Consulting Services	300	4.5%
Highway, Street, and Bridge Construction	150	2.2%
Employment Services	100	1.5%
Colleges, Universities, and Professional Schools	90	1.3%
Utility System Construction	50	0.7%

Note: Only industries/sectors with top employment of civil engineers are shown. Percentages and numbers will not aggregate to 100 percent. North Carolina does not provide aggregated figures for all construction occupations. Source: NC Careers[36]

[34] Ibid.
[35] "Occupational Employment Statistics Query System." BLS. http://data.bls.gov/oes/search.jsp?data_tool=OES
[36] "Staffing Patterns by Occupation. NC Careers. http://nccareers.org/staffingpatterns/Inverse_Staffing_Patterns.html

According to NCWorks, the most civil engineering job candidates are located around Raleigh and Charlotte (Figure 2.15).[37] BLS data also show that Raleigh employs the most civil engineers in the state, with 2,610 civil engineers as of May 2015, and at concentration of 2.3 times the national average.[38]However, Charlotte and North Carolina, as a whole, have a lower concentration of civil engineers than the national average, with location quotients of only 0.82 and 0.89.[39] Compared with similarly-sized southern states North Carolina's location quotient is low, as South Carolina and Virginia both have above average concentrations of civil engineers (1.57 and 1.23, respectively).[40] Such findings could indicate a deficit of civil engineers in North Carolina.

Figure 2.15: Number of Job Candidates for Civil Engineering Occupations by County, 2015



Source: NCWorks[41]

[37] "Summary of Current Labor Market for Civil Engineers in North Carolina." Op. cit.

[38] [1] Ibid.
[2] "May 2015 State Occupational Employment and Wage Estimates." BLS. http://www.bls.gov/oes/current/oessrcst.htm

[39] [1] Ibid.
Location quotients are ratios that allow an area's distribution of employment by occupation to be compared to a reference area's distribution, such as the U.S. as a whole. The reference area's distribution is always scaled to 1.0. Areas with location quotients that exceed 1.0 have a higher share of individuals employed in a certain occupation. Conversely, areas with location quotients below 1.0 have a small share of individuals employed in a certain occupation. See: "QCEW Location Quotient Details." BLS. http://data.bls.gov/cew/doc/info/location_quotients.htm

[40] [1] "May 2014 State Occupational Employment and Wage Estimates." BLS. http://www.bls.gov/oes/current/oessrcst.htm
[2] "Occupational Employment and Wages, May 2014." BLS. http://www.bls.gov/oes/current/oes251043.htm, http://www.bls.gov/oes/current/oes191031.htm, http://www.bls.gov/oes/current/oes251053.htm, http://www.bls.gov/oes/current/oes192041.htm, and http://www.bls.gov/oes/current/oes191032.htm.

[41] Figure copied from: "Summary of Current Labor Market for Civil Engineers in North Carolina." Op.cit.

SECTION III: COMPETITIVE LANDSCAPE

In this section, Hanover benchmarks trends among 47 exemplary, peer, and regional civil engineering PhD programs. For the purposes of this report, regional programs include those that are offered at public institutions located in North Carolina and similarly-sized southern states (South Carolina, Florida, and Virginia). Hanover also includes peer institutions identified by UNCC for benchmarking and profiles civil engineering PhD offerings at North Carolina State University and Duke University, both of which are exemplary programs.

BENCHMARKING TRENDS

RANKINGS

PhD programs are widespread among top ranked institutions in graduate civil engineering. To determine whether PhD programs may positively affect civil engineering program rankings, Hanover compiled a list of the top 20 graduate civil engineering programs according to 2016 U.S. News and World Report rankings, and found that all of these exemplary institutions offer PhD programs in civil engineering.[42, 43]. Hanover also scanned the top 110 ranked institutions offering graduate-level civil engineering programs for programs located in similarly-sized southern states and programs offered by peer institutions. Ten out of 11 graduate civil programs in similarly-sized southern states offer civil engineering PhD programs (UNCC is the only exception). In addition, all 14 peer institutions identified by UNCC offer PhD programs in civil engineering, regardless of whether these programs are ranked highly by U.S. News and World Report**.** Program rankings are located in the companion spreadsheet to this report.

PROGRAM STRUCTURE

Most civil engineering programs do not list specific coursework requirements beyond a dissertation for PhD programs, allowing candidates to select their own coursework. Credit requirements also vary widely, depending on whether programs allow individuals to apply with only a bachelor's degree, or whether candidates must already possess a master's degree prior to program entry. In general, bachelor's entry programs require 70 to 90 credits, while master's entry programs require 45 to 65 credits.

Only seven out of 47 benchmarked programs offer separate civil and environmental engineering PhDs, while 20 offer combined civil and environmental PhD programs. The remainder offer only a civil engineering PhD.[44] Notably, the majority (57.4 percent) of civil engineering PhD programs provide environmental engineering-related concentrations. Such program structures may prevent separate civil and environmental engineering PhD programs

[42] "Civil Engineering." U.S. News and World Report. http://premium.usnews.com/best-graduate-schools/top-engineering-schools/civil-engineering-rankings

[43] The University of California – San Diego does not offer an overall degree in civil engineering, but offer two PhD programs within traditional civil engineering fields: Materials Science and Engineering and Structural Engineering.

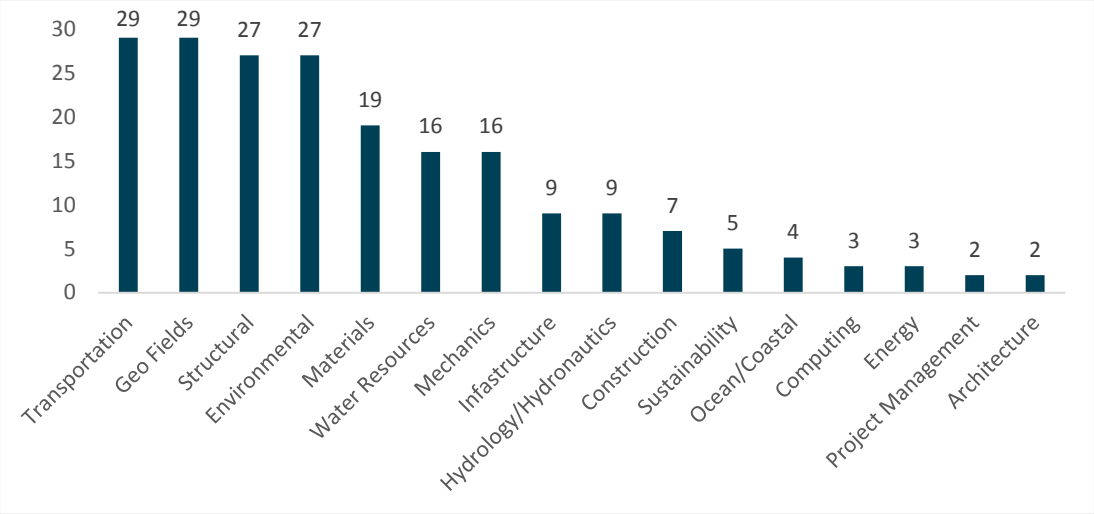
[44] Ibid.

from "cannibalizing" each other and facilitate curricular overlap and sharing of resources, facilities, and faculty. Furthermore, nearly all programs require students to specialize in a particular civil or environmental engineering area.

CONCENTRATIONS

Thirty-six out of 47 benchmarked programs offer concentrations or specialized PhD degrees within their civil engineering departments or programs. Transportation, geo fields (such as Geoengineering, Geotechnology, and Geoenvironmental engineering), environmental, and structural engineering are the most prevalent specialization options (Figure 3.1).

