Creation of a Co-Terminal BS/MS Civil Engineering Degree Program

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Abstract

A civil engineering department at a small teaching-focused polytechnic university recently overhauled its undergraduate program to develop a practice-focused, co-terminal, bachelor's/master's degree program. The department, staffed with five faculty members, has instructed an average enrollment of 126 students for the past two years. The faculty created a program that allows freshmen to enter at college algebra, expands technical elective offerings for both BS and BS/MS students, allows students to graduate with bachelor's and master's degrees in five years, and can be offered with minimal adjunct faculty. The new program supports the university's hands-on practice-oriented mission and allows for the first degree program of its kind in the region to provide students with a graduate experience that satisfies the M/30 path to licensure proposed in the ASCE Policy Statement 465 and supported by the NCEES Model Law. The program structure and content was informed by the ASCE Body of Knowledge, ABET requirements, recent changes to the Fundamentals of Engineering exam, similar co-terminal programs at others schools, faculty background and university general education requirements. This paper provides a review of BS/MS programs, outlines the previous and current civil engineering degree programs at the institution, describes the process of crafting the new program and discusses the benefits and challenges of such a program for a small faculty body.

Introduction

Graduate education in civil engineering, indeed in all fields, has developed in a relatively unregulated fashion with departments creating and offering programs in response to demands of the profession and informed by institutional culture and faculty interests and expertise. While civil engineering graduate programs initially served the profession through fundamental research and academic training, the structure and requirements of civil engineering graduate degrees in the United States have evolved in recent years to serve future practicing professionals with coursework-only or project-based degrees. With a focus on professional skills and discipline-specific education, these degree programs offer less traditional research instruction and tend not to require a formal thesis. Co-terminal degree programs, which blend the undergraduate and graduate programs, have also become more popular in recent years.

Professional, or practice-oriented, masters programs have grown in recent years as a result of various drivers, many of which are addressed by ASCE's Raise the Bar initiative and articulated in ASCE's Policy Statement 465. In summary, there is a general need for formal education beyond a tradition four-year engineering degree to support adequately broad and deep technical knowledge and ability, as well as an understanding of the increasingly complex context of engineering decisions. Other drivers include the state of the nation's aging infrastructure, the changing nature of design requirements driven by climate change and population growth, and the needs of local agencies and engineering consultancies for creative solutions and knowledge of emerging technologies. Indeed, even the social makeup of the workforce provides motivation for increased education. As experienced workers retire in greater numbers, more well-educated graduates will be needed to fill the resulting holes in the workforce and they must come prepared with current and relevant knowledge in addition to the traditional engineering curriculum.

According to ASEE, nationwide enrollment trends are essentially flat for civil engineering. There was an increase of 5.5 percent in civil engineering master's degrees and a very notable 104 percent increase in master's degrees in civil/environmental engineering (a newer program designation) between 2011 and 2012 with projections for a plateau for both in 2013 and for next few years (Yoder, 2012). The BS/MS at Oregon Tech, while just begun in the Fall of 2013, has proven to be valuable to our incoming freshmen, with many saying "why wouldn't I take another year for a master's degree?" In the future, enrollment data will be reviewed to determine if the new program has had an effect now that marketing has begun in earnest.

This paper will address the creation of a degree program in which both the bachelor's and master's degrees are awarded concurrently. The state of master's-level education and co-terminal degrees in civil engineering will be described. The nature of the institution as well as the various drivers will be discussed. The process of transitioning from the bachelor's degree to a co-terminal degree will be described as it occurred coincident with a substantial curriculum revision for the bachelor's-only degree.

The State of Civil Engineering Co-Terminal Degrees

There are currently 330 ABET accredited civil engineering programs, 97 of which are civil engineering technology programs (ABET Annual Report with statistics current to 2012). There are 233 ABET-accredited civil engineering bachelor's degree granting institutions in the United States and Canada (ABET, 2013). In 2011, there were 227 ABET-accredited civil engineering programs with 186 offering a master's degree of some kind. Russell et al (2011) evaluated the characteristics of these master's programs and found that a slight majority offered "course-only options," indicating that many institutions are already offering professional or practice-oriented master's degree options; interestingly, only one program name of the 227 reviewed referred to a co-terminal degree. O'Brien et al (2011) provide data showing a growing trend in civil engineering master's degrees awarded between 2005 and 2009, perhaps as the result of Policy Statement 465 and accelerated by the economic downturn. In any case, the market for master's degrees, and specifically professional master's degrees, appears to be a good one.

As of this writing, 37 of the 233 ABET-accredited programs offer bachelor's and master's degrees in some sort of combined way (see Appendix A for institutions and web links). Co-terminal programs offer a means to combine undergraduate and graduate coursework, either by allowing master's-level courses to be taken earlier in a program or by allowing a certain number of credits to count toward both degrees. Based on available data of these 37 programs, 27 allow 'double counting' of classes towards the BS/MS degree. These double-counted credits range from zero to 11 semester hours, depending on the institution and credits required for the BS and MS degrees separately (see Appendix A).

Co-terminal degrees go by a variety of names or are marketed differently depending on the institution. Descriptors for the programs include joint, accelerated, integrated, co-terminal, combined, concurrent, 4+1 or blended and nearly all allow for completion of both degrees in five years. The most common shared term used by institutions offering a co-terminal program is "BS/MS." Most programs require enrollment in a bachelor's program and attendance at the institution for three years prior to enrollment in the co-terminal option. This represents an opt-in approach and requires an additional pitch to students to sell the co-terminal option. Others offer an opt-out program rather than an opt-in program, whereby students are enrolled in the co-

terminal program in their freshman or transfer year and are considered master's seeking students from the beginning.

Co-terminal degrees are attractive to students for a variety of reasons. Jackson et al (2008) classify these reasons on a spectrum of intentionality, from thoughtful consideration of alternatives and careful choice of the program to little consideration of alternatives and casual continuation at an institution based on ease of doing so. This paper makes it clear that advising and structure in such programs is important.

The Size and Shape of Oregon Tech

Oregon Tech is a small teaching-focused polytechnic university with a total student enrollment of around 4,000. The university has two campuses described as residential (Klamath Falls, OR) and urban (Wilsonville, OR) with programs in La Grande, OR, Salem, OR and Seattle, WA. The original campus located in Klamath Falls, OR began operation in 1947 and is where the civil engineering program is offered. Starting as a true polytechnic school, the first ABET-accredited bachelor's degrees in technology were awarded in 1970 while the first bachelor's degree in civil engineering was awarded in 1999. It is anticipated that the first co-terminal civil engineering bachelor's/master's degree will be awarded in June 2015. While Oregon Tech offers a variety of bachelor's degrees, only three master's degrees are currently offered including the co-terminal bachelor's/master's degree in civil engineering.

Oregon Tech's bachelor of science in civil engineering program was first accredited by ABET in October 1997, graduating its first class in 1999 and phasing out its civil engineering technology program at the same time. Since receiving accreditation, the program has gone through two additional accreditation cycles (2003 and 2009), each of which has spurred changes to the degree requirements. The last accreditation visit occurred prior to the curriculum redesign and rollout of the co-terminal program. The updated BSCE has not been accredited yet.

The civil engineering department functions with five faculty members: four full-time teaching faculty and one part-time teaching/department chair. In addition, the department includes one full-time technician who aids in the operation of its laboratory space. With only five faculty members, the program has four specialty areas: structural, transportation, geotechnical and water resources engineering. Each of these specialty areas has its own dedicated laboratory space and is directed by the faculty member(s) with the associated subject matter expertise.

The primary objective of the civil engineering program at Oregon Tech is to prepare students to enter into professional practice, where professional practice means to practice as a professional (i.e., licensed) engineer. Indeed, graduates of Oregon Tech's Civil Engineering program routinely seek professional licensure. Over the past five years, some 90% of graduates from the Bachelor of Science in Civil Engineering (BSCE) program at Oregon Tech have taken the FE exam and a recent survey showed that 84 percent of BSCE students intend to seek a PE license.

Justification for Developing the New Program – An Updated BS with a Co-Terminal MS

In the summer of 2012, the Oregon Tech civil engineering faculty considered how they might simultaneously revise a piecemeal-updated undergraduate curriculum and launch a master's program that had been approved in 2009, but not yet offered due to faculty turnover without equivalent replacement. The faculty considered a traditional thesis-based master's, a project-

based master's, a coursework-only master's and the co-terminal. Rather than create a standalone, and more traditional, master's program, which would require additional faculty before launching, the faculty identified the co-terminal degree option, with its potential for double-counting bachelor's and master's credits, as perhaps the only way to launch the program with the five existing faculty. With a bachelor's curriculum that had not been comprehensively updated in ten years, the time was right.

The co-terminal program was crafted to appeal to students as they considered various institutions for transfer or from high school. An opt-out approach was chosen such that students would be considered master's-seeking students from their freshman or transfer year and would declare either the BS or the BS/MS in the spring of their third year. With a 3.0 GPA cutoff, the faculty felt this would function as an incentive for students to focus on their academics earlier and more earnestly in their first few years. It has the added benefit of marketing the profession's intended academic credential, a graduate degree, directly to students entering college for the first time.

The co-terminal does not allow any double-counted credits. While it was this very element that had initially made the co-terminal option attractive to the small faculty body, after much discussion, it was decided that no double-counted credits would be allowed. The BS program had already been reduced to 121 semester hours under state pressure and double-counting credits with a 30-semester-credit MS would have placed the program at the low end for total credits required in a BS/MS program. This perceived lack of rigor was not something the faculty wanted for their new program.

