CEE 505 TS / ONL

TRANSPORTATION SOIL STABILIZATION

Instructor Dr. Erol Tutumluer, 1205 Newmark CEE Lab., 217-333-8637, tutumlue@illinois.edu

Schedule Tuesdays and Thursdays: 9:30 – 10:50 AM, 1311 Newmark CEE Laboratory

Office Hours MWF 1:00 – 2:00 PM
(Feel free to call, e-mail, or stop by any other time to consult and interact!)

Prerequisite CEE 483 – Soil Mechanics and Soil Behavior or equivalent

Text Assigned Readings from Essential Texts and Reference Compilations, Technical Literature, and Class Notes and Handouts

Course Content This 4-hour graduate course aims to introduce the theory, techniques, and practical applications of chemical and mechanical stabilization of geomaterials – soils and aggregates/rocks – used in the construction and maintenance of transportation facilities, i.e., roads, railroads, and airfields. Chemical stabilization includes the use of chemicals, admixtures such as lime and fly ash, and emulsions as compaction aids to soils, as binders and water repellents, and as a means of modifying the behavior of soil. Mechanical stabilization deals with the use of non-biodegradable reinforcement, such as geosynthetics and fibers, of geomaterials to improve strength.

The course is designed to introduce students with the need for soil stabilization, provide an understanding of chemical and mechanical stabilization technologies and mechanisms, guide them on the stabilizer selection process, and equip them with the skills needed to design and evaluate geomaterial stabilization for transportation facilities. The course involves advanced topics in transportation facilities that are based on both current established practices and recent research findings and provides minimum overlap on topics of pedology and chemical and mineralogical soil properties covered in CEE 509 Transportation Soils course. Such minimum introductory content is in fact needed to allow graduate students to take this course before taking CEE 509.

Course topics include:

- Block 1: Introduction
- Block 2: Transportation Soils
  - ✓ Pedology and Soil Properties
  - ✓ Soil Chemistry and Mineralogy
- Block 3: Lime Stabilization
- Block 4: Lime-Fly Ash and Pozzolanic Stabilized Materials
- Block 5: Cement Stabilization
- Block 6: Bituminous Stabilization/Emulsions
- Block 7: Geosynthetics and Other Techniques

Each stabilization topic will cover detailed design, construction and compaction, mixing/blending, and field control aspects.

Course website https://canvas.illinois.edu/courses/67689 ***Download and fully utilize texts / class materials!***

Media Space https://mediaspace.illinois.edu/channel/channelid/399744663 ***Recorded lectures***

Learning Objectives

Upon completion of this course, student should be able to:

Block 1:

1. Acquire knowledge on the Need for Transportation Soil Stabilization
   - Understand problems with silty/sandy and clayey soils
   - Define aims and objectives of Soil Stabilization
   - Define and compare Soil Modification in relation to Soil Stabilization
2. Recognize Chemical or Admixture Stabilization alternatives
   - Understand Admixture Stabilization Technology and Mechanisms
   - Evaluate soil conditions for Stabilizer Selection
   - Acquire knowledge on the uses of lime, cement, and pozzolanic and bituminous materials as admixtures
3. Recognize Mechanical or Geosynthetic Stabilization alternatives
   - Understand types and functions of geosynthetics used in Transportation Soil Stabilization
   - Distinguish between subgrade restraint and base reinforcement uses of geosynthetics

Block 2:

1. Acquire general knowledge on the classification and engineering properties of soils
2. Recognize the problematic natures and identification methods of expansive, high shrink-swell potential, frost susceptible and collapsible natural soils and highly compressible organic soils
3. Recognize importance of Pedology in Soil Stabilization
   - Define Pedology and relate it to soil formations and development of soil horizons
   - Define Soil Taxonomy and recognize various soil associations and series
   - Be able to use a County Soil Survey and extract key soil properties for stabilization
4. Understand role of Clay Mineralogy in Soil Stabilization
   - Define mineralogical compositions and properties of major clays
   - Identify techniques used in soil mineralogical composition analyses
5. Recognize importance of Soil Chemistry affecting Stabilizer-Soil Reactions
   - Define soil chemical properties used to evaluate soil stabilizer reactivity
   - Evaluate techniques to determine soil chemical properties
   - Understand behavior of soil water systems