Figure 3.1: Number of Programs Offering Civil Engineering Specializations by Field



Note: Concentrations may be counted more than once if they contain multiple key terms. Source: Institutional websites

RESOURCES

All benchmarked programs have multiple engineering laboratories for both learning and research. In addition, all institutions possess institutionally-run research centers or institutes. Exemplary institutions tend to have more research centers and facilities than institutions in other peer groups, indicating that program prestige is, perhaps unsurprisingly, correlated with expanded research bandwidth and capabilities.

The vast majority of benchmarked civil engineering departments and/or engineering schools maintain partnerships with relevant industries through advisory boards, which participate in curriculum design and inform institutions of workforce needs. Additionally, the University of Wisconsin-Madison and Western Michigan University have capstone partnerships with employers in relevant industries, through which civil engineering graduate students complete substantial projects addressing specific industry problems. Civil engineering departments may also maintain inter-institutional, governmental, and industry partnerships through research centers and institutes. Research areas for centers and institutes for each benchmarked institution are listed in the companion spreadsheet and specific examples of such arrangements are provided in the program profiles in subsequent sections.

Benchmarking trends also indicate that institutions with civil engineering PhD programs employ sizeable faculties. However, it remains unclear how many faculty members are specifically devoted to PhD programs, as institutions typically only list faculty at the departmental level. Exemplary programs tend to have larger faculties, typically ranging from 30 to more than 60 members. Institutions at similarly-sized southern states have between 14 and 50 teaching faculty members, while peer institutions have between 10 and 40 teaching faculty members within their civil engineering departments.

TUITION

The vast majority of institutions only publish general graduate tuition rates and do not appear to charge separate rates for engineering and/or PhD programs. However, there are some notable exceptions: the University of Michigan-Ann Arbor, Cornell University, Texas A&M University-College Station, Clemson University, George Mason University, and Western Michigan University all list separate rates for engineering graduate programs. Furthermore, tuition rates are often published using different units, such as credit hours, semester rates, or yearly rates, which precludes comparison. In addition, PhD students may take as little as four years and as long as six or seven years to complete their coursework and dissertation; as a result, longer completions timelines would lead to increased costs. Tuition rates per institution are listed in the companion spreadsheet.

HIGHER EDUCATION FUNDING

GENERAL TRENDS

The National Science Foundation (NSF) tracks data on higher education grants and R&D expenditures at the institutional level. Hanover first analyzed data on NSF grants awarded through its Civil Infrastructure Systems program from April 2011 to January 2017 and compared recipients with institutions with PhD programs in civil engineering, based on IPEDS data.[45] To ensure comprehensiveness, Hanover also scanned institutional websites of non-IPEDS reporting institutions to ensure that a relevant PhD program truly did not exist.

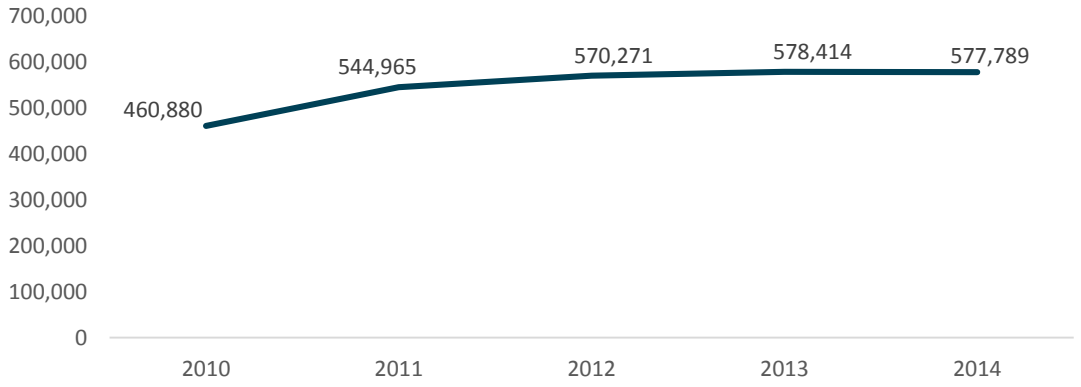
NSF funding data through the Civil Infrastructure Systems program reveal that institutions with civil engineering PhD programs may be more likely to receive grants, in general, and receive larger grants overall: 85 percent of all grants recipients through this program offer

[45] [1] Hanover uses grants data from NSF instead of USASpending.gov, as NSF data have greater award amounts and more institutional recipients. Furthermore, Hanover's search methodology for USAspending.gov only returns grants with civil engineering in the description, which may exclude closely related programs that received funding under NSF's Civil Infrastructure Systems program but lack such keywords. Hanover limits its analysis to this program, as it is the one most closely associated with civil engineering, whereas other programs may award grants institutions that offer a wide range of programs. See: "Civil Infrastructure Systems (CIS)." NSF. http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13352&org=ENG&sel_org=ENG&from=fund
[2] "What Has Been Funded Through Awards and Abstracts." NSF. http://www.nsf.gov/awardsearch/advancedSearchResult?WT.si_n=ClickedAbstractsRecentAwards&WT.si_x=1&WT.si_cs=1&WT.z_pims_id=13352&ProgEleCode=1631&BooleanElement=Any&BooleanRef=Any&ActiveAwards=true&#results

doctoral degrees in civil engineering. In addition, PhD programs received almost $100,000 more per grant, on average, with a median award of $740,000 versus $644,998 for all recipients. A list of recipient institutions with award amounts, with PhD programs designated, is located in the Appendix.

Hanover also gathered NSF data on all federally-financed higher education civil engineering R&D expenditures between 2010 and 2014 to determine whether other federal agencies were more likely to fund institutions with PhD programs. Between 2010 and 2014, U.S. higher education institutions spent more than $2.73 billion in federally-financed R&D expenditures in civil engineering, alone (Figure 3.2). Furthermore, federally-financed R&D expenditures grew by an average of 5.8 percent per year during this time frame. The plurality of funding from major agencies came from NSF, the Department of Defense, and the Department of Energy (Figure 3.3). **A comparison of institutional recipients overall with institutions that offer civil engineering PhD programs based on IPEDS data and keyword searches reveals that institutions with PhD programs received between 93.2 and 96.7 percent of federal funds each year** (Figure 3.4). Moreover, funding to institutions with PhD programs grew by more than 12 percent on average annually over the last five years.

Figure 3.2: Federally Financed Higher Education R&D Expenditures, 2010-2014
(Numbers in Thousands)



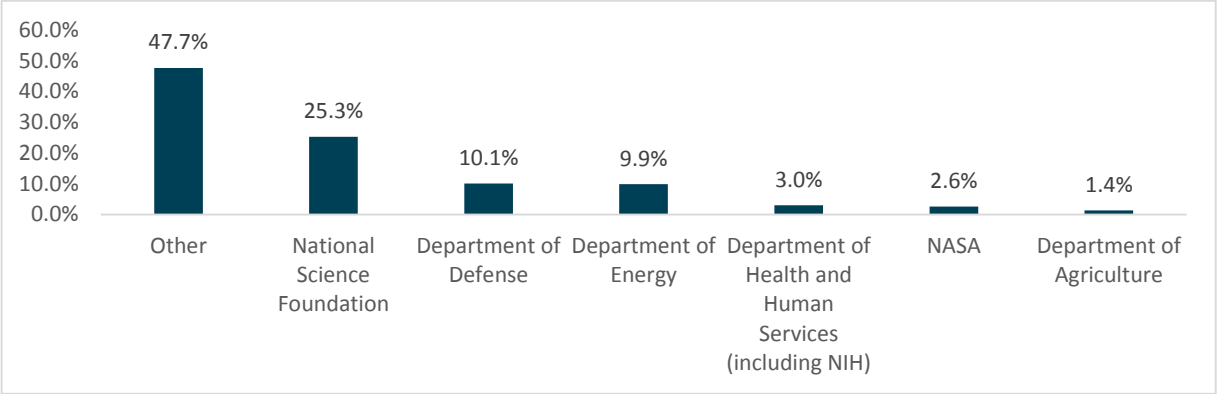
Category	2011	2012	2013	2014	2015	CAGR	AAC	STDEV
R&D	460,880	544,965	570,271	578,414	577,789	5.8%	29,227	33,017

