California State Polytechnic University, Pomona

REQUEST FOR A NEW OPTION
Construction Engineering and Management Option
in the Master of Science in Civil Engineering (MSCE) Program

Submitted by:

Construction Engineering Group
Civil Engineering Department

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1. Purpose

The Civil Engineering Department at Cal Poly Pomona (CPP) proposes to make curricular changes to the Master of Science in Civil Engineering (MSCE) program. These changes include:

1. Adding a new option: Construction Engineering and Management (CEM);
2. Adding eight new courses within the new CEM option emphasis (four required courses and four elective courses).

The curriculum of the CEM emphasis is provided in Appendix A, the Road Map in Appendix B, and a 2-year course plan in Appendix C, Course Catalog description in Appendix D. In addition, the assessment plan is provided in Appendix E. This proposal provides the justification for the proposed curricular changes to the MSCE program and details of these changes.

2. Background

Local industries have looked to the Civil Engineering Department for graduates to fill internships, part-time and full-time entering positions in construction engineering and management related areas. In addition, private companies support our construction engineering undergraduate program by providing corporate donations to student organizations and competitions and offering scholarships. Additionally, both the private and public sectors from time to time have requested that faculty in construction engineering recommend our students for job openings.

Cal Poly Pomona's hands-on educational approach creates a smooth transition from school to practice, which results in a high demand for our graduates to fill engineering openings. The *learn-by-doing philosophy* makes our construction engineering option special and different from any other program in the local area. In the current undergraduate Construction Engineering Technology program, the construction engineering technology major provides general knowledge at the Bachelors of Science (BS) level. However, the complexity of contemporary engineering problems encountered on construction projects requires specialization, hence creating demand for advanced degrees. Moreover, agencies such as the CalTrans have approached Cal Poly Pomona to seek support with the development of training tools to prepare the new generation of employees since the "baby boomer" generation is close to retirement. There is a critical need for well-trained young professionals that can replace the seasoned personnel in Southern California in both the public and private sectors. ***In addition, as one of the largest undergraduate Civil Engineering programs in the country, the addition of the MSCE CEM emphasis is an essential part of the department's strategic plan to ensure continued success and professional growth of our graduates and ensure lifelong learning and development of our alumni.***

The development of the CEM option will create many opportunities from various different perspectives. Locally, the program will act as a pipeline to other PhD granting schools. From a research perspective, it will help enforce the ***faculty teacher–scholar model*** as it will allow our faculty to work with Master students on research topics related to their theses or projects. Many of our undergraduate students have shown interest in continuing their education and receiving a Master's degree in CEM that will help them assume leadership roles in their careers. On the professional industry perspective, the expansion of the MSCE program to include the CEM emphasis will support the technical training of construction professionals that will be capable of running the California construction industry.

3. Demand and Current Challenges

Although there are many excellent employment opportunities for individuals who have a BS in Construction Engineering as their terminal degree, there is an increasing demand for professionals who

hold an advanced degree in construction engineering and management. This need for additional education reflects the increasing technical demands on complex projects that we are increasingly being faced with. For example, proficiency in the need for infrastructure management, quantitative risk analysis techniques, lifecycle cost assessments, and other important construction engineering requirements increasingly requires more formal education.

In Southern California, there is an unmet demand for master's degrees in construction engineering and management, especially for programs that are catered primarily to working professionals in the Cal Poly service area. There are very limited Master programs that service this area. Table 1 lists the major Southern California institutions that currently have Masters of Construction Management or Masters of Construction Engineering and Management and the departments offering this degree. Most of them are too distant to effectively serve students in our service area, especially those from the Inland Empire. The radius of influence of the proposed MSCE CEM program is approximately 20 miles (~30 miles away from Fullerton campus), with more or less distance in different directions. The areas of greater impact and with major benefit from the proposed emphasis will be the LA, the San Gabriel Valley and the San Bernardino areas. In addition, the program proposed will be blend the Engineering and the Management depth of Construction in one program.

Table 1 – Existing Masters of Construction (Engineering and) Management programs

University	Degree	Department	Comments
USC	Masters of Construction Management Master if Construction Engineering and Management	Civil and Environmental Engineering	Too distant from Cal poly service area
CSU - Long Beech	Master of Science in Civil Engineering with emphasis in Construction Engineering and Management	Department of Civil Engineering and Construction Engineering Management	Too distant from Cal poly service area
CSU - Fullerton	Master of Science in Civil Engineering with a track in Construction Engineering and Management	Civil and Environmental Engineering	Smaller department and college

A unique element of the undergraduate program is the hands-on approach; therefore, the proposed MSCE CEM emphasis will also provide a hands-on experience through the laboratories, seminars, software usage and other relevant activities that will enhance the professional preparation of the professional practitioners for which the program has been designed. The proposed MSCE CEM emphasis shares similar characteristics with existing local programs, including standards of GPA and the offering of thesis and project options, which will allow the proposed emphasis to compete with these existing local programs. Unlike our undergraduate program, which is catered primarily to full-time day students, the MSCE programs will cater primarily to working professionals who are completing their graduate degree on a part-time basis in the evenings. Cal Poly Pomona's location is ideal for such a program, and can serve such students from the Inland Empire, Orange County, and the San Gabriel Valley.

The number of students enrolled in the undergraduate construction engineering technology option is growing every year due to the excellence of the program, and the addition of the program to the Civil Engineering Department has created unlimited opportunities. Currently, if Cal Poly Pomona graduates wanted to obtain an MS degree in CEM, they would have to choose from other local graduate programs, such as those in local CSU's and out-of-state institutions. The addition of the MSCE emphasis in CEM

would offer to our graduates the opportunity to continue their academic preparation at Cal Poly Pomona.

During the last three years, multiple tenure-track faculty joined the Construction Engineering Technology group, with different sets of expertise including building information modeling, sustainability, and project delivery methods. Thus, such a program would provide professional and research opportunities to CEM faculty that would not be possible if the CEM faculty teach only undergraduate classes. While it is expected that most of the students will be part-time students and professional practitioners, it is expected some students will be full-time and will seek the MS degree through a thesis or project. The Cal Poly Pomona privileged location, learn-by-doing reputation, technical needs of the professional practitioners, and the current and future needs for trained professionals in Construction Engineering and Management (retirement of the baby boomers), make the MSCE CEM emphasis a priority for the Civil Engineering Department.

4. Mission Statement and Educational Objectives

4.1 Mission Statement

The Master of Science in Civil Engineering (MSCE) program is intended to serve both full-time and part-time graduate students who have a BSCE or closely-related undergraduate degree in order to strengthen their knowledge and understanding of civil engineering principles and practices. The program is primarily intended for students who currently are, or intend to become, practicing civil engineers, and thus focuses on the application of these principles and practices to real-world problems encountered by professional civil engineers.

Another purpose of the program is to facilitate applied research on relevant civil engineering topics. Such research should 1) serve societal needs by addressing contemporary issues, 2) contribute to the professional development of both students and faculty and 3) provide preparation for further academic study and research for those students who wish to pursue a Ph.D.

4.2 Program Educational Objectives

Current MSCE educational objectives will be adopted by the proposed MSCE CEM option:

1. Apply advanced technical knowledge to analyze and design civil engineering projects.
2. Demonstrate professional-level communication, teamwork, leadership, and lifelong learning skills.
3. Demonstrate a high level of individual, professional, and social responsibility.

5. Admission Requirements

The existing admission requirements as stated in the Catalog for admission to the MSCE program will be adopted.

6. Proposed Curriculum Changes

We propose the addition of the ***Construction Engineering and Management (CEM) Option*** to the existing MSCE program. The curriculum of the CEM emphasis is included in Appendix A. For the proposed option, the responses to the numbered items in the “Proposal Format for Emphases, Options, and Minors” in the “Curriculum Guide” are specifically given here.

1. *Give the name of the department submitting the request, the full and exact title of the proposed aggregate of courses, and whether it is an option, emphasis, or minor.*

- Civil Engineering Department.
- Construction Engineering and Management
- Option.

2. Provide the full and exact title of the degree major program under which the aggregate of courses will be offered, where applicable.

- Master of Science in Civil Engineering (MSCE)

3. List options, or special emphases already existing under the degree major program for which the new aggregate of courses is proposed.

- Transportation engineering emphasis
- Structural engineering emphasis
- Geotechnical engineering emphasis
- Environmental and Water Resources emphasis

4. Give the name of the department, or collection of departments, offering the aggregate of courses.

- Civil Engineering

5. State the aims of the proposed aggregate of courses.

- The objective of the proposed new aggregate of courses is to improve and broaden the students' professional capabilities in construction through offering specialized courses that address advanced and contemporary construction engineering and management topics.

6. Justify the need for the proposed aggregate of courses.

- The existing program in MSCE does not offer the required classes in the construction engineering and management areas.
- The objective of the new Construction Engineering and Management (CEM) Option under MSCE program is to improve and broaden the students' professional capabilities in construction.
- Since the Construction Engineering Technology (CET) program moved in the Civil Engineering Department, the name of CET program will be changed to CEM to reflect the demand for the construction engineering and management program. Thus, adding the CEM option will strengthen the existing MSCE curriculums.
- CEM option will allow students seeking upper level construction engineering and management to develop their ability in construction field and project management. Additionally, CEM option will enable students to deal with diverse management methods in order to contribute to upgrading the deteriorated U.S. infrastructure systems that were rated as "D" according to ASCE Report.

7. List courses by catalog number, title, and units of credit as well as the total units to be required under the proposed aggregate.

Please refer to Appendix A: Curriculum Sheet of the MSCE CEM option.

8. List courses by catalog number, title, and units of credit as well as the total units to be required for the major in which the proposed aggregate of courses is to be included.

Please refer to Appendix A: Curriculum Sheet of the MSCE CEM option.

9. List new courses to be developed. Include proposed catalog descriptions.

Please refer to

- Appendix A: Curriculum Sheet of the MSCE CEM option.
- Appendix D: Course Catalog Descriptions

10. List all present faculty members with rank, appointment status, highest degree earned, date and field of highest degree, and professional experience, who would teach in the proposed aggregate of courses.

Please see below a list of the faculty members who will be involved in the CEM Option. In addition, please see Appendix C for a list of faculty expected to teach the proposed courses.

1. **Hovel Bavikian, M.S., P.E.**, Professor, full-time, M.S. in Civil Engineering, California Institute of Technology. He is a registered Professional Engineer in the State of California, and a licensed General Building Contractor in in the State of California. He has expertise in pre-engineered metal building systems, building information modeling and computer aided modeling.

2. **Yasser Salem, Ph.D., S.E.**, Professor, full-time, Ph.D. in Civil Engineering, University of California, Irvine, MSCE in Civil Engineering in San Jose State University, California. He is a registered Structural Engineer in the State of California, a registered Professional Engineer in the States of California and Alaska and a registered General Contractor in the State of California. He has expertise in structural vibration and experimental structural dynamics.

3. **Jinsung Cho, Ph.D.,** Assistant Professor, full-time, Ph.D. in Construction Management from Arizona State University and Masters of Science in Civil and Environmental Engineering from Carnegie Mellon University. He has 15-year experience in construction and geotechnical engineering areas before academia. His research areas are 3D Virtual Design Construction (Building Information Modeling: BIM), Construction Productivity, Soil and Utility Behavior, Underground Infrastructure Management & Utility Construction, and Trenchless Technology.

4. **Rosa Vasconez, Ph.D., P.E., LEED AP,** Assistant Professor, full-time, Ph.D. in Civil Engineering with an emphasis in structural engineering from The University OF Michigan, Ann Arbor, Master of Science in Civil Engineering with an emphasis in structural engineering from the University of Michigan, Ann Arbor. She is a registered Professional Engineer in the State of Massachusetts with extensive experience in structural, bridge and blast engineering in the United States. Dr. Vasconez is also a Leadership in Energy and Environmental Design Accredited Professional. Her research interests are seismic resistant bridge and building structures as well as new materials such as high performance concrete, fiber polymer and fiber cement composites, and sustainability

5. **Ghada M. Gad, Ph.D.,** Assistant Professor, full-time, Ph.D. in Civil Engineering from Iowa State University, Bachelor of Science and Masters of Science in Construction Engineering from the American University in Cairo. Her research areas of expertise includes procurement and project delivery methods, risk management, contracts and dispute resolution methods, social factors effect on construction management, and construction materials.

11. Describe additional instructional resources (faculty, space, equipment, library volumes, etc.) needed to implement and sustain the proposed aggregate of courses. List all resources needed for the first five years beyond those currently projected, including specific resource, cost, and source of funding.

We anticipate offering eight graduate-level courses during the academic year (Fall and Spring). We also anticipate offering the elective courses on a two-year cycle. The 690-series capstone courses would be offered as dictated by student demand. The table below presents the

estimated resources required from the College of Engineering to support the MSCE program. We expect the enrollment in the construction option will continue to grow in subsequent years.

Table 2- Estimated Resources from College of Engineering

		2018-2019	2019-2020	2020-2021	2021-2022	2022-2023	2023-2024
Enrollment							
	CE	10	18	20	23	26	28
Courses Offered							
	CE Required	2	2	2	2	2	2
	CE Electives	4	3	4	3	4	3
	Projects	0	5	5	7	10	10
	Theses	0	0	4	4	4	4
WTU							
	CE Required	6	6	6	6	6	6
	CE Electives	12	9	12	9	12	9
	Projects						
	Theses						

7. Assessment Plan

An Assessment Plan describing the meaning of the MSCE degree, including the program educational objectives and student outcomes is included in Appendix E. It also details the process of assessing and improving the level of performance in achieving these objectives and outcomes, to uphold the quality and integrity of the degree.

Appendix

Appendix A: Curriculum of the MSCE CEM emphasis

Appendix B: Road Map

Appendix C: 2-year course plan

Appendix D: Catalog description of proposed new courses

Appendix E: Assessment plan

Appendix A: Curriculum of the MSCE CEM emphasis

Program Name: MSCE – Construction Engineering & Management (CEM) Option				
Total Units: 30				
Core Courses – Units: 3-9 (Culminating experience satisfied by CE 6970, CE 6950, or CE 6960)				
Course Number	**Title**	**Units (lec/lab)**	**Revisioned/ Converted**	**GE Area Double Count (Y/N)**
CE 5020	Applied Probability Concepts in Civil Engineering	3	Converted	N
CE 6950	Master's Project	3	Converted	N
CE 6960	Master's Thesis	6	Converted	N
CE 6970	Comprehensive Examination	0	Revisioned	N
Option Courses – Units: 12				
Course Number	**Title**	**Units (lec/lab)**	**Revised/ Converted**	**GE Double Count (Y/N)**
CE 5111	Construction Productivity	3	New	N
CE 5131	Construction Risk Analysis	3	New	N
CE 5141	Advanced Construction Project Management	3	New	N
CE 5191	Construction Project Delivery Methods	3	New	N
Option Electives – Units: 9-15 (Up to 3 units of approved 4000-level courses)				
Course Number	**Title**	**Units (lec/lab)**	**Revised/ Converted**	**GE Double Count (Y/N)**
CE 5121	Construction Financial Management	3	New	N
CE 5161	Underground Construction and Trenchless Technology	3	New	N
CE 5171	Temporary Construction Structure	3	New	N
CE 5181	Construction Leadership and Ethics	3	New	N
CE 5310	GIS Applications in Civil Engineering	3	Converted	N
CE 5430	Advanced Foundation Engineering	3	Converted	N
CE 5440	Earth Retaining Structures	3	Converted	N
CE 5451	Pavement Design and Construction	3	Revisioned	N
CE 5491	Street Maintenance, Rehabilitation and Management	3	New	N
CE 5990	Special topics for Graduate Students	3	Converted	N
CE 4031	Sustainable Buildings and Infrastructure	3	New	N
CE 4120	Construction Scheduling	3	Converted	N
CE 4130	Construction Contracts	2	Converted	N
CE 4140	Construction Project Management and Accounting	2	Converted	N
CE 4171/Lab	Virtual Design Construction Management – BIM & Lab	2/1	Revisioned	N

Appendix B: Road Map

Civil Engineering Department
Construction Major
Curriculum Year: 2018-2019

Your department has developed this road plan, taking into account prerequisites and schedule restrictions.
You should pay attention to these concerns when deviating from this plan.

	Fall	Units	Spring	Units	Comment
Year 1	**CE 5141** Advanced Construction Project Management	3	**CE 5131** Construction Risk Analysis	3	*The three columns in a semester refer to the three possible culminating experiences: Master's Thesis, Master's Project, or Comprehensive Exam,, respectively* *CE XXXX (Option Elective) courses must be approved in advance by your advisor.*
	CE XXXX Option Elective	3	**CE XXXX** Option Elective	3	
	CE 5020 Applied Probability Concepts in Civil Engineering	3			
	Total Units	**9**	**Total Units**	**6**	
			Total Units for Year	**16/16/18**	

	Fall	Units	Spring	Units	Comment
Year 2	**CE 5191** Construction Project Delivery Methods	3	**CE 5111** Construction Productivity	3	*The three columns in a semester refer to the three possible culminating experiences: Master's Thesis, Master's Project, or Comprehensive Exam,, respectively* *CE XXXX (Option Elective) courses must be approved in advance by your advisor.*
	CE XXXX Option Elective	3	**CE 6960** Master's Thesis / **CE 6950** Master's Project / **CE 6970** Com. exam	3/3/0	
	CE 6960 Master's Thesis / **CE XXXX** Option Elective / **CE XXXX** Option Elective	3/3/3	**CE XXXX** Option Elective	0/0/3	
	Total Units	**9/9/9**	**Total Units**	**6/6/6**	
			Total Units for Year	**15**	

Total Units on Plan	**30**
Option Core Units	**21/18/15**
Option Support Units	**9/12/15**
General Education Units	**0**
Unrestricted Elective Units	**0**

Appendix C: 2-year course plan

Coordinator	TAC	Dept	No.	Lab	Units	Title	Articulation	Fall '18	Spring '19	Sum. '19	Fall '19	Spring '20	Sum. '20
Jinsung Cho	CON	CE	5111		3	Construction Productivity	NA		x			x	
Jinsung Cho	CON	CE	5121		3	Construction Financial Management	NA		x			x	
Yasser Salem	CON	CE	5131		3	Construction Risk Analysis	NA		x			x	
Jinsung Cho	CON	CE	5141		3	Advanced Construction Project Management	NA	x			x		
Jinsung Cho	CON	CE	5161		3	Underground Construction and Trenchless Technology	NA		x			x	
Yasser Salem	CON	CE	5171		3	Temporary Construction Structures	NA	x			x		
Hovel Babikian	CON	CE	5181		3	Construction Leadership & Ethics	NA	x			x		
Jinsung Cho	CON	CE	5191		3	Construction Project Delivery Methods	NA	x			x		

Appendix D: Catalog description of proposed new courses

Construction Engineering and Management (CEM) option: Course Catalog Description

- CE 5111: Construction Productivity: Jinsung Cho

Definition of construction productivity and study how to measure construction productivity and how it relates to other organizational functions. Lean construction and influential factors (i.e. human factors) related to productivity.

- CE 5121: Construction Financial Management: Jinsung Cho

Fundamental theories and applied methods for financial management of construction companies. Construction accounting, cash flow analysis, financial planning and management, and risk analysis.

- CE 5131: Construction Risk Analysis: Yasser Salem

This course covers the basic principles of construction risk as it relates to project budget, schedule and managing job site safety risk. The course covers qualitative and quantitative methods of assessing these risks with discussion in how to mitigate them.

- CE 5141: Advanced Construction Project Management: Jinsung Cho

Overviews of various project management tasks for construction project. Learning the use of various commercially-available project management software systems for a real-life problem given on each assignment. On-line collaboration, value engineering, and document management systems, cost estimating systems, scheduling systems, and 4D CAD visualization systems.

- CE 5161: Underground Construction and Trenchless Technology: Jinsung Cho

Learning methods that can be applied to make deteriorating underground pipeline infrastructures more sustainable. Theory and practice of underground construction methods including trenchless construction. Types of equipment, roles of site personnel, engineering design, contractual issues, and safety

- CE 5171: Temporary Construction Structure: Yasser Salem

This course covers the basic design and construction of temporary structures with applications to concrete vertical and horizontal formwork; shoring and scaffolding, foundation underpinning, design of cofferdams, diaphragm/slurry walls, and construction dewatering.

- CE 5181: Construction Leadership and Ethics: Hovel Babikian

Individual, organizational and process/structure leadership in project setting. Four-step leadership transformational model for project leaders. Project leadership tools and applications to motivation, conflict management, team building and delegation of risk.

- CE 5191: Construction Project Delivery Methods: Jinsung Cho

Various project delivery methods, made up of organizations, contracts, and award methods, with certain types of projects and owners. Innovative contract types such as a Guaranteed Maximum Price, and award methods, such as Multi-Parameter Bidding.

Appendix E: Assessment plan

California State Polytechnic University, Pomona
Civil Engineering Department
Graduate Program Assessment Plan (Semesters)

November 30, 2015

The Master of Science in Civil Engineering (MSCE) program at Cal Poly Pomona builds upon an undergraduate education and facilitates more advanced studies in one of the branches of civil engineering. The program consists of 30 semester units. Currently, there are four emphases under the MSCE program: Environmental and Water Resources Engineering, Geotechnical Engineering, Structural Engineering, and Transportation Engineering. They will be converted into options.

This Assessment Plan describes the meaning of the MSCE degree, including the program educational objectives and student outcomes. It also details the process of assessing and improving the level of performance in achieving these objectives and outcomes, to uphold the quality and integrity of the degree.

Meaning of the MSCE Degree

The MSCE degree provides students with advanced knowledge and understanding of civil engineering principles and practices, which they apply to solve civil engineering problems. It enables the graduate to articulate the significant challenges confronting the field utilizing a solid foundation of advanced courses. Through a careful selection of challenging projects, students propose creative approaches to solving contemporary civil engineering problems. These project experiences distinguish the MSCE graduate by providing them with the analysis and design background necessary to tackle complex civil engineering projects using state-of-the-art methods. Graduates with the MSCE degree are expected to attain certain Program Educational Objectives (PEOs) within a few years of graduation and demonstrate certain Student Outcomes (SOs) at the time of graduation. These PEOs and SOs are given below.

Program Educational Objectives

Program Educational Objectives are broad statements that describe what MSCE graduates are expected to attain within a few years of graduation. Graduates of the MSCE program will be able to:

1. Apply advanced technical knowledge to analyze and design civil engineering projects.
2. Demonstrate professional-level communication, teamwork, leadership, and lifelong learning skills.
3. Demonstrate a high level of individual, professional, and social responsibility.

Student Outcomes

Student Outcomes are the knowledge, skills, and values MSCE graduates are expected to demonstrate at the time of graduation. Graduates of the MSCE program will have:

1. An ability to design and conduct experiments, as well as to analyze, interpret, and explain data.
2. An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
3. An ability to identify, formulate, analyze and solve engineering problems.
4. An ability to plan, compose, and integrate the verbal, written, virtual, and graphical communication of a project to technical and non-technical audiences.

5. An ability to evaluate the design of a complex system or process, or evaluate the validity of newly created knowledge or technologies in a traditional or emerging advanced specialized technical area appropriate to civil engineering.

Table 1 shows the relationship between the PEOs and SOs.

Table 1: Relationship between Program Educational Objectives and Student Outcomes

Program Educational Objectives	Student Outcomes				
	SO1	**SO2**	**SO3**	**SO4**	**SO5**
PEO1	X	X	X		X
PEO2			X	X	X
PEO3		X			X

Mapping of Student Outcomes to Required and Elective Courses

The five SOs listed above (SO1 to SO5) and the required courses and elective courses aimed at providing students practice and mastery of these outcomes are mapped in Table 2.

Table 2: Course-to-Student Outcome Map: MSCE Construction Engineering and Management Option

Course No.	Course Title	Required/ Elective	SO1	SO2	SO3	SO4	SO5
CE 5111	Construction Productivity	Required		P		P	P
CE 5121	Construction Financial Management	Required		P	P	P	P
CE 5131	Construction Risk Analysis	Required	P	P	P	P	P
CE 5141	Advanced Construction Project Management	Required		P		P	P
CE 5161	Underground Construction and Trenchless Technology	Elective	P	P	P	P	
CE 5171	Temporary Construction Structure	Elective	P	P	P	P	P
CE 5181	Construction Leadership and Ethics	Elective				P	
CE 5191	Construction Project Delivery Methods	Elective				P	P
CE 6950	Master's Project	Required	M	M	M	M	M
CE 6960	Master's Thesis	Required	M	M	M	M	M
CE 6970	Comprehensive Examination	Required	M	M	M	M	M

P: Practice; M: Master

Assessment Plan

The level of achievement of the PEOs and SOs will be assessed through collecting and analyzing data from courses and other means. Assessment data in the form of direct and indirect measures will be collected. Examples of direct measure data include:

A. Performance on embedded final exam problems
B. Quality of Master's Project reports and Master's Theses

C. Performance on oral presentations of Master's Projects and Theses
D. Quality of written term papers and course project reports
E. Performance on oral presentations of written term papers and design project reports

Examples of indirect measure data include:

F. Results of exit survey of graduating students
G. Results of survey of graduates
H. Results of survey of employers of graduates

The Civil Engineering Department Graduate Committee will analyze collected assessment data, discuss the analysis results, and develop and implement an action plan to improve the program.

A general assessment plan schedule is given in Table 3 to show the schedule of assessment data collection and action plan discussion and development for each SO. Table 6 also shows the kinds of data to be collected, identified by the letters in the list of data above. The courses from which data will be collected in each semester will be determined from the actual course offerings for the semester.

The PEOs will be assessed by collecting data (Data G. and H. listed above) once every three years or twice per ABET accreditation cycle, starting in 2018-19.

Table 3 Assessment Plan Schedule

	F 18	S 19	F 19	S 20	F 20	S 21	F 21
SO1	**C (Data A. to C.)**	**D**	**C (Data A. to C., and F.)**	**D**	**C (Data A. to C.)**	**D**	
SO2	**C (Data A. to E.)**	**D**	**C (Data A. to F.)**	**D**	**C (Data A. to E.)**	**D**	
SO3		**C (Data B. and C.)**	**D**	**C (Data B., C. and F.)**	**D**	**C (Data B. and C.)**	**D**
SO4		**C (Data B. and C.)**	**D**	**C (Data B., C. and F.)**	**D**	**C (Data B. and C.)**	**D**
SO5		**C (Data B. and C.)**	**D**	**C (Data B., C. and F.)**	**D**	**C (Data B. and C.)**	**D**

***C**: Collection of direct or indirect data identified by letter(s) in data list*
***D**: Discussion of data analysis results and development of action plan to improve program*