Block 3:

1. Acquire general knowledge on the Manufacturing Processes and Types and Properties of Lime Products
2. Recognize Clay and Lime Reactions that are responsible for soil drying, soil modification, and stabilization of subgrade soils
3. Acquire perspective on Properties Improved through Soil-lime Reactions
   - Define immediate effects on soil lime mixtures
   - Define long term effects on lime stabilization and properties of soil lime mixtures
   - Acquire knowledge on Soil-Lime Mixture Design Procedures
4. Recognize important steps for Constructing Lime Treated Soil Layers
5. Acquire knowledge on Field Successes and Case Histories including problematic cases of sulfate soils

Block 4:

1. Acquire general knowledge on the Coal Combustion Products, i.e.,
   - Bottom ash
   - Boiler slag
   - Flue gas desulfurization (FGD) material, and
   - Fly ash

2. Describe properties of Fly Ash As a Pozzolanic Material
3. Recognize Fly Ash and Soil Reactions and Mixture Design Procedures
4. Acquire knowledge on Engineering Properties of Fly Ash and Soil Mixtures
5. Recognize important steps for Constructing Pozzolanic Stabilized Materials (PSMs)
6. Recognize important steps for Stabilization with Self-Cementing Class C Coal Fly Ash

Block 5:

1. Acquire general knowledge on Cement Based Pavement Materials, Cement Manufacture, and Hydration Reactions
2. Describe properties of Cement Modified Soils (CMS) and Soil Cement for Base Construction or Cement Treated Base (CTB)
3. Recognize Laboratory Test Methods and Soil-Cement Mixture Design
4. Acquire knowledge on Engineering Properties of Soil-Cement Mixtures
5. Recognize important steps for Constructing Soil-Cement Materials
   - Cracking Problems
   - Cement Recycled Asphalt Base (CRAB) or Full-Depth Reclamation (FDR)
6. Review case histories for successful CMS, CTB, and FDR Projects

Block 6:

1. Acquire general knowledge on Types and Properties of Asphalt Cements and Liquid Asphalts
2. Describe properties of Asphalt Emulsions
3. Recognize Emulsion-Aggregate Mixture (EAM) Designs and Properties
4. Recognize important steps for Constructing Stabilized Layers with EAMs including Pavement Construction with Reclaimed Asphalt Product (RAP)
5. Acquire knowledge on Use of Foamed Asphalt in Recycling of Pavements

Block 7:

1. Acquire general knowledge on Types and Functions of Geosynthetics used in Transportation/Pavement Applications for Mechanical Stabilization
2. Describe applications in Asphalt Reinforcement
3. Describe applications in Unpaved Roads
   - Subgrade Restraint / Stabilization
4. Describe applications in Paved Roads
   - Base/Ballast Reinforcement / Stabilization
5. Review UIUC Full-scale Field Pavement Test Sections
   - Recent Developments – Mechanical Stabilization

Student Outcomes

1. Demonstrate an ability to manage multiple and complete assignments by given deadlines
2. Demonstrate an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
3. Demonstrate an ability to communicate (oral and written) with a range of audiences through written, verbal, and graphic communications.
4. Demonstrate an ability to identify, formulate, and solve soil stabilization engineering problems by applying principles of engineering and science

Exams

There will be two in-class exams during the semester. The final class project will be due with a presentation during the last week of classes and the final exam period.