Source: NSF[46]

[46] "WebCASPAR." NSF. https://ncsesdata.nsf.gov/webcaspar/

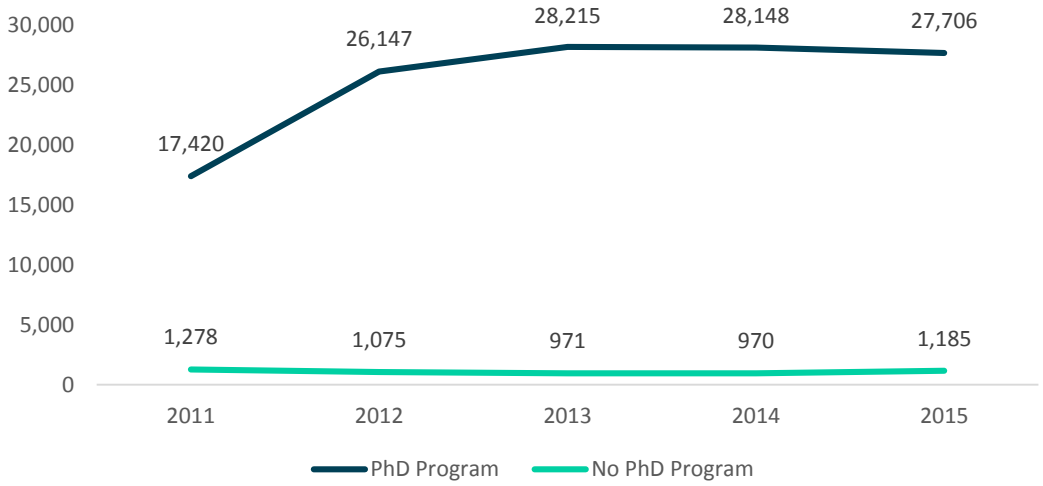
Figure 3.3: Federally-Funded Higher Education Civil Engineering R&D Expenditures by Agency

(Percentage of Total Five-Year Funds)



Source: NSF[47]

Figure 3.4: Federally-Funded Higher Education Civil Engineering R&D Expenditures for Institutions with and without Civil Engineering PhD Programs



Category	2011	2012	2013	2014	2015	CAGR	AAC	STDEV
PhD Program	17,420	26,147	28,215	28,148	27,706	12.3%	2,572	3,681
No PhD Program	1,278	1,075	971	970	1,185	-1.9%	-23	155

Institutional Trends

Comprehensive institutional-level grant data that include not only federal, but also local government and industry sources are difficult to obtain as there is no central repository for this information. However, some benchmarked institutions publically list grants awards on civil engineering department websites. Based on institutional websites, several civil engineering departments have received hundreds of thousands or even millions of dollars in external research funding. For example, **Duke University** received $8.3 million in total funding in FY 2015 and $11.5

[47] Ibid.

million in FY 2016,[48] while **University of Tennessee** "conducts approximately $5 million in externally-funded research per year."[49] **Stanford University** received $18.5 million in 2011 as a five-year grant for a collaborative project for the Engineering Research Center for Re-inventing the Nation's Urban Water Infrastructure, funded by the NSF.[50] **University of California-San Diego** also won $5.2 million dollars from NSF for "the world's largest" outdoor earthquake shake table, alone.[51] Figure 3.5 provides examples of recent six-figure grants received by **George Mason University** and **University of Texas at San Antonio** (UT-San Antonio) by amount and agency.

Figure 3.5: Examples of Recent Six-Figure Grants Won by George Mason and UT-San Antonio, 2013-2016

Amount	Funding Agency	Purpose
George Mason University		
$280K	NASA	Hyper-Resolution Hydrologic Modeling
$265K	NSF	Comprehensive Structural Assessments through Hierarchical Computer Vision
$239K	National Oceanic and Atmospheric Administration	Optimal Precipitation Estimation for Land Surface Modeling
$102K	University of Texas at Austin and U.S. Department of Transportation	Defining Boundary Conditions for Composite Behavior of Geosynthetic Reinforce Soil Structures
University of Texas at San Antonio		
$203.7K	Texas Department of Transportation	Pavement Scores, Performance Models and Needs Assessment
$174.0K	NSF	Sorption Behavior of Contaminants to Nanomaterials for Water Remediation
$354.5K	NSF	Plant Root Templated Geotextiles
$104.0K	Texas Department of Transportation	Empirical Flow Parameters – A Tool for Hydraulic Model Validity Assessment
$225.0K	Department of Education	Opportunities for Research Experience in Earth Science and Environmental Engineering
$501.8K	NASA	Climate Change Communication: Engineering, Environmental Science and Education
$128.5K	Texas Department of Transportation	Regional Channel Stability and Sediment Transport on Roadway Hydraulic Structures
$409.0K	NASA	Curriculum Improvement for Enhancing Engineering Education

Source: George Mason University and UT-San Antonio[52]

[48] [1] "Civil and Environmental Engineering." Duke University. http://cee.duke.edu/
[2] "Duke CEE at a Glance." Op. cit.
[49] "Department of Civil and Environmental Engineering: Research Overview." University of Tennessee. http://cee.utk.edu/research/overview/
[50] "Re-inventing America's urban water infrastructure." *Stanford News.* July 20, 2011. http://news.stanford.edu/news/2011/july/urban-water-infrastructure-072011.html
[51] "World's largest outdoor shake table gets $5.2 million from NSF." *UC San Diego News Center.* September 24, 2015. http://ucsdnews.ucsd.edu/pressrelease/worlds_largest_outdoor_shake_table_gets_5.2_million_from_nsf
[52] [1] "Volgenau School of Engineering: Grants." George Mason University. https://volgenau.gmu.edu/research/grants#2015anchor
[2] "Civil and Environmental Engineering Research Funding." UT-San Antonio. http://engineering.utsa.edu/ce/research/researchfunding.html

While federal agencies and state departments of transportation tend to account for the largest grants, institutions have also received funding from diverse sources, such as cities and counties, councils, and institutes. For example, **University of Colorado-Denver**'s civil engineering department received funds from the City and County of Denver, along with the Urban Drainage and Flood Control District, Colorado Department of Transportation, NSF, and Federal Highway Administration.[53] Similarly, **University of Wisconsin-Milwaukee'**s civil engineering department won awards from the Wisconsin Sea Grant Institute, Wisconsin Groundwater Coordinating Council, Illinois Clean Coal Institute, Milwaukee Metropolitan Sewerage District, in addition to the NSF, U.S. DOT, USDA Forest Services, National Oceanic and Atmosphere Administration, and U.S. DOD.[54]

NORTH CAROLINA STATE UNIVERSITY

North Carolina State University's (NC State) PhD in Civil Engineering program could potentially compete with a new program at UNCC. According to 2016 U.S. News and World Report rankings, NC State is ranked 24th nationwide in civil engineering, outranking Duke University.[55] Furthermore, civil engineering doctorate enrollment volumes remain high, exceeding 100 candidates each year over the last five years and exceeding enrollments in NC State's on-campus, research-based Master of Science in civil engineering program (Figure 3.6). NC State civil engineering doctorate completions data, located in the Appendix, also show a CAGR of 16.7 percent, indicating growing student demand.