Proposed Changes in Licensure Requirements and Testing

Recently, civil engineering's major professional society and accrediting body have pushed to increase the educational requirements for licensure. The American Society of Civil Engineers (ASCE) has recognized the need for both broad and specialized education in civil engineering and has adopted ASCE Policy Statement 465 (PS 465). The central issue addressed by PS 465 is that "It is evident that the exploding body of science and engineering knowledge cannot be accommodated within the context of the traditional four-year baccalaureate degree (NAE, 2005)." One way to provide this additional, specialized training is with a series of graduate-level courses and/or the attainment of an advanced engineering degree. Specifically, PS 465 recommends that states require either a master's degree or 30 semester credits of graduate-level coursework as an additional requirement for licensure.

In response to PS 465, ASCE prepared a Body of Knowledge (BOK) that should be attained by every civil engineer entering into professional practice. It was concluded that significant portions of the BOK could only be obtained through graduate coursework, most notably at the higher levels of achievement in the area of Technical Specialization (ASCE, 2008). The Master of Science in Civil Engineering (MSCE) program would allow students to gain more specialized knowledge to better prepare them to enter the workforce and seek licensure as professional engineers. Technical and professional breadth in the undergraduate curriculum is also a significant consideration of the BOK and was also addressed in the curriculum revision.

Also in response to PS 465, the National Council of Examiners for Engineering and Surveying (NCEES), the agency responsible for writing and administering the FE and PE exams, adopted a new model law that would require candidates for professional engineering licensure to possess a

bachelor's degree in engineering plus either a master's degree or 30 semester credit hours of advanced technical education (NCEES, 2006). This provision of the NCEES model law would go into effect in 2020, meaning that students entering a traditional engineering program starting in 2012 would be affected (this assumes a four-year BS and four years of pre-professional practice).

If Oregon and neighboring states choose to adopt licensing laws related to PS 465, students will need to have advanced-level education to become licensed professional engineers. As such, the civil engineering faculty at Oregon Tech proposed and gained permission to offer an MSCE degree, which would allow the civil engineering department to continue to fulfill its objective to prepare students for professional practice.

Institutional Change

The decision to offer an MSCE program was also institutionally influenced. Oregon Tech has strategically been moving away from associate's degrees and toward advanced degrees. The number of master's degrees offered at Oregon Tech has tripled in the last four years and more are in the proposal phase for implementation in the next couple of years. The civil engineering faculty strongly desired to be a part of this forward momentum. Like most public universities, however, the department was expected to accomplish more with decreased support. The number of faculty members has continually decreased in recent decades resulting in a faculty that presently includes only five members. The department determined that it would be impossible to offer both a full slate of undergraduate elective courses and all of the courses required for a master's degree in any given year with only five professors without a unique model.

Expressed Interest from Current Students

Since the approval of a master's program in 2009, informal surveys were conducted during advising sessions that indicated a majority of seniors would stay for a fifth year if the department offered a master's degree that could be completed in just one year. Many cited their good relationships with the civil engineering faculty, ease of transitioning into a master's at the same school, and the obvious benefit of the credential as a primary reason for staying at Oregon Tech.

Support of the Civil Engineering Industry Advisory Council

The master's program was long supported by the department's industrial advisory council, which is comprised of engineers representing the civil engineering sub-disciplines. Each of them recognized the obvious benefit of the program for the school and also supported master's-level education, particularly members with a focus on structural engineering, where a master's degree is already a common requirement for employment.

Curricular Transition

A side-by-side comparison of previous and revised curricula including the co-terminal option can be found in Appendix B. The previous BS program satisfied accreditation requirements and served the needs of students taking the FE exam prior to Spring 2014. The Oregon Tech general education requirements were satisfied: three credits of college-level algebra or higher, nine credits of humanities, 12 credits of social science, 18 credits of communication and six credits of

math/science electives. The faculty referenced the ASCE Body of Knowledge and their own ABET-inspired program outcomes in developing and modifying courses.

Transition to the New Bachelor's Degree Requirements

Challenges of the previous BSCE program included courses that tended to seem incongruous to students in a civil engineering program, such as thermodynamics, circuits, dynamics or the third term of physics dealing primarily with waves, sound and optics. These courses were not prerequisites for later work and were not part of the institution's general education requirements. They were relics of a general, rather than focused, engineering curriculum. Indeed, these courses are still found in many curricula, especially general engineering programs. While these courses are indeed potentially useful to students working in an interdisciplinary environment or valuable in a general education sense, the faculty and IAC felt the addition of technical electives, additional depth in the civil sub-disciplines, as well as increased breadth in the form of courses in GIS and geology were more beneficial than retaining coursework that would not be included in the new civil FE exam and held marginal interest for students. The "horse trading" that occurred in the breadth courses was probably the most contentious issue the faculty and IAC faced in their deliberations about the changes. In the end, however, there was agreement that, given the various drivers of civil engineering curriculum (ASCE's BOK, FE exam changes, faculty expertise, and employer and student expectations and desires), the new curriculum more effectively satisfied them all compared to the old one.