Grading

- Two In-class Exams 25% each
- Final Class Project 30%
- Reading Assignments and Homework 20%

The final class project is a research assignment to be conducted by students working in teams. There will be altogether 6 teams. Each team will compile a technical report to describe (1) original laboratory research projects or (2) successful or unsuccessful field applications, i.e., case histories (e.g., recent field practices which may include full-depth reclamation and/or in place recycling), of the following transportation soil stabilization admixtures and their design and construction practices related to the topics covered in CEE 505 course content on:

- Lime stabilization
- Fly ash, lime-fly ash and other pozzolanic stabilized materials
- Cement stabilization
- Bituminous stabilization, emulsions
- Bituminous stabilization, foamed asphalt
- Geosynthetics (geotextiles, geogrids, geofoam and geocomposites) and
- Any other new and emerging stabilization topics (bio, fiber, polymer, full depth reclamation, etc.)

Reading Assignments/Homework

- Reading assignments will be in the form of one-page summaries/critiques of assigned readings from the technical literature provided. Homework will mainly consist of problem assignments. Both will be due the class period assigned due. If not indicated otherwise, each assignment/homework will be worth 10 points. Unexcused late homework will receive a maximum mark of 8 points.
- Be prepared to discuss and share with class your reading assignments. Student participation inside and outside the classroom is required. This is your opportunity to learn and inquire about the current practice of transportation soils engineering. Make this an educational and profitable semester for you.
- You are encouraged to give feedback to the instructor all throughout the semester.

GradeScope (https://www.gradescope.com/login), Entry Code: J4N3GD

Chapters from Essential Texts and Other Reference Compilations

- Mitchell, J.K., "Fundamentals of Soil Behavior," John Wiley, 1993 (Chapters 2, 3, 4, 5, 6, and 7)
- Koerner, R.M., "Designing with Geosynthetics," 6th Edition, Prentice Hall, 2012 (Chapters 1, 2, & 3).
- "Soil Stabilization for Pavements," UFC 3-250-11, *Manual for the Departments of US Army*, *US Air Force and US Navy*, University Press of the Pacific, 30 November 2020.
- "Soil Stabilization for Roads and Airfields," Chapter 9, *Military Soils Engineering*, TM 3-34.64, Department of the Army, Washington, DC, 25 September 2012.
- Little, D.N. and Nair, S., "Recommended Practice for Stabilization of Subgrade Soils and Base Materials," Final Task Report for NCHRP Project 20-07, Web-only Document 144, August 2009.

- "Lime Treated Soil Construction Manual," Bulletin 326, National Lime Association, January 2004.
- Little, D.N., "Handbook for Stabilization of Pavement Subgrades and Base Courses with Lime," National Lime Association, APG Lime Company, Published by Kendall/Hunt Pub. Co., 1995.
- "Lime Stabilization," State of the Art Report 5, Transportation Research Board, Sept. 1987.
- "Fly Ash Facts for Highway Engineers," American Coal Ash Association, June 2003.
- "Soil-Cement Construction Handbook," Portland Cement Association, 1995.
- "A Basic Asphalt Emulsion Manual," MS-19, Asphalt Institute, Fourth Edition, January 2008.

CEE 505 Course Timetable
Spring 2026 – 1311 Newmark CEE Laboratory

Class Notes – Assigned Readings from Technical Literature and Class Notes/Handouts