Figure 3.6: NC State University Civil Engineering Graduate Enrollments 2011-2016

	2011	2012	2013	2014	2015	2016*	CAGR	AAC	STDEV
Doctorate	110	109	110	126	119	118	2.0%	2	8
MS	85	79	66	55	40	35	-17.2%	-11	3
M. in Civil Eng.	58	50	102	51	70	123	4.8%	3	38

Note: 2016 enrollments are for the spring semester; all other years are for the fall semester. 2016 figures are omitted from growth metrics. The Master of Civil Engineering is a professional degree which can be completed online or on-campus.[56] Source: NC State University[57]

PROGRAM STRUCTURE

Students must complete at least 54 credits or the equivalent of a year of advanced coursework beyond a master's degree, a preliminary exam, and a dissertation to graduate

[53] "Civil Engineering: Research." University of Colorado-Denver. http://www.ucdenver.edu/academics/colleges/Engineering/Programs/Civil-Engineering/Research/Pages/Research.aspx

[54] "Civil and Environmental Engineering Department: Research." University of Wisconsin-Milwaukee. http://uwm.edu/engineering/academics-2/departments/civil-and-environmental-engineering/civil-engineering-research/

[55] [1] U.S. News and World Report. Op, cit.
[2] "Graduate Programs: PhD in Civil Engineering." NC State University. https://www.ccee.ncsu.edu/academics/graduate-programs/#civil-engineering

[56] "Graduate Programs: Master's Degrees in Civil Engineering." NC State University. https://www.ccee.ncsu.edu/academics/graduate-programs/#civil-engineering

[57] "Headcount Enrollment." NC State University. https://oirp.ncsu.edu/students/enrollment/headcount-enrollment

with a PhD from NC State.[58] Although NC State provides master's degrees in environmental engineering, it does not offer a PhD in environmental engineering; instead environmental and geoenvironmental specializations are available within its civil engineering doctorate program (Figure 3.7). At least one year must be completed in residence.[59]

Figure 3.7: Civil Engineering PhD Specializations

COMPUTING AND SYSTEMS Addresses problems throughout civil and environmental engineering. Courses are available in civil engineering systems, computer methods and applications, numerical methods, high performance computing, evolutionary computation, stochastic modeling, complex adaptive systems, information technology and modeling, and inverse modeling. **FOCUS AREAS IN:** Systems and Optimization, High Performance Computing, Software Engineering, and Numerical Methods
CONSTRUCTION ENGINEERING Seeks to develop and apply advanced materials and structural systems to enhance sustainability and resiliency of built infrastructure through experimental, theoretical, and computational research at scales ranging from nanometers to large structures. **FOCUS AREAS IN:** Virtual Design and Construction, Sustainable Concrete Materials, Pollutant Emission Reduction, Lean Construction
ENVIRONMENTAL, WATER RESOURCES, AND COASTAL ENGINEERING Addresses tough questions across a range of environmental domains. **FOCUS AREAS IN:** Air Pollution Engineering, Coastal Engineering, Environmental Process Engineering, Energy Systems Analysis, Modeling and Systems Analysis, Water Resources Engineering
GEOTECHNICAL/GEOENVIRONMENTAL ENGINEERING Studies the interface between the natural and built environments with emphasis on ensuring sustainability and resilience of the world's infrastructure through large-scale testing, field studies, and numerical simulations. **SPECIAL TOPICS:** Scour and Erosion, Infrastructure Resiliency, Offshore Energy Shortage, Soil Improvement, Earthworks Studies, Seabed Mechanisms, Geotechnical Earthquake Engineering, Modeling and Computing, Granular Mechanics
MECHANICS AND MATERIALS Works toward understanding, modeling, and improving a wide spectrum of traditional and emerging materials, using theoretical, experimental, and computational mechanics from nano to macro scale. **FOCUS AREAS IN:** Theoretical Mechanics, Computational Mechanics, Experimental Mechanics, Applications to Specific Materials
TRANSPORTATION MATERIALS AND SYSTEMS Researches the planning, analysis, design, construction, and management of transport facilities and the materials from which they are built. **FOCUS AREAS IN:** Transportation Materials, Transportation Systems
STRUCTURAL ENGINEERING AND MECHANICS Addresses tough questions by drawing upon multiple areas of expertise to address system failure, probing the limits of materials, techniques, and structures. **FOCUS AREAS IN:** Materials, Sensing and Monitoring, Probabilistic Approaches in Structural Design, Structural Behavior and Design, Solid Mechanics, Engineering, Retrofitting and Service Life Extension

Source: NC State University[60]

[58] "Graduate Programs: PhD in Civil Engineering." Op. cit.

[59] Ibid.

[60] [1] Taken verbatim from: "Computing and Systems." NC State University. https://www.ccee.ncsu.edu/research/computing-systems/

FACULTY AND RESOURCES

NC State's Civil, Construction, and Environmental Engineering department maintains 66 faculty members and possesses substantial resources. In 2015 NC State spent $970,000 in research expenditures per doctoral degree recipient, ranking 30th nationwide [61] The department maintains multiple research laboratories, such as: [62]

- **Constructed Facilities Laboratory**, enables large to full-scale testing of structural systems under a variety of environmental conditions in order to support advanced research and development of construction materials, structural systems, and processes to enhance sustainability and economy of civil infrastructure;
- **Natural Hazards Mapping Program Lab**, which focuses on research using state-of-the-art GIS-based techniques, geospatial tools, and numerical models to visualize coastal processes and hazard identification and response; and
- **Civil and Environmental Engineering High Performance Computing Laboratory**, which maintains four Opteron clusters totaling nearly 1,000 cores and several high end workstations to enable high performance computing.

The Constructed Facilities Laboratory also includes smaller laboratories in geotechnics/geotechnology, microscopy and petrography, social/structure interaction, large structural systems, concrete, and computing, as well as an outdoor staging and testing area, specialized testing equipment, and full-scale structural tests.[63] In addition, NC State also maintains a number of research centers and institutes, many of which involve partnerships with industry (Figure 3.8).

[2] Taken verbatim from: "Construction Engineering." NC State University. https://www.ccee.ncsu.edu/research/construction-engineering/
[3] "Environmental, Water Resources, and Coastal Engineering." NC State University. https://www.ccee.ncsu.edu/research/ewc/
[4] Taken verbatim from: "Geotechnical and Geoenvironmental Engineering." NC State University. https://www.ccee.ncsu.edu/research/geotechnical-geoenvironmental-engineering/
[5] Taken verbatim from: "Mechanics and Materials." NC State University. https://www.ccee.ncsu.edu/research/mechanics-materials/
[6] Taken verbatim from: "Transportation Materials and Systems." NC State University. https://www.ccee.ncsu.edu/research/transportation-materials-systems/
[7] Taken verbatim from "Structural Engineering and Mechanics." NC State University. https://www.ccee.ncsu.edu/research/structural-engineering-mechanics/

[61] Yoder, B. "Engineering by the Numbers." ASEE. P. 36. https://www.asee.org/papers-and-publications/publications/college-profiles/15EngineeringbytheNumbersPart1.pdf

[62] "Centers and Facilities." NC State University. https://www.ccee.ncsu.edu/research/centers-and-facilities/

[63] "Constructed Facilities Lab." NC State University. https://www.ccee.ncsu.edu/cfl/cici/

Figure 3.8: Examples of NC State Civil Engineering Research Centers and Institutes