The department's industrial advisory committee (IAC) was approached first for their approval of the co-terminal degrees and again for detailed review of proposed changes. While concerns about dropping dynamics from the curriculum were voiced, they were not shared by the majority. Dynamics treatment within the physics course sequence, transportation courses, and in graduate-level courses in structural dynamics was determined to be more appropriate for preparation of civil engineers and the change was made.

Major changes were proposed to the structural course sequence whereby individual courses in structural steel and reinforced concrete design (each four quarter credits) would be replaced by a single five-credit course covering beam and column design in each of the major structural materials (steel, concrete, masonry and timber). Again, a single IAC member objected on the grounds that student transcripts would be more difficult to parse by employers seeing "Elementary Structural Design" rather than the individual material-based courses. While this seemed a valid concern to the faculty, the benefit in balancing credit counts between the disciplines as well as a broader treatment of structural design in the junior year was more important and the change was made.

Other curricular changes included moving targeted treatment of sustainability from a 2-credit sophomore sequence to a required 3-credit 400-level course. Two 3-credit courses in engineering economics and project management were combined into a 4-credit course entitled Principles of Professional Practice, which would treat the bulk of the professional skills. The total number of elective credits was increased from nine to 15.

Transition to the New Co-Terminal Degree

Transitional advising from BS to BS/MS programs provided both benefits and challenges, the magnitude of which varied largely by advising cohort.

Freshman and Senior Students

Entering freshman students were advised using only the new curriculum map, thus were essentially unaffected by any transition. Graduating seniors were also largely unaffected as the former senior year was similar to the new fourth year; a limited number of course substitutions were required to address those instances of graduating seniors still completing courses scheduled for prior years, well off any curriculum map. Most seniors are graduating under the previous curriculum as they were most deeply vested in that program of study.

Sophomore Students

Sophomore students were generally unaffected, or even positively affected due to the additional terms allowed in the curriculum map for calculus and related post-requisite course completion. For last year's freshman class, many students were advised to enroll in the university's physical geology course as a math/science elective, understanding that it would become a required course in the new curriculum. Those students who did not or could not complete that course as advised will be required to complete the course during their current sophomore year, causing challenges in both Spring term scheduling and student workload.

Junior Students

The most significant transitional advising challenges are related to students in the current junior cohort. As the vast majority of the courses offered in the junior year of study are civil engineering discipline- and program-specific courses, this should be an easy transition—on paper. However, the number of students entering this year already off the mapped curriculum—in terms of prerequisite courses—combined with the reduced number of repeat course offerings in other terms (required to accommodate the expanded selection of graduate elective courses within the limits of faculty workload availability) created a significant advising backlog and documentation barrier during the first term of the new program.

General Transition Issues

Many courses within the program were primarily a change in name and number, and could be addressed using blanket substitutions for any prerequisite issues. However, a significant number of singular course substitutions were still required to adapt a particular student's progress to the new program of study, particularly for those courses that involved a change in credit count. A typical example would be the shift from the two-credit CIV201/202 Sustainable Civil Engineering sequence to the three-credit CE405 Sustainability & Infrastructure course; a substitution may borrow a single credit from another course under the old curriculum, such as CIV317 Engineering Economics. The intent in making any of these substitutions is to both satisfy accreditation criteria for the selected program of study under which the student plans to matriculate, while also maximally accounting for course credits already completed by the student.

Another notable benefit, albeit one that takes some acclimation from current student advisors, is the course numbering structure that was implemented with the new curriculum. A system was adopted that more clearly identifies the technical area associated with the course, thus improving course balance across all four technical areas covered by the faculty and aiding planning and accreditation auditing.

Challenges and Benefits of a Major Curriculum Revision and the Co-Terminal Option

New and Removed Course Offerings

Yet another benefit of the change to the co-terminal was expansion of technical elective offerings and requirements. Only nine technical elective credits were required in the previous BSCE program and elective offerings were limited to two per term, distributed roughly evenly between the civil engineering sub-disciplines. This made it difficult for students interested in a particular sub-discipline to focus on it during their senior year. The faculty agreed that offering more electives in the revamped curriculum should be a goal. Dropping the courses mentioned above and adjusting credits in the junior core allowed for 15 technical elective credits, two full additional courses, while the co-terminal program allowed the small faculty body to double the elective offerings from 17 courses offered sporadically depending on available faculty workload (and sometimes very infrequently) to 34 courses offered regularly on a two-year cycle (see Table 1).

The scheduling of graduate-level electives is also very significant. The department's attempt to overcome this challenge is to offer complimentary graduate-level courses on alternating years. Examples of complementary courses include earthquake engineering (geotechnical specialty) with advanced bridge design (structural specialty). An attempt was also made by the department to limit graduate-level pre-requisites. This helps to eliminate scheduling difficulties caused by co-terminal degree students during their fifth year of study.

Given faculty workload limitations, co-terminal students would be unable to graduate in a timely manner by taking graduate courses in only one specialty area. While this may be seen as a challenge to a student wishing to study only one specialty area, it broadens the knowledge of our co-terminal students, for instance by allowing a student with an interest in structures to supplement coursework in structural design of buildings and bridges with advanced mechanics, a geotechnical basis for seismic design, advanced foundation engineering, or transportation design to provide context for specific structures. While ASCE's BOK recommends the M/30 to ensure depth in a technical discipline, it is the interpretation of the faculty at Oregon Tech that civil engineering is itself a discipline and the interrelatedness of the sub-disciplines makes a diverse master's curriculum reasonable. Indeed, many other more traditional master's programs already offer a café approach to course selection in the development of one's curriculum.

A final challenge to note is an apparent student-faculty disconnect in what constitutes and what is expected in a master's-level course. Without a strong history of graduate education at the institution, students are not inculcated in an environment where rigorous independent study is the norm. The faculty has recognized this and are adjusting graduate and undergraduate advising accordingly to develop the cultural elements necessary for our students to be successful.

Table 1. Elective offerings increased from 17 to 34 as a result of the curricular change.

Previous BSCE Elective Offerings		Updated BSCE/MSCE Elective Offerings	
CIV 410	Basic Dynamics of Structures	CE 411	Engineering Geology
CIV 416	Structural Design for Lateral Loads	CE 413	Advanced Soils
CIV 418	Structural Matrix Analysis	CE 432	Structural Loading and Lateral Forces
CIV 435	Timber Design	CE 442	Intermediate Concrete Design
CIV 445	Design of Reinforced Masonry Structures	CE 444	Intermediate Steel Design
CIV 464	Water and Wastewater Treatment Plant Design	CE 447	Masonry Design
CIV 466	Solid and Hazardous Waste Management	CE 448	Timber
CIV 467	Groundwater	CE 457	Transportation & Land Development
CIV 468	Environmental River Mechanics	CE 456	Pavement Engineering
CIV 469	Treatment Wetlands	CE 473	Groundwater
CIV 475	Traffic Engineering	CE 481	Environmental Engineering 1
CIV 476	Environmental Remediation Technologies	CE 489	Treatment Wetlands
CIV 499	Independent Studies	CE 511	Seepage and Earth Structures
CIV 531	Open-Channel Hydraulics	CE 512	Earthquake Engineering
CIV 551	Bridge Design	CE 513	Deep Foundations
CIV 573	Transportation and Land Development	CE 522	Advanced Shear Strength of Soils
CIV 574	Advanced Pavement Design	CE 533	Matrix Structural Analysis
		CE 534	Advanced Solid Mechanics
		CE 535	Structural Dynamics
		CE 542	Advanced Concrete Design
		CE 544	Advanced Steel Design
		CE 539	Bridge Rating
		CE 549	Bridge Design
		CE 550	Transportation Structures
		CE 551	Geometric Design of Roadways
		CE 554	Advanced Traffic Engineering
		CE 558	Transportation Safety
		CE 568	Travel Demand Modeling
		CE 571	Open-Channel Hydraulics
		CE 572	Hydrometry
		CE 574	Environmental River Mechanics
		CE 576	Applied Hydraulic Design
		CE 586	Water and Wastewater Treatment
		CE 587	Environmental Remediation Technologies

Faculty Workload Requirements

One of the challenges of offering this degree is the small number of faculty members in the department. With the exception of structural engineering, the other three specialty areas are served by only one individual faculty member. Limited workload availability, even with

overload taken, forces only one or two graduate-level courses to be offered in each specialty area per term, with a goal of offering four 400- or 500-level electives each term. Some elective courses are only taught in the summer or if adjunct instructors are available to ensure that the full suite of 34 elective courses can be offered in a given two-year cycle.

Faculty are currently teaching overload to initiate the co-terminal program with plans to request an additional faculty member next year (Table 2). Standard load at Oregon Tech is 36 work load hours. Thus, total workload for the two year cycle amounts to 36.5 workload hours. With the program demonstrating steady to increasing enrollment, growth in the graduation of master's students, strong interest in the co-terminal option by freshmen, fiscal stability and need for an additional faculty line, it is likely that this faculty line will be granted.

Table 2. Workload hours (WLH) per faculty member in each year of the planned two-year cycle.

Faculty Specialty	WLH - 1st Year of Cycle	WLH - 2nd Year of Cycle
Transportation	43.5	38.5
Structures	43	36
Geotechnical	37.5	35.5
Structures + Chair	40	40
Water/Environmental	42	40
Adjunct	10	9

Conclusion

With BS/MS options growing for institutions of all sizes, the co-terminal degree appears at this point to be an excellent choice for a department composed of a small faculty body to expand into offering a master's degree. With 2020 looming, and action on the part of NCEES to implement the model law anticipated, many smaller institutions offering civil engineering programs will likely be in a situation similar to ours. The potential of this model for such institutions appears to be good. Despite transition and scheduling challenges that are expected during curricular changes of this kind, the creation and implementation of the co-terminal program has been relatively smooth and has been welcomed by the students, faculty and IAC.

Acknowledgements

The authors would like to thank our first graduate student, Amanda Lauck, for her assistance in compiling the list of schools offering similar programs.

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Appendix A

Colleges and universities in the United States offering joint, accelerated, integrated, co-terminal, combined, concurrent, 4+1 or blended BS/MS degree programs, including bachelor's degree credit hours, master's credit hours, and double-counted or share credits. A web link to the source of this information is included.

School	Bachelor Credit Hours (reported as equivalent semester hours)	Masters Credit Hours (reported as equivalent semester hours)	Double Counted Hours between Bachelors and Masters Degrees
Arizona State University	120	30	6
California Polytechnic State University, San Louis Obispo	126	30	6
California State University, Los Angeles	129	30	5
Carnegie Mellon University			
Case Western Reserve University	130	27	9
Cleveland State University	127	30	11
Drexel University	127	30	
Florida Atlantic University	128	30	9
Florida International University	128	30	9
George Mason University	120	24	6
The George Washington University	132	33 - non-thesis, 30 thesis, 27 5-yr program	3
Georgia Institute of Technology	128	30	
Illinois Institute of Technology	137	32	
Iowa State University	128	30	6
Johns Hopkins University	128	30	2 courses
Michigan Technological University	131	30	6

School	Bachelor Credit Hours (reported as equivalent semester hours)	Masters Credit Hours (reported as equivalent semester hours)	Double Counted Hours between Bachelors and Masters Degrees
Milwaukee School of Engineering	157 for BS/MS		
Northeastern University	135		
Northwestern University			
Old Dominion University	130	30	6
Oregon Institute of Technology	121	30	0
Rensselaer Polytechnic Institute	128	30	0
Santa Clara University	130	30	0
Stanford University	120	30	0
Tennessee Technological University	128	30	6
Trine University	132	32	
University of Alabama at Birmingham	128	33	6
University of Colorado Boulder	128	30	6
University of Illinois Urbana-Champaign	128	32 - thesis, 36 non-thesis	
University of Iowa	129	3	3 courses
University of Maryland	122	30	2 courses
University of Massachusetts, Lowell	128	30	6
University of Oklahoma	127	30	6
University of Tennessee at Knoxville	126	30	6
Utah State University	126	30	6
Villanova University	131	30	6
Worcester Polytechnic Institute			6

School	Website
Arizona State University	http://ssebe.engineering.asu.edu/prospective-students/gradstudies.html http://ssebe.engineering.asu.edu/current-students/applications/Joint%20Degree%20ApplicationCEE_03272013.pdf
California Polytechnic State University, San Louis Obispo	http://ceenve.calpoly.edu/programs/blended/
California State University, Los Angeles	http://ecatalog.calstatela.edu/preview_program.php?catoid=4&poid=639&returnto=106
Carnegie Mellon University	http://www.ce.cmu.edu/graduate/degree-programs/imb-program.html
Case Western Reserve University	http://engineering.case.edu/eciv/BS_MS
Cleveland State University	http://www.csuohio.edu/engineering/civil/acceleratedms.html
Drexel University	http://www.drexel.edu/engineering/programs/grad/CivilEngineering/
Florida Atlantic University	http://www.cege.fau.edu/civil-engineering/5-year-joint-bsms-degree-program
Florida International University	http://www.cec.fiu.edu/academics/accelerated-bsms/bsms-civil-engineering/
George Mason University	http://civil.gmu.edu/undergraduate/accelerated-b-s-m-s-in-civil-and-infrastructure-engineering/
The George Washington University	http://www.cee.seas.gwu.edu/five-year-dual-degree-program-bs-and-ms-civil-engineering-0
Georgia Institute of Technology	http://www.ce.gatech.edu/academics/undergraduate
Illinois Institute of Technology	http://admissions.iit.edu/graduate/apply/co-terminal-degrees
Iowa State University	https://www.ccee.iastate.edu/academics/graduate/concurrent-msbs-program/
Johns Hopkins University	http://eng.jhu.edu/wse/civil/page/current_undergraduate_concurrent
Michigan Technological University	http://www.mtu.edu/cee/graduate/accelerated/
Milwaukee School of Engineering	http://www.msoe.edu/community/academics/engineering/page/1188/civil-engineering-overview
Northeastern University	http://www.coe.neu.edu/coe/undergraduate/degree/BS-MS_Programs.html
Northwestern University	http://www.civil.northwestern.edu/undergraduate/BS_MS/
Old Dominion University	http://eng.odu.edu/cee/academics/fiveyearprogram.shtml
Oregon Institute of Technology	http://www.oit.edu/academics/degrees/civil-engineering
Rensselaer Polytechnic Institute	http://srfs.rpi.edu/update.do?artcenterkey=291
Santa Clara University	http://www.scu.edu/engineering/graduate/programs-2013/dual-degree.cfm
Stanford University	http://cee.stanford.edu/current/CoTerm_program.html
Tennessee Technological University	http://www.tntech.edu/cee/fasttrack/
Trine University	http://www.trine.edu/academics/majors-and-minors/major/civil-engineering/courses.aspx
University of Alabama at Birmingham	http://www.uab.edu/engineering/home/degrees-cert?id=354:fast-track-masters&catid=3
University of Colorado Boulder	http://civil.colorado.edu/current-students/undergraduate/msbs-program/
University of Illinois Urbana-Champaign	http://cee.illinois.edu/ConsMgt
University of Iowa	http://www.engineering.uiowa.edu/cee/graduate-program/information-prospective-graduate-students-civil-environmental-engineering
University of Maryland	http://www.civil.umd.edu/undergrad/bs-ms
University of Massachusetts, Lowell	https://www.uml.edu/Engineering/Civil-Environmental/Programs-of-Study/Undergrad/BS-MS.aspx
University of Oklahoma	http://checksheets.ou.edu/civil-bsms.pdf
University of Tennessee at Knoxville	http://catalog.utk.edu/preview_program.php?catoid=1&poid=181
Utah State University	http://www.cee.usu.edu/htm/graduate-program/concurrent-bsms
Villanova University	http://www1.villanova.edu/villanova/engineering/departments/civil/undergrad/5year.html
Worcester Polytechnic Institute	http://www.wpi.edu/academics/cee/ug-bsms.html

Appendix B

Side by Side Comparison of Previous and Updated Curricula

Existing BS Civil Engineering Curriculum (until spring 2013)				*BS/MS Civil Engineering Curriculum (from fall 2013)*			
Freshman	*Fall*			***Freshman***	*Fall*		
CHE 201	General Chemistry		3	CHE 221	General Chemistry	5	provides extra tutorial time in chemistry
CHE 204	General Chemistry Laboratory		1				
ENGR 101	Introduction to Engineering I		2	ENGR 101	Introduction to Engineering I	2	
MATH 251	Differential Calculus		4				moved to spring term freshman year, allows students to start at college algebra (MATH 111)
SPE 111	Fundamentals of Speech		3	SPE 111	Fundamentals of Speech	3	
WRI 121	English Composition		3	WRI 121	English Composition	3	
		Subtotal	*16*	_____	Humanities elective*	3	provides schedule room for college algebra if necessary
					Subtotal	*16*	
Freshman	*Winter*			***Freshman***	*Winter*		
CHE 202	General Chemistry		3	CHE 222	General Chemistry	5	provides extra tutorial time in chemistry
CHE 205	General Chemistry Laboratory		1				
ENGR 102	Introduction to Engineering II		2	ENGR 102	Introduction to Engineering II	2	
MATH 252	Integral Calculus		4				
PHY 221	General Physics with Calculus		4				
		Subtotal	*14*	WRI 122	English Composition	3	
				_____	Humanities elective*	3	
				_____	Social Science elective*	3	
					Subtotal	*16*	
Freshman	*Spring*			***Freshman***	*Spring*		
CIV 112	Engineering Graphics		2	CE 203	Engineering Graphics	3	course number change, added one credit devoted to civil design in CADD environment
MATH 254N	Vector Calculus I		4				
PHY 222	General Physics with Calculus		4				
WRI 122	English Composition		3				
_____	Humanities elective*		3	_____	Humanities elective*	3	
		Subtotal	*16*	MATH 251	Differential Calculus	4	moved from fall term freshman year, allows for students to take preparatory classes
		Year 1 total	***46***	GEOL 201	Physical Geology	4	added to curriculum to support upper-division geotechnical area
					Subtotal	*14*	
					Year 1 total	***46***	
Sophomore	*Fall*			***Sophomore***	*Fall*		
CIV 223	Elementary Properties of Materials		4	CE 212	Civil Engineering Materials	4	new course including soils, asphalt and concrete
ENGR 211	Statics		4				
GME 161	Plane Surveying I		4	GME 161	Plane Surveying I	4	
PHY 223	General Physics with Calculus		4				deleted from curriculum
		Subtotal	*16*	MATH 252	Integral Calculus	4	
				PHY 221	General Physics with Calculus	4	
					Subtotal	*16*	
Sophomore	*Winter*			***Sophomore***	*Winter*		
CIV 201	Sustainable Civil Engineering I		1				deleted from curriculum, sustainability content moved to CE 405 in senior year
ENGR 213	Strength of Materials		4				
MATH 221	Introduction to Computational Software		2	CE 205	Computational Methods	2	new course with content specifically designed for CE students
MATH 361	Statistical Methods I		4				
WRI 227	Technical Report Writing		3				
_____	Social Science elective*		3				
		Subtotal	*17*	ENGR 211	Engineering Mechanics: Statics	4	
				MATH 254N	Vector Calculus I	4	
				PHY 222	General Physics with Calculus	4	
					Subtotal	*14*	
Sophomore	*Spring*			***Sophomore***	*Spring*		
CIV 202	Sustainable Civil Engineering II		1				course deleted from curriculum, sustainability content moved to CE 405 in senior year
CIV 317	Economics for Civil Engineers		3				course deleted from curriculum, primary content moved to CE 208
ENGR 212	Dynamics		3				course deleted
MATH 321	Applied Differential Equations I		4	GME 134	Geographic Information Systems	3	course added to curriculum to meet growing GIS demand from employers

Existing	BS Civil Engineering Curriculum (until spring 2013)	
_____	Social Science elective*	3
	Subtotal	*14*
	Year 2 total	***47***
Junior	*Fall*	
CIV 315	Principles of Environmental Engineering	3
CIV 328	Structural Analysis	4
CIV 358	Project Management	3
ENGR 231	Fluid Mechanics	4
	Subtotal	*14*
Junior	*Winter*	
CIV 321	Introduction to Geotechnical Engineering	4
CIV 331	Reinforced Concrete Design	4
CIV 361	Closed Conduit Design	4
CIV 371	Introduction to Transportation Engineering	3
	Subtotal	*15*
Junior	*Spring*	
CIV 344	Structural Steel Design	4
CIV 362	Hydrology and Surface Water Management	4
CIV 322	Foundation Engineering	4
CIV 375	Highway Engineering	4
	Subtotal	*16*
	Year 3 total	***45***
Senior		
ENGR 355	Thermodynamics OR	3
ENGR 236	Fundamentals of Electric Circuits	
CIV 401/COM 401	Civil Engineering Project I	6
CIV 415	Civil Design Software Applications	2
CIV 402/COM 402	Civil Engineering Project II	6
PHIL 331	Ethics in the Professions	3
_____	Social Science elective*	6
CIV ___	Civil Engineering electives	9
_____	Humanities elective*	3
_____	Math/Science elective**	6
	Year 4 total	***44***
	BS total	***180***

	BS/MS Civil Engineering Curriculum (from fall 2013)		
CE 208	Principles of Professional Practice	4	course added to curriculum
ENGR 213	Engineering Mechanics: Strength of Materials	4	
WRI 227	Technical Writing	3	
	Subtotal	*14*	
	Year 2 total	***44***	
Junior	*Fall*		
			deleted from curriculum, content moved to elective course
CE 331	Structural Analysis	4	
			deleted from curriculum, content moved to CE 208
ENGR 318	Engineering Mechanics: Fluids	4	
CE 311	Introduction to Geotechnical Engineering	5	
MATH 361	Statistical Methods I	4	
	Subtotal	*17*	
Junior	*Winter*		
CE 341	Elementary Structural Design	5	modified course content
CE 371	Closed Conduit Design	4	
CE 351	Introduction to Transportation Engineering	4	curriculum modified to provide complete muli-modal transport introduction
ANTH/HIST 335	Social Science elective*	3	
	Subtotal	*16*	
Junior	*Spring*		
CE 374	Hydrology	4	
CE 312	Earth Pressures & Foundations	3	modified course content
			introduction to pavement moved to sophomore level, senior-level pavement engineering elective cre
CE 354	Traffic Engineering	3	traffic engineering content moved from elective course
MATH 321	Applied Differential Equations I	4	
	Subtotal	*14*	
	Year 3 total	***47***	
Fourth Year			
CE 401/COM 401	Civil Engineering Project I	*5*	
CE 402/COM 402	Civil Engineering Project II	*7*	
CE 405	Sustainability & Infrastructure	*3*	new course
CE 442, *OR*	Advanced Reinforced Concrete Design	*4*	
CE 444	Intermediate Steel Design		
_____	Technical electives**	*3*	
_____	Technical electives >500**	*12*	
CE 501	Graduate Seminar	*1*	new course
WRI 521	Writing at the Graduate Level	*3*	new course
MATH 4__	Math/Science elective	*3*	new requirement
_____	Social Science elective	*3*	
	Year 4 total	***44***	
Fifth Year			
ANTH 452	Globalization	*3*	new requirement
CE 591	Graduate Project	*3-9*	allows for great flexibility in project scope
_____	Technical electives**	*15*	
_____	Technical electives >500**	*17-23*	
	Year 5 total	***44***	
	BS/MS total	*225*	