Date	**Topic**	
Jan 20	Block 1: Introduction	Reading Assignment 1
Jan 22	Block 1: Introduction – Admixture Selection	"
Jan 27	Block 1: Introduction – Lime Cement, Fly Ash	"
Jan 29	Block 1: Introduction – Bituminous & Geosynthetics	"
Feb 3	Block 2: Transportation Soils	Assignment 2
Feb 5	Block 2: Transportation Soils – Pedology	"
Feb 10	Block 2: Transportation Soils – Mineralogy	"
Feb 12	Block 2: Transportation Soils – Chemistry & Electrolytes	"
Feb 17	Block 3: Lime Stabilization	Assignment 3
Feb 19	Block 3: Lime Stabilization – Reactions	"
Feb 24	Block 3: Lime Stabilization – Mixture Design	"
Feb 26	Block 3: Lime Stabilization – Field Construction	"
Mar 3	Block 3: Lime Stabilization – Case Histories	"
Mar 5	***Examination 1*** *(date tentative, covers Blocks 1-3)*	
Mar 10	Block 4: Lime-Fly Ash and Pozzolanic	Assignment 4
Mar 12	Block 4: Lime-Fly Ash and Pozzolanic	"
	Spring break March 14-22	
Mar 24	Block 4: Lime-Fly Ash and Pozzolanic	"
Mar 26	Block 5: Cement Stabilization	Assignment 5
Mar 31	Block 5: Cement Stabilization – Cement Modified Soil	"
Apr 2	Block 5: Cement Stabilization – Soil Cement	"
Apr 7	Block 5: Cement Stabilization – FDR & Case Histories	"
Apr 9	Block 6: Bituminous Stabilization	Assignment 6
Apr 14	Block 6: Bituminous Stabilization	"
Apr 16	Block 6: Bituminous Stabilization - Emulsions	"
Apr 21	Block 6: Bituminous Stabilization – Foamed Asphalt	"
Apr 23	Block 7: Geosynthetic Stabilization – Types	Assignment 7
Apr 28	Block 7: Geosynthetic Stabilization – Subgrade Stabilization	"
Apr 30	Block 7: Geosynthetic Stabilization – Base Stabilization	"
May 5	Block 7: Geosynthetic Stabilization – Case Histories	"
	Take-home Examination 2 *(primarily covers Blocks 4-7)*	
May 12	7:00-10:00 p.m., ***Final Exam period – Class Project Presentations***	

Classroom Etiquette

To foster and promote integrity among students, the CEE Honor Code was developed with input from several CEE undergraduate organizations, the CEE Graduate Student Advisory Committee, and the CEE Graduate Affairs Committee. You (the student) commit to honor the code each time you sign an exam, and implicitly whenever you sign homework or other class assignments.
The **CEE Honor Code** pledge is the following:

"I pledge to uphold the highest levels of professional and personal integrity in all of my actions, including (1) never assisting or receiving unfair assistance during exams, (2) never assisting or receiving assistance on class assignments beyond that specified by an instructor, and (3) always fully contributing to group activities that are part of a course activity."
For University policies and regulations please refer to the Student Code (http://studentcode.illinois.edu/). You are responsible for maintaining compliance with the University policy on academic integrity as defined in Section 1-402 (http://studentcode.illinois.edu/article1/part4/1-401/) of the Student Code, and the Department Honor Code as defined above.
Finally, please note that posting any content from this course, including homework assignments, exams, quizzes, etc. to the Web without explicit permission from the course instructors violates copyright law, the Student Code, and the CEE Honor Code and is therefore not permitted.

Other Important Policies

Academic Integrity
The University of Illinois at Urbana-Champaign Student Code should also be considered as a part of this syllabus. Students should pay attention to Article 1, Part 4: Academic Integrity. Read the Code at the following URL: http://studentcode.illinois.edu/.
Academic dishonesty will result in a sanction proportionate to the severity of the infraction, with possible sanctions described in 1-404 of the Student Code (https://studentcode.illinois.edu/article1/part4/1-404/). Every student is expected to review and abide by the Academic Integrity Policy as defined in the Student Code: https://studentcode.illinois.edu/article1/part4/1-401/. As a student it is your responsibility to refrain from infractions of academic integrity and from conduct that aids others in such infractions. A short guide to academic integrity issues may be found at https://provost.illinois.edu/policies/policies/academic-integrity/students-quick-reference-guide-to-academic-integrity/. Ignorance of these policies is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.
In this course you are expected to produce your own work in all assignments. Written assignments will be submitted through SafeAssign, a software tool that compares your writing against a large database as well as to the work of your current classmates and previously submitted assignments. Assignments with close matches to other work will be flagged and investigated.
In this course you are expected to produce your own work in all laboratory reports. You may collaborate with your partner, but each report must be written by everyone separately. We will compare all reports each week against current classmates. If your report has a close match with another it will be flagged and investigated.
In this course the use of calculators or electronic devices (cell phones or others) will not be allowed during examinations. If you are found using one, it will be investigated as potential cheating.

Anti-Racism and Inclusivity Statement
The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along several dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together amid the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.
The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us.

Community of Care
As members of the Illinois community, we each have a responsibility to express care and concern for one another. If you come across a classmate whose behavior concerns you, whether in regard to their well-being or yours, we encourage you to refer this behavior to the Connie Frank CARE (Coordination, Assistance, Response, and Education) Center (217-333-0050 or https://odos.illinois.edu/community-of-care/CAREcenter) Based on your report, the staff in the Connie Frank CARE Center reaches out to students to make sure they have the support they need to be healthy and safe.
Further, we understand the impact that struggles with mental health can have on your experience at Illinois. Significant stress, strained relationships, anxiety, excessive worry, alcohol/drug problems, a loss of motivation, or problems with eating and/or sleeping can all interfere with optimal academic performance. We encourage all students to reach out to talk with someone, and we want to make sure you are aware that you can access mental health support at McKinley Health Center (https://mckinley.illinois.edu/). Or the Counseling Center (https://counselingcenter.illinois.edu/). For urgent matters during business hours, no appointment is needed to contact the Counseling Center. For mental health emergencies, you can call 911.

Disruptive Behavior
Behavior that persistently or grossly interferes with classroom activities is considered disruptive behavior and may be subject to disciplinary action. Such behavior inhibits other students' ability to learn and an instructor's ability to teach. A student responsible for disruptive behavior may be required to leave class pending discussion and resolution of the problem and may be reported to the Office for Student Conflict Resolution (https://conflictresolution.illinois.edu; conflictresolution@illinois.edu; 333-3680) for disciplinary action.

Emergency Response Recommendations
Emergency response recommendations can be found at the following website: http://police.illinois.edu/emergency-preparedness/. I encourage you to review this website and the campus building floor plans website within the first 10 days of class. https://police.illinois.edu/emergency-management/mitigation/emergency-action-plans/.

Family Educational Rights and Privacy Act (FERPA)
Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See https://registrar.illinois.edu/academic-records/ferpa/ for more information on FERPA.

Mental Health
Significant stress, mood changes, excessive worry, substance/alcohol misuse or interferences in eating or sleep can have an impact on academic performance, social development, and emotional wellbeing. The University of Illinois offers a variety of confidential services including individual and group counseling, crisis intervention, psychiatric services, and specialized screenings which are covered through the Student Health Fee. If you or someone you know experiences any of the above mental health concerns, it is strongly encouraged to contact or visit any of the University's resources provided below. Getting help is a smart and courageous thing to do for yourself and for those who care about you.
Counseling Center (217) 333-3704
McKinley Health Center (217) 333-2700
National Suicide Prevention Lifeline (800) 273-8255
Rosecrance Crisis Line (217) 359-4141 (available 24/7, 365 days a year)
If you are in immediate danger, call 911
*This statement is approved by the University of Illinois Counseling Center

Religious Observances
Students should complete the Request for Accommodation for Religious Observances form should any instructors require an absence letter to manage the absence. In order to best facilitate planning and communication between students and faculty, we request that students make requests for absence letters as early as possible in the semester in which the request applies.

Sexual Misconduct Reporting Obligation
The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX and Disability Office. In turn, an individual

with the Title IX and Disability Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.
A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: https://wecare.illinois.edu/resources/students/#confidential
Other information about resources and reporting is available here: https://wecare.illinois.edu.

Students with Disabilities
To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the as soon as possible. To ensure that disability-related concerns are properly addressed from the beginning, students with disabilities who require assistance to participate in this class should contact Disability Resources and Educational Services (DRES) and see the instructor as soon as possible. If you need accommodation for any sort of disability, please speak to me after class, or make an appointment to see me or see me during my office hours. DRES provides students with academic accommodation, access, and support services. To contact DRES you may visit 1207 S. Oak St., Champaign, call 333-4603 (V/TDD), or e-mail disability@illinois.edu. http://www.disability.illinois.edu/.