CENTER FOR INTEGRATION OF COMPOSITES INTO INFRASTRUCTURE (CICI) A NSF Industry/University Cooperative Research Center (I/UCRC) with the purpose of developing long-term partnerships among industry, academics, and government. CICI was started with a small NSF grant and is funded through membership fees from private industrial members. Other CICI university partners include University of West Virginia, Rutgers University, and the University of Miami. CICI's purpose is to usher applications and cost effective rehabilitation schemes using composites in civil and military structures. **FACILITIES:** Constructed Facilities Laboratory (main lab), plus eight other support laboratories **PARTNERS:** Diversakore, Grancrete, Martin Marietta Composites, Fyfe Company, Freyssinet USA, Nova Chemicals, The Steel Network, Inc., NC Department of Transportation, University of Missouri-Rolla.
INSTITUTE FOR TRANSPORTATION RESEARCH AND EDUCATION (ITRE) ITRE conducts surface and air transportation research, training and technical support activities for municipal, state, federal, and international clients to address critical transportation issues. ITRE was chartered by the North Carolina General Assembly in 1978 and is overseen by the ITRE Advisory Council which includes experts from public, private, and academic sectors. ITRE also conducts trainings and provides technical support to government agencies. **FOCUS AREAS:** NC Local Technical Assistance Program, Aviation, Bicycle and Pedestrian, Economics and Policy Assessment, Highway Systems, Modeling and Computation, Port and Ferry, School Planning and Transportation, Transit.
WATER RESOURCES RESEARCH INSTITUTE OF THE UNC SYSTEM (WRRI) Established in 1965, WRRI is an inter-institutional partnership between the U.S. Geological Survey and the UNC System and is one of 54 National Institutes of Water Resources. State funding is provided by the General Assembly via NC State University. WRRI also maintains research partnerships and competes for federal, state, and foundation grants and contracts, supporting nine UNC institutes with investments totaling more than $13 million. WRRI also provides technical and professional support to the NC Department of Environment and Natural Resources, training more than 10,000 erosion and sediment control professionals in 25 years. WRRI is governed by an advisory committee representing state and federal agencies, industry, local government, and NGOs. **OTHER PARTNERSHIPS:** Urban Water Consortium, Stormwater Group, Center of Excellence for Watershed Management, NC Water Resources Association, NC Department of Environment Quality, U.S. Environmental Protection Agency

Source: NC State University[64]

TUITION

NC State appears to charge one tuition rate for all graduate programs of $4,044 per semester for in-state students and $11,305 per semester for out-of-state students. Engineering students must pay an additional fee of $500 per semester.[65]

[64] [1] "Center for Integration of Composites into Infrastructure (CICI)." NC State University. https://www.ccee.ncsu.edu/cfl/cici/
[2] "Institute for Transportation Research and Education." NC State University. https://itre.ncsu.edu/about/
[3] "Water Resources Research Institute of the UNC System." NC State University. https://wrri.ncsu.edu/mission/

[65] "Fall 2016-Spring 2017 Rates per Semester." NC State University. https://treasurer.ofb.ncsu.edu/cashier/tuition/gradtuition.php

DUKE UNIVERSITY

Duke University's Civil and Environmental Engineering department is currently ranked 27th nationwide according to 2016 U.S. News and World Report rankings.[66] Roughly 50 PhD students enroll in Duke's program each year. In comparison, master's enrollments remain much lower (Figure 3.9).[67] Low master's enrollments may be due to the fact that Duke offers a bachelor's entry PhD program, with an optional en-route MS degree.[68]

Figure 3.9: Duke University Civil and Environmental Engineering Enrollments, 2011-2015

	2011	2012	2013	2014	2015	CAGR	AAC	STDEV
PhD	49	52	50	49	55	2.9%	2	3
Master's	8	10	6	1	2	-29.3%	-2	3

Source: Duke University[69]

CURRICULA

To graduate, candidates must complete at least 36 credits beyond the master's level. The program is designed for completion in as little as four years. Figure 3.10 displays other requirements for PhD candidates. Duke also offers a PhD Plus program for all STEM fields, which focuses on professional development. The program provides summer workshops, seminars, networking opportunities, and internship resources for PhD students.[70]

[66] [1] U.S. News and World Report. Op, cit.
[2] "Duke CEE at a Glance." Duke University. http://cee.duke.edu/about
[67] "Duke CEE at a Glance," Op. cit.
[68] "Frequently Asked Questions." Duke University. http://cee.duke.edu/grad/applicants/faq
[69] "Graduate School: Statistics." Duke University. https://gradschool.duke.edu/about/program-statistics
[70] "Preparing PhD Students for Success." Duke University. http://phdplus.pratt.duke.edu/

Figure 3.10: Overview Civil and Environmental Engineering PhD Requirements

CURRICULAR	EXAMINATIONS AND DISSERTATION
▪ 36 credits beyond the master's level including: ○ 15 credits from core track course ○ 21 credits related to student's area of research ▪ Participate in Department's Graduate Colloquium on Mechanics and the Environment (no grade awarded) ○ 18 seminars over two years on topics such as "Preparing and Writing a Research Proposal" and 'Research Communications" ▪ Complete Responsible Conduct of Research training ▪ Complete two-semesters of Teaching Assistantship between third and eighth semesters	▪ Establish and meet with the Qualifying Exam Committee ○ A written test based on content from core courses ○ Five-page minimum research based proposal ○ An oral defense of the research proposal with follow-up questions to their answers on written exam ▪ Pass the preliminary examination ○ Submits a research proposal which includes a literature review and contributions, describes research tasks to be performed, and suggests a completion timeline ○ Oral defense of research proposal ▪ Complete and defend a dissertation ▪ Pass a final examination

Source: Duke University[71]

The PhD in Civil and Environmental Engineering program has five tracks including three related to environmental engineering (Figures 3.11 and 3.12). Despite lacking a distinct PhD degree in environmental engineering, Duke is ranked eleventh in the world by the *Academic Ranking of World Universities* in this field.[72] Students must take at least five courses per track, with at least one course per area.

Figure 3.11: Civil Engineering PhD Tracks

COMPUTATIONAL MECHANICS AND SCIENTIFIC COMPUTING
Mathematics ▪ Basic Analysis, Applied Stochastic Processes, Applied Partial Differential Equations, Scientific Computing I, Functional Analysis, Mathematical Analysis of the Finite Element Methods **Numerical Methods** ▪ Introduction to Finite Element Method, Finite Element Methods for Problems in Fluid Mechanics, Nonlinear Finite Element Method, Numerical Optimization **Computer Science** ▪ Data Structures and Algorithms; Software Design; Programming, Data Structures, and Algorithms **Engineering Sciences and Mechanics** ▪ Continuum Mechanics, Thermodynamics, Computational Materials Science, Intermediate or Advanced Fluid Dynamics

[71] "PhD: Degree Requirements." Duke University. http://cee.duke.edu/grad/degrees/phd
[72] "Civil and Environmental Engineering." Duke University. http://cee.duke.edu/

Engineering Environmental Geomechanics and Geophysics
Engineering Sciences and Mechanics ▪ Continuum Mechanics, Structural Dynamics, Thermodynamics, Intermediate or Advanced Fluid Mechanics **Numerical Methods** ▪ Introduction to Finite Element Method, Finite Element Methods for Problems in Fluid Mechanics, Computational Methods for Evolving Discontinuities and Interfaces **Geomechanics and Geophysics** ▪ Wae Propagation in Elastic and Poroelastic Media, Environmental Transport Phenomena, Plasticity, Environmental Geomechanics, Ecohydrology **Mathematics** ▪ Applied Partial Differential Equations and Complex Variables, Scientific Computing I, Introduction to Partial Differential Equations, Mathematical Modeling
Dynamic Systems, Uncertainty, and Optimization
Mathematics ▪ Applied Partial Differential Equations and Complex Variables, Ordinary Differential Equations, Scientific Computing I, Linear Systems Theory **Numerical Methods** ▪ Introduction to the Finite Element Method, Nonlinear Finite Element Method, Numerical Optimization **Uncertainty Modeling** ▪ Introduction to Modern Statistics, Uncertainty Quantification Methods, Applied Stochastic Processes, Probability **Engineering Sciences and Mechanics** ▪ Continuum Mechanics, Structural Dynamics, System Identification, Buckling of Engineering Structures, Nonlinear Mechanical Vibration, Viscoelastic Biomechanics

Note: Course areas are in bold. Source: Duke University[73]

Figure 3.12: Environmental Engineering PhD Tracks

Hydrology and Fluid Dynamics
Applied Mathematics/Statistics ▪ Applied Mathematics for Engineers, Engineering Data Analysis, Introduction to Statistical Methods, Scientific Computing, Mathematical Modeling **Environmental Fluid Dynamics** ▪ Intermediate or Advanced Fluid Mechanics, Introduction to Turbulence, Environmental Fluid Mechanics **Hydrometerology and Ecohydrology** ▪ Physical Hydrology and Hydrometeorology, Ecohydrology, Vegetation and Hydrology, Biogeochemistry **Contaminant Transport Hydrology** ▪ Pollutant Transport Systems, Vadose Zone Hydrology, Groundwater Hydrology and Contaminant Transport

[73] "Study Tracks for MS/PhD." Duke University. http://cee.duke.edu/grad/degrees/study-tracks#CMSC

HYDROLOGY AND FLUID DYNAMICS
ENVIRONMENTAL PROCESS ENGINEERING
Applied Math/Statistics ▪ Applied Mathematics for Engineers, Engineering Data Analysis, Applied Data Analysis in Environmental Sciences, Applied Stochastic Processes, Applied Partial Differential Equations and Complex Variables **Transport Phenomena** ▪ Transport Phenomena in Biological Systems, Environmental Transport Systems, Pollutant Transport Systems **Environmental Science** ▪ Aquatic Chemistry, Chemical Fate of Organic Compounds, Environmental Microbiology, Introduction to Atmospheric Particles **Environmental Design** ▪ Biological Processes in Environmental Engineering, Physical and Chemical Treatment Processes in Environmental Engineering, Control of Hazardous and Toxic Waste, Air Pollution, Aerosol Measurements

Note: Course areas are in bold. Source: Duke University[74]

FACULTY AND RESOURCES

Duke's Civil and Environmental Engineering department employs 18 tenure-track professors and two adjuncts, as listed publically on its website. Two of these professors are among the most highly cited researchers of 2015 according to Thomson Reuters, suggesting high research impact.[75] Duke is actively seeking to hire assistant professors, specifically, but is also open to associate and full professors.[76]

Duke has committed substantial resources to its civil engineering department, and is currently building a $100 million, 85,000 square-foot state-of-the-art facility for engineering and physics education and research. 40,000 square-feet will be dedicated to engineering research alone. Enrollment and faculty increases, along with a two-fold increase in external research funding, are stated as reasons for Duke's expansion of its engineering facilities.[77]

Duke maintains several civil engineering research laboratories in computational mechanics, dynamic systems research, engineering and environmental geophysics, and structural dynamics and the seismic response control. In addition, Duke possesses civil engineering research groups in nonlinear dynamics and environmental geomatics and geophysics,[78] along with eight environmental engineering research groups in areas such as hydrology, air pollution, bioremediation, molecular biotechnology, aquatic and soil chemistry, sanitation, applied fluid dynamics, and water quality.[79] Environmental engineering laboratories include an environmental analytical chemistry laboratory and Duke's Forest Teaching and Research Laboratory comprised of 7,060 acres of land.[80]

[74] Ibid.
[75] "Four Pratt Faculty Among "Most Highly Cited." Duke University. January 21, 2016. http://cee.duke.edu/about/news/60490
[76] "Careers." Duke University. http://cee.duke.edu/careers
[77] "New Duke Facility Will Advance Engineering, Physics." Duke University. April 29,2015. https://cee.duke.edu/about/news/14577
[78] "Civil Engineering Research Groups." Duke University. http://cee.duke.edu/research/civil/centers-groups
[79] "Research Centers and Groups." Duke University. http://cee.duke.edu/research/environmental/centers-groups
[80] Ibid.

Duke is also home to the **NSF/EPA Center for the Environmental Implications of NanoTechnology** (CEINT), a collaboration between Duke, Carnegie Mellon University, Howard University, Virginia Tech, the University of Kentucky, and Stanford University. CEINT activities also involve faculty at Clemson University, NC State, Rice University, UCLA, and North Carolina Central universities. Researchers at National Institute of Standards and Technology (NIST) and EPA government labs and international partners also participate.[81] Duke also belongs in the Partnership for International Research and Education (PIRE) which brings together three U.S. universities; five international academic institutions in Turkey, Singapore, and France; and international companies to give students opportunities related to "environmentally sustainable commerce."[82]

Duke University's Civil and Environmental Engineering Department has won millions of dollars in external research funding. Duke won a $14.4 million grant from NSF and EPA to establish CEINT in 2008, and further secured a $15 million grant renewal for CEINT in 2013.[83] More recently, the department has received $8.3 million in external research awards in FY 2015 and $11.75 million in FY 2016.[84]

TUITION

Duke charges a general graduate tuition rate for PhD students, which varies by year. Students pay $52,925 per calendar year for years one through three and $10,275 per calendar year for years four and beyond.[85]

[81] "Center for the Environmental Implications of NanoTechnology." Duke University. http://ceint.duke.edu/about
[82] "Welcome to PIRE." Partnership for International Research & Education, Pratt School of Engineering, Duke University. http://pire.pratt.duke.edu/
[83] [1] "Department History." Op. cit.
[2] "Duke Wins $15 Million Grant Renewal to Study Effects of Nanomaterials." Duke University. November 11, 2013. http://cee.duke.edu/about/news/4461
[84] [1] "Civil and Environmental Engineering." Duke University. http://cee.duke.edu/
[2] "Duke CEE at a Glance." Op. cit.
[85] "Cost to Attend." Duke University. https://gradschool.duke.edu/financial-support/cost-attend#phd

APPENDIX

COMPLETIONS METHODOLOGY

As part of the analysis for student demand, Hanover uses recent completions data from the National Center for Education Statistics (NCES) to estimate student demand for graduate civil engineering programs. NCES uses a taxonomic system of numeric codes to classify postsecondary academic programs, known as the Classification of Instructional Programs (CIP) system. All degree conferral data presented in this report were drawn from NCES's Integrated Postsecondary Education Data (IPEDS) Data Center.[86] Note that 2015 completions data are preliminary release, meaning that they have yet to undergo IPEDS quality assurance process.

When interpreting completions data, some considerations should be taken into account:

- Institutions classify their programs independently, meaning that two programs that share identical content could hypothetically be classified under different CIP codes. In addition, for any given institution it cannot be assumed that IPEDS completions data for an individual CIP classification always correspond directly to an individual program.
- Newer programs may be excluded from completions data, as these programs will not have graduated students yet.

Hanover analyzes completions trends in terms of compound annual growth rate (CAGR), average annual change (AAC), and the standard deviation of the year-to-year changes (STDEV):

- **CAGR** reflects the percentage growth that would occur each year if one assumed the same change occurred yearly between the first year and the final year. It gives an impression of a theoretical, steady growth rate by ignoring data presented during middle years.
- **AAC** shows average year-to-year differences. It allows for a more comprehensive view of the yearly average change in completions, with each year playing a role in determining the figure.
- **STDEV** indicates how significantly each year's change varies from the AAC. The larger the STDEV, the greater amount of variance present over a five-year period. Inconsistency in STDEV does not necessarily mean a negative outcome—growth patterns that rapidly accelerate over time will have a higher STDEV than generally consistent ones.

LABOR PROJECTIONS METHODOLOGY

Similar to the CIP classification system developed by NCES, the Bureau of Labor Statistics (BLS) maintains its own classification system for occupations using Standard Occupational

[86] "IPEDS Data Center." National Center for Education Statistics. http://nces.ed.gov/ipeds/datacenter/

Classification (SOC) codes. To identify relevant occupations associated with each academic program, Hanover consulted a crosswalk provided by the NCES that links CIP codes with SOC codes.[87] Using the 2010 CIP-SOC crosswalk matrix, Hanover identified three SOC codes associated with civil engineering. These are 17-2051 Civil Engineers, 11-9041 Architectural and Engineering Management, and 25-1032 Engineering Teachers, Postsecondary.

SUPPLEMENTAL DATA

NC INSTITUTIONAL LEVEL COMPLETIONS

Figure A.1: North Carolina Institutional Level Completions, 2011-2015

INSTITUTION	2011	2012	2013	2014	2015	CAGR	AAC	STDEV
Master's								
Duke University	3	9	6	12	5	13.6%	1	6
North Carolina A & T State University	13	7	4	11	4	-25.5%	-2	6
North Carolina State University at Raleigh	87	100	81	91	66	-6.7%	-5	17
University of North Carolina at Charlotte	20	17	22	18	27	7.8%	2	5
Doctorate								
Duke University	8	6	6	12	6	-6.9%	-1	4
North Carolina State University at Raleigh	14	19	18	19	26	16.7%	3	3

Note: Data include completions reported under 14.0801 Civil Engineering, General and 14.0899 Civil Engineering, Other.
Source: IPEDS

[87] "CIP 2010 Search." National Center for Education Statistics. http://nces.ed.gov/ipeds/cipcode/search.aspx?y=55

NSF Funding by Institution and PhD Offerings

Figure A.2: NSF Civil Infrastructure Systems Grant Recipients, 2011-2017

Institution	Total Award Amount	PhD Program?
Arizona State University	$3,159,788.00	X
University of California-Berkeley	$2,304,093.00	X
Virginia Polytechnic Institute and State University	$2,002,973.00	X
Lehigh University	$1,903,209.00	X
Georgia Tech Research Corporation	$1,709,846.00	X
University of Puerto Rico Mayaguez	$1,499,988.00	X
University of Washington	$1,490,947.00	X
University of Colorado at Boulder	$1,434,774.00	X
University of New Mexico	$1,409,942.00	X
University of Oklahoma Norman Campus	$1,381,958.00	X
Massachusetts Institute of Technology	$1,364,511.00	X
University of Texas at Austin	$1,283,339.00	X
Pennsylvania State University-University Park	$1,277,171.00	X
University of California-Davis	$1,274,759.00	X
Northwestern University	$1,250,000.00	X
New York University	$1,099,740.00	X
University of Illinois at Urbana-Champaign	$1,075,401.00	X
University of South Florida	$994,243.00	X
Purdue University	$916,595.00	X
Rutgers University New Brunswick	$916,000.00	X
Michigan Technological University	$899,796.00	X
Florida International University	$879,142.00	X
George Washington University	$779,103.00	X
University of Tennessee Knoxville	$749,311.00	X
Illinois Institute of Technology	$740,000.00	X
Stanford University	$719,715.00	X
University of Wisconsin-Madison	$700,501.00	X
University of Illinois at Chicago	$685,000.00	X
William Marsh Rice University	$669,996.00	X
University of Maryland College Park	$620,000.00	X
Rensselaer Polytechnic Institute	$556,500.00	X
University of Florida	$534,941.00	X
Indiana University	$500,000.00	
Catholic University of America	$475,002.00	X
University of Nebraska-Lincoln	$419,999.00	X
University of Texas at Dallas	$417,051.00	
University of Southern California	$410,689.00	X
Ohio State University	$383,716.00	X
Cornell University	$375,000.00	X
Johns Hopkins University	$348,152.00	X
Rochester Institute of Tech	$309,660.00	
University of California-Irvine	$300,000.00	X
Florida Atlantic University	$296,793.00	
Iowa State University	$285,305.00	X
Missouri State University	$275,000.00	

INSTITUTION	TOTAL AWARD AMOUNT	PHD PROGRAM?
Portland State University	$211,636.00	X
Georgia Southern University Research and Service Foundation, Inc.	$200,049.00	
Cal Poly Pomona Foundation, Inc.	$200,000.00	
Drexel University	$199,924.00	X
Texas Tech University	$188,505.00	X
Board of Regents, NSHE, obo University of Nevada, Reno	$180,000.00	X
Claremont Graduate University	$174,962.00	
Southern Methodist University	$154,920.00	X
University of California-Riverside	$99,364.00	
George Mason University	$50,000.00	X
University of Virginia Main Campus	$49,600.00	X
University of Michigan Ann Arbor	$34,553.00	X
Texas A&M University Main Campus	$25,000.00	X

Source: NSF[88]

[88] [1] "Civil Infrastructure Systems (CIS)." NSF. http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13352&org=ENG&sel_org=ENG&from=fund
[2] "What Has Been Funded Through Awards and Abstracts." NSF. http://www.nsf.gov/awardsearch/advancedSearchResult?WT.si_n=ClickedAbstractsRecentAwards&WT.si_x=1&WT.si_cs=1&WT.z_pims_id=13352&ProgEleCode=1631&BooleanElement=Any&BooleanRef=Any&ActiveAwards=true&#results

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Appendix 2. Analysis of Faculty and Student Resources Needed to Support the Civil Engineering Ph.D. Program at UNC Charlotte

A sustainable C.E. Ph.D. program requires sufficient faculty resources to teach the entire curriculum at an appropriate frequency and also requires a sufficient number of students to populate the courses taught. This appendix analyzes those resource needs. For the purposes of this analysis, the program is divided into three concentrations:
1.Structures and Geotechnical Engineering
2.Environmental and Geo-Environmental Engineering
3.Transportation Engineering

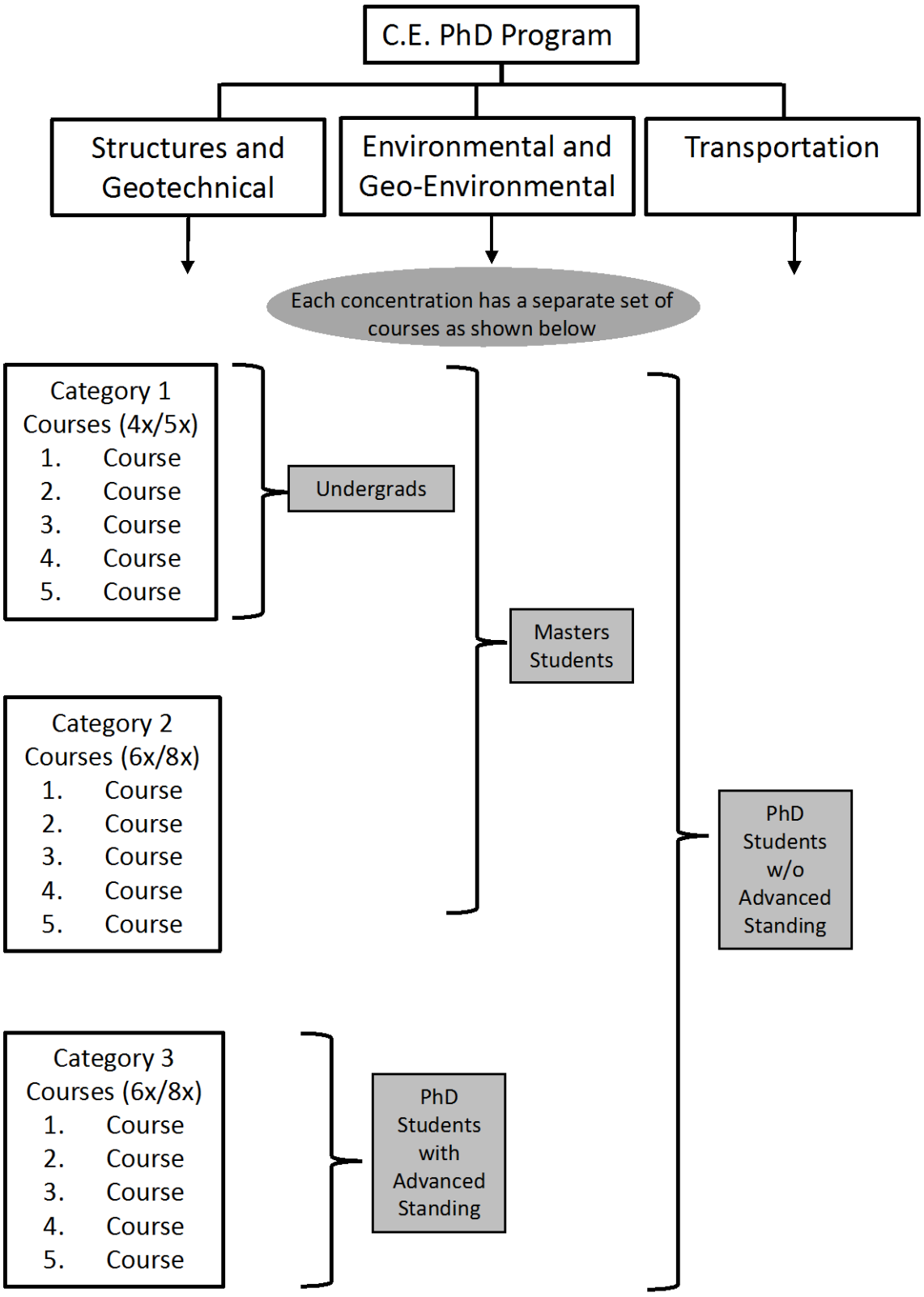
Each of the three concentrations will offer graduate-level coursework in three general categories, as shown below. For each of these types of courses, the number of courses within the category and the frequency that each course is offered is also shown.

