The University Senate of Michigan Technological University
Proposal 15-21
(Voting Units: Academic)

Establishment of a New Graduate Certificate in Sustainable Pavement Design and Construction

Submitted by: Department of Civil & Environmental Engineering

1. Proposal Date:
May 19, 2020

2. Proposing Contacts and Department:

Dr. Jake Hiller
- Department of Civil & Environmental Engineering jhiller@mtu.edu

Dr. Amlan Mukherjee
- Department of Civil & Environmental Engineering amlan@mtu.edu

Dr. Zhanping You
- Department of Civil & Environmental Engineering zyou@mtu.edu

3. Sponsor Department Approvals
At the end of the document

4. General Description and Characteristics of Program:

4.1 General Description of Certificate
Sustainable Pavement Design and Construction

4.2 Catalog Description

The graduate certificate will introduce students to best practices in pavement design and construction with a strong emphasis on recent advances in sustainability. The topics will focus on asphalt and concrete materials, mechanistic-empirical pavement design methods, life cycle assessment, life cycle cost analysis, and sustainability practices in project procurement and construction. Successful completion of the certificate will enable a professional to develop a life cycle approach to strategic project selection, apply advanced knowledge of innovative materials in design and specify construction practices, to improve long-term performance, and reduce environmental impacts while improving access and socioeconomic equity.

5. Rationale for Certificate:

In the last 20-years a set of methods and practices have emerged in life cycle engineering that are today driving innovative approaches and strategic decision-making in the design and management of civil infrastructure assets. During project selection, there is an increasing emphasis on maximizing value , with an eye to (i) improving performance, (ii) reducing long-

term environmental impacts, and (iii) accounting for socio-economic benefits to all stakeholders involved in the value chain. This has led to the rise of life cycle thinking that views the project holistically integrating sustainability into core project requirements and selecting design, construction and long-term maintenance strategies to align with the desired project outcomes. In the industry, that is often anecdotally referred to as *not just building the project right, but also building the right project.* Meanwhile, as the science of Life Cycle Assessment (LCA) has advanced, so has the public's understanding of its usefulness in supporting decision-making. This has led to pressure on regulatory bodies in considering the use of LCA, and ISO compliant instruments such as Environmental Product Declarations (EPD) (used to communicate LCA outcomes), to inform public procurement. Design choices and construction methods are being guided by LCA based outcomes. Legislatively, the Buy Clean California Act, 2017, (Assembly Bill 262), now requires successful bids on public construction projects in California to produce EPDs for eligible materials during construction. Similar bills have been introduced in Washington and Minnesota. Washington initiated a study to consider the feasibility of the use of EPDs in procurement, and recently Dr. Mukherjee concluded the first phase of a feasibility study with the Minnesota Department of Transportation to consider the use of EPDs in procurement, should a legislative mandate come into effect in Minnesota.

The construction materials industry and decision-makers in state agencies are finding themselves unprepared to use and interpret LCA/EPD information, particularly as it applies to design standards and construction specifications, as these are recent additions to the body of knowledge, and yet to be completely integrated into the Civil Engineering curriculum. This has opened up a need to serve early-mid to mid-career decision-makers who need to enhance their skills to keep up with advances in the field. Evidence for this lies in the enthusiastic attendance on recent webinars facilitated by the National Cooperative for Highway Research Programs (NCHRP), of the National Academies that Dr. Mukherjee chaired. The webinar on Sustainable Procurement in 2019 October had 190 attendees. In April of 2020, the webinar on a recently concluded NCHRP research project on Sustainable Construction Practices that Dr. Mukherjee was Co-PI on attracted 450 attendees. The Academy of Pavement Science and Engineering that Drs. Hiller, Mukherjee and You are members of, have recently undertaken an effort in surveying the state of undergraduate and graduate curricula in universities to meet current workforce needs.

6. Related Programs:

Peer Programs:
Iowa State University: https://prosper.intrans.iastate.edu/
Arizona State University: https://pavements-lab.engineering.asu.edu/degree-programs/

7. Projected Enrollments:

These numbers are based on a conservative estimate of students who are likely to be registered on campus (both undergraduate senior level and graduate) based on typical registration for the listed courses. We expect the numbers to go up as advertising and communication of the program value picks up. Online enrollment estimate is based on other similar program enrollments.

Semester	On-campus Enrollment	On-line Enrollment
Fall 2021	4-6	5-7
Fall 2022	6-8	6-8
Fall 2023	6-8	6-8
Fall 2024	6-8	6-8

8. Scheduling Plans:

No change in the regular scheduling of the existing courses is anticipated. Courses will be available online throughout the academic year and during summer semester.

9. Curriculum Design:

Required Coursework: 6 credits

CEE 5400 - Pavement Design (3, Fall)

Choose one of the following:

CEE 5109 - Sustainable Pavement Engineering and Civil Engineering Materials (3, Spring)

CEE 5350 - Infrastructure Life Cycle Engineering (3, Spring)

Elective Coursework: 3 credits (not counted in Required Coursework)

CEE 5101 - Bituminous Materials (3, Fall)

CEE 5102 - Advanced Concrete Materials (3, Spring)

CEE 5109 - Sustainable Pavement Engineering and Civil Engineering Materials (3, Spring)

CEE 5350 - Infrastructure Life Cycle Engineering (3, Spring)

Course Descriptions:

CEE 5101 - Bituminous Materials (3, Fall)

Applications and properties of asphalt binder, aggregates for bituminous mixtures, and analysis and design of asphalt concrete mixtures. Includes asphalt cement production, rheology, chemistry, and grading, aggregate grading and blending, and mixture design and characterization. Also discusses asphalt mixture production, construction, and recycling.

CEE 5102 - Advanced Concrete Materials (3, Spring)

Properties and applications of portland cement and portland cement concrete. Includes cement production, chemistry and hydration, concrete admixtures, and the properties of fresh and hardened concrete. Presents concrete microstructure and durability. Other topics include high-strength and high early-strength concrete, fiber-reinforced concrete, and advanced cement-based materials.

CEE 5109 - Sustainable Pavement Engineering and Civil Engineering Materials (3, Spring)

This class will develop fundamental knowledge of sustainable pavements, recycled materials, asphalt and concrete materials, basic concept of characterization of pavement materials, data analysis, and basic modeling procedures. The course will cover a wide range of advanced knowledge of sustainable pavements and materials.

CEE 5350 - Infrastructure Life Cycle Engineering (3, Spring)

The course examines how life cycle assessment (LCA), life cycle costing analysis (LCCA), green rating systems, value engineering and alternative project delivery systems influence design decisions and project outcomes. Topics will be discussed within the context of the underlying scientific principles and relevant standards.

CEE 5400 - Pavement Design (3, Fall)
Analysis, behavior, performance, and structural design of highway pavements. Introduces pavement types and performance concepts, highway traffic and subgrade characterization, materials employed in highway construction, and highway drainage. Presents common methods used for designing pavement structures as well as mechanistic- empirical approaches.

10. Model Schedule Demonstrating Completion Time

The certificate is designed to be completed in 2 semesters.

Fall Semester

CEE 5400 - Pavement Design (3)
Elective 1

Spring Semester

CEE 5109 - Sustainable Pavement Engineering and Civil Engineering Materials (3)
OR CEE 5350 - Infrastructure Life Cycle Engineering (3)
Elective 2

11. Library and other Learning Resources

No library or other learning resources are required at this time.

12. Faculty Resumes

The following faculty will be supporting the program.

Dr. Amlan Mukherjee, Department of Civil & Environmental Engineering amlan@mtu.edu
Website: https://www.mtu.edu/cee/people/faculty-staff/faculty/mukherjee/

Dr. Jake Hiller, Department of Civil & Environmental Engineering jhiller@mtu.edu
Website: https://www.mtu.edu/cee/people/faculty-staff/faculty/hiller/

Dr. Zhanping You, Department of Civil & Environmental Engineering zyou@mtu.edu
Website: https://www.mtu.edu/cee/people/faculty-staff/faculty/you/

13. Equipment

No additional equipment will be required.

14. Program Costs

Initial costs for offering the certificate will not incur additional costs. As online/remote instruction enrollment grows, the additional costs associated with instruction will be covered from tuition return from the students who are enrolled online.

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15. Space

There are no new space requirements.

16. Policies, Regulations, and Rules

Not applicable

17. Accreditation Requirements

Michigan Tech is accredited by the Higher Learning Commission (HLC). The proposed certificate will meet HLC criteria 3 and 4. The proposed certificate will not seek additional accreditation.

18. Planned Implementation Date

Spring 2021

19. Assessment

The learning objectives of the Certificate are:

1. Apply life cycle assessment and explain how it applies to innovative and sustainable pavement designs.
2. Apply pavement design guides, standards and construction best practice frameworks, to pavement selection and project procurement.

Approval Process

Departmental Graduate Committee: May 28, 2020
Department: May 29, 2020
College of Engineering: June 9, 2020
Provost's Office and Deans' Council: June 17, 2020
Graduate School: June 23, 2020
Approved by the Senate:
Approved by the President: