Certificate in Climate Change Adaptation and Resilience

Two courses should be from the following five courses:

- CE 613: Resilient Systems Planning and Design

- CE 621: Hydrology

- CE 671: Performance and Analysis of Infrastructure Systems

- ENE 672: Stormwater Management

- ENE 673: Sustainability and Life Cycle Analysis

Remaining two courses from the following courses:

1. CE 620. Open Channel Flow
   The principles developed in fluid mechanics are applied to flow in open channels. Steady and unsteady flow, channel controls, and transitions are considered. Application is made to natural rivers and estuaries.

   Prerequisite: undergraduate fluid mechanics.

2. CE 621. Hydrology
   The statistical nature of precipitation and runoff data is considered with emphasis on floods and droughts. The flow of groundwater is analyzed for various aquifers and conditions. Flood routing, watershed yield, and drainage problems are considered.

   Prerequisite: undergraduate fluid mechanics.

3. CE 622. Coastal Engineering
   An introductory course covering basic wave theory, sediment transport and ocean circulation. The application of these principles to various coastal engineering problems will be discussed, including beach erosion, pollution transport in coastal waters, and the design of shore protection structures.

   Prerequisite: fluid mechanics and calculus.

4. CE 618. Applied Hydrogeology
   Examines ground water and contaminant movement through the subsurface environment. A basic understanding of the aquifer geology is emphasized. Hydrogeologic applications including well design, pumping tests, and computer modeling of subsurface flow, and methods to monitor and remediate contaminated groundwater are introduced.

   Prerequisites: undergraduate courses in earth science/geology, fluid mechanics, and calculus or permission of instructor.

5. ENE 672. Stormwater Management
   This course provides a comprehensive study of stormwater management with emphasis on design practices. Topics include regulatory framework, an overview of structural and non-structural BMPs, groundwater recharge analysis, estimate of runoff, and design of detention basin and drainage systems.

6. ENE 673. Sustainability and Life Cycle Analysis
   The course provides a systematic foundation for the connection between evolving technology and human activity impacts on natural systems by emphasizing the sources of environmental degradation and energy use and strategies to reduce risk and promote sustainability. The course provides hands-on experience with life cycle assessment computer tools and approaches. The course emphasizes relationships between industrial activities and regional and global natural systems-physical, chemical and biological-focusing on the importance of sustainability goals and practices.

7. CE671 Performance & Analysis of Infrastructure Systems
   This course presents a comprehensive systems approach to infrastructure asset management across areas of public and private infrastructure. Topics include the framework of integrated asset management illustrated in transportation, water and wastewater systems, the economic evaluation of infrastructure options, using life cycle cost analysis (LCCA) and cost-benefit analysis (CBA). The elements of performance measurement and modeling, including condition assessment and information management, failure and impact analysis are covered. Decision and risk analysis are covered to enable students to develop a holistic economic, performance and risk analysis approach to infrastructure management illustrated in a term project.

8. CE672 Security Management of Critical Infrastructure

This course focuses on the areas of vulnerability assessment and security management of critical infrastructure systems. A review of techniques for facility and network modeling and performance simulation, leads to sector-specific approaches to vulnerability analysis and critical infrastructure protection strategies using a Model-Based Vulnerability Analysis (MBVA). Covered critical infrastructure systems include water supply/ environmental, transportation, power and energy systems, SCADA systems, cyber-infrastructure and telecommunications. The course ends with a review of the combined use of multi-criteria analysis techniques, expert heuristic response to scenarios and network analysis techniques in a general framework for vulnerability and security management of infrastructure systems in its key aspects: prevention, warning/detection and event mitigation and response planning and execution.

9. CE613: Resilient Systems Planning and Design
   This course provides an overview of natural hazards and resilient systems planning and design with a focus on flood-related considerations. This course reviews state-of-the-art responses to disasters and floods, the limitations of traditional resilience approaches, and recent developments in floodproofing and retrofitting solutions according to the requirements and recommendations provided by the Federal Emergency Management Agency (FEMA) and the American Society of Civil Engineers (ASCE). The course further discusses the different physical, economic, and social impacts of disasters on infrastructures, communities, and economies as well as presents contemporary considerations in resilience risk management, planning, and design. The course also examines how to assess, measure, model, and quantify uncertainty and resilience as well as perform sound economic analysis and make informed decisions for flood mitigation projects. Case studies of critical infrastructure resilience, floodproofing, and other natural disaster-related events, impacts, and strategies are discussed in this course.

   Pre-requisites: CS 101, MATH 211, and MATH 279 or approval of instructor.

10. CE703 Concrete Durability

    This course will cover the design and maintenance of concrete structures and pavements from a material choice point of view. Students will learn how to design concrete mixtures, choose alternative and sustainable concrete materials, produce concrete specifications, protect concrete from long-term deterioration, and design solutions for repairing existing concrete. Students will learn about the mechanisms and chemistry and concrete deterioration. The following key topics will be covered: cement production, supplementary cementitious materials, mixture design and proportioning, concrete durability, dimensional stability, freeze-thaw attack, sulfate attack, corrosion, alkali-silica reaction, alternative cements, concrete specifications, and concrete construction.

    Prerequisites: Undergraduate course in construction materials or reinforced concrete design, or permission of the instructor.

11. CE662 Energy from Underground Resources
    This course will provide students with fundamental and applied engineering knowledge critical for identifying, designing, and harnessing various economically valuable materials from deep underground to provide society with renewable and non-renewable energy. This course covers essential energy engineering concepts and technologies related to advancing the current and emerging underground energy resources such as oil and gas, metallic and non-metallic minerals, coal, tar sands, deep underground water, carbon sequestration, and hydrogen geological storage. This course will also explore the governing mechanisms controlling the transfer of fluid and mass at varying deep underground temperature and pressure conditions for safe and efficient extraction and utilization of these energy resources. Case study applications are included to show students how to apply the learned energy techniques in various engineering and science practices.

    Prerequisites: CE 342, or CE 320/ME 304, or EVSC 325, or permission of instructor.

12. CE644 Applied Engineering Geology
    Geology has a significant influence on how we plan, design, and construct engineering works. This course examines how the geologic formations underlying a locale will ultimately determine land use, control structure design, and affect construction material availability. Included is a study of the various rock-forming processes and geologic agents that have shaped Earth's surface. The course also explores the role of geologic factors in assessing environmental impacts and natural hazards such as earthquakes, subsiding soils, and landslides. Case study applications and a field trip are included.

    Prerequisites: undergraduate course in geology or permission of instructor.

13. TRAN650 Urban Systems Engineering
    The course introduces the basic quantitative methods that underline modern urban systems engineering and management science analysis. The basic theory of these methods will be described along with a strong emphasis on the practical applications of these methods. This latter objective is accomplished through the use of various software packages and case studies. In particular, the concept of mathematical programming, stochastic processes, queuing theory, and modern decision analysis will be presented and applied to a variety of problems arising in transportation, civil engineering, and engineering management.

    Prerequisite: computer programming background.

14. CE725 (Independent Study I) or CE726 (Independent Study II)*
    *approval of faculty advisor and relevant topic to climate change adaptation and resilience required.

15. EnE725 (Independent Study I) or EnE726 (Independent Study II)*
    *approval of faculty advisor and relevant topic to climate change adaptation and resilience required.

16. TRAN725 (Independent Study I) or TRAN726 (Independent Study II)*
    *approval of faculty advisor and relevant topic to climate change adaptation and resilience required.

17. Any other course approved by the student advisor