1. Advanced undergraduate and Master's level courses (4xxx/5xxx course numbers)
    - Five separate courses offered
    - Each course offered once per year
2. Master's and Ph.D. level courses (6xxx/8xxx course numbers)
    - Five separate courses
    - Each course offered every other year
3. Ph.D. and advanced Master's level courses (6xxx/8xxx course numbers)
    - Five separate courses
    - Each course offered once every third year

Each successive category of courses is designed to be at a more advanced level offered to a reduced number of more advanced students. The teaching frequency provides the opportunity for all undergraduates to take all of the category one courses sometime during their final three semesters of their undergraduate study. Master's level students pursuing a coursework only option are able to take all five category one courses and all five category two courses during a two-year Master's program. Ph.D. students entering the program without a Master's degree will be able to take all fifteen graduate-level courses over a three-year time period. Students who enter the Ph.D. program with advanced standing after earning a Master's degree at UNC Charlotte or elsewhere will have available all five of the category three courses for their Ph.D. program.

The teaching plan is designed to meet the coursework needs of each graduate program. Master's student pursuing a coursework only option have available the needed 30 hours of coursework. The needs of both project-based (27 hours) and thesis-based (24 hours) Master's programs are also satisfied. On the Ph.D. level, students entering without a Master's need 54 hours of coursework. This requirement will be met with the fifteen category one, two, and three courses shown above (45 hours) and three additional courses (9 hours) to be taken outside the concentration and/or outside the department. The 24 hours of coursework needed by Ph.D. students with advanced standing will be met with the five category three courses (15 hours) and three additional courses (9 hours) taken outside the concentration and/or outside the Department. This course curriculum plan is shown schematically in the following figure.

Figure A.4.1. Schematic of Civil Engineering Ph.D. Curriculum Plan



The teaching plan presented on the previous page requires that in each concentration 9.16 courses be taught at the graduate level (9.16 = 5 + 5/2 + 5/3) each year. For the three concentrations combined across the department a total of 28 courses need to be taught at the graduate level each year. With a current faculty of twenty-five (22 tenure-track + 3 instructors), the Civil and Environmental Engineering Department can meet this teaching demand with slightly more than one graduate course taught per faculty per year. At either the current or anticipated future course loads for the faculty, twenty-eight graduate courses per year does not seem to be an undue burden.

The teaching plan can also be examined to estimate class sizes for each category of graduate courses. For this analysis it is assumed that 100 undergrads graduate each year, 25 Masters students graduate each year (50 students / 2-year program), and 13 Ph.D. students graduate each year (52 students / 4-year program). These numbers are reasonable given the current size of the undergraduate and graduate population in the Department and the expected size of the C.E. Ph.D. program once it reaches maturity. Undergrads are each assumed to take three of the five category one courses as electives in their specialty. The undergraduate curriculum includes department and technical electives that allow them to take these courses. Masters students are assumed to take all five category one courses, and all five category two courses. Ph.D. students with advanced standing (assumed 50% of total) are assumed take all five category three courses. Ph.D. students without advanced standing (assumed 50% of total) are assumed to take all fifteen courses within a concentration. Students are assumed to be equally distributed between the concentrations and all courses within a category are assumed to have equal average enrollment. With these assumptions, the anticipated average course enrollment in each category is as follows:

- Category One Courses – 31 students
- Category Two Courses – 11 students
- Category Three Courses – 13 students

These average enrollments are considered reasonable for each category. Even with some variability in enrollments from course to course, the vast majority of courses offered at the graduate level will have acceptable enrollments.

UNC CHARLOTTE

Student Learning Outcomes Assessment Plan and Report

College: The William States Lee College of Engineering
Department: Civil & Environmental Engineering
Name of Degree: Ph.D. in Civil Engineering

Reflection on the Continuous Improvement of Student Learning

Methodology to Assess Student Learning Outcomes
All activities related to Ph.D. Dissertation are organized by each doctoral student's Ph.D. Committee Chair, administered by each student's Ph.D. Committee, and managed by the Ph.D. Program Director. Ph.D. Committee Chair and Members review the written reports (Dissertation Proposal and Dissertation) and provide their feedback, comments and input. Each doctoral student also makes presentations (Dissertation Proposal Defense and Final Dissertation Defense) to their Ph.D. Committee. The student's Ph.D. Dissertation Committee Chair reports results to the Ph.D. Program Director.

Student Learning Outcome 1 (knowledge, skill or ability to be assessed - written)
Students will analyze and evaluate advanced topics in civil engineering.

Changes to the Student Learning Outcomes Assessment Plan:

Effectiveness Measure:
Written dissertation report is used for the assessment.

Performance Outcome:
90% of students earn at least 80% (24/30) on their dissertation reports submitted to the examining committee.

Previous Year Assessment Data	**Current Year Assessment Data**
% (X of Y) of students earned at least 80% on their dissertation reports.	% (X of Y) of students earned at least 80% on their dissertation reports.

Plans for Next Year:

Student Learning Outcome 2 (knowledge, skill or ability to be assessed - written)
Students will communicate technical information through written reports.

Changes to the Student Learning Outcomes Assessment Plan:

Effectiveness Measure:
Written dissertation report is used for the assessment.

Performance Outcome:
90% of students earn at least 83% (5/6) on their dissertation reports submitted to the examining committee.

Previous Year Assessment Data	**Current Year Assessment Data**
% (X of Y) of students earned at least 83% on their dissertation reports.	% (X of Y) of students earned at least 83% on their dissertation reports.

Plans for Next Year:

Student Learning Outcome 3 (knowledge, skill or ability to be assessed - oral)
Students will analyze and evaluate advanced topics in civil engineering.

Changes to the Student Learning Outcomes Assessment Plan:

Effectiveness Measure:
Dissertation presentation is used for assessment.

Performance Outcome:
90% of students earn at least 80% (24/30) on their dissertation presentations to the examining committee.

Previous Year Assessment Data	**Current Year Assessment Data**
% (X of Y) of students earned at least 80% on their dissertation presentations.	% (X of Y) of students earned at least 80% on their dissertation presentation.

Plans for Next Year:

Student Learning Outcome 4 (knowledge, skill or ability to be assessed - oral)
Students will communicate technical information through oral presentation.

Changes to the Student Learning Outcomes Assessment Plan:

Effectiveness Measure:
Dissertation presentation is used for assessment.

Performance Outcome:
90% of students earn at least 83% (5/6) on their dissertation presentations to the examining committee.

Previous Year Assessment Data	**Current Year Assessment Data**
% (X of Y) of students earned at least 83% on their dissertation presentations.	% (X of Y) of students earned at least 83% on their dissertation presentation.

Plans for Next Year: