Critical State Soil Mechanics - CE6350

Spring (Jan-May) 2020

Instructor: Ramesh Kannan K and Robinson R G
Slot: C (Mon 10 Hrs, Tue 9 Hrs, Wed 8 Hrs, Fri 12 Hrs)
Email: rameshkk@iitm.ac.in, robinson@iitm.ac.in
Place: STR - 401

Course Objectives:
The fundamental mechanics of geomaterials are extremely complex. A distinct understanding of the material behaviour is key to solve complex boundary value problems. This course is primarily designed for graduate students and the objectives are listed below.

- Introduce a critical state (theoretical) frame work which encompasses a comprehensive geomaterial response
- Utilising fundamental tenets of plasticity theory and critical state framework, classical behavioural/constitutive models will be detailed

Learning Outcomes:
At the end of the course, students will be aware of various tenets of classical continuum models and also the how critical state soil mechanics framework acts as a basis for developing many advanced constitutive models. Specific outcomes are listed below.

- Comprehending simple to advanced experimental techniques to quantify the geomaterial behaviour
- The unified framework and plasticity theory will help to reimagine the material behaviour in two dimensional and three dimensional space
- Predict the material response using classical behavioral/constitutive (elasto-plastic and critical state) models

Course Outline:

1. Revisiting fundamental aspects of soil behaviour
2. Elemental testing of geomaterials
3. Compression of soils
   - Behaviour of OC and NC soils
   - State boundary surfaces
4. Stress path and invariants
5. Critical state concepts, Roscoe and Hvorslev surface

6. Brief introduction to continuum mechanics
    - Vector calculus and indicial notation
    - Tensors
    - Kinetics and Kinematics
7. Linear elasticity and viscoelasticity
    - Isotropic linear elastic stress-strain relations
    - Two and three element time dependent models
8. Constitutive laws (classical plasticity)
    - Yield function
    - Flow rule and plastic potential
    - Hardening law
    - Associated and non-associated plasticity
9. Tresca, Von-Mises, Mohr-Coulomb, original Cam clay, Modified cam clay and other constitutive models
10. Introduction to anisotropic critical state theory

Office Hours: After class, or by appointment.
Main References: The following are a restricted list of various interesting and useful books. Class notes and the books mentioned below will help you gain confidence in this course.

- Wood, D. M. (1990). *Soil behaviour and critical state soil mechanics.* Cambridge university press.
- Wood, D. M. (2014). *Geotechnical modelling.* CRC press.
- Atkinson, J. H. and Bransby, P. L. (1982). *The Mechanics of Soils- An Introduction to Critical State Soil Mechanics*, McGraw-Hill Book Company Limited, London
- Davis, R. O., and Selvadurai, A. P. (2005). *Plasticity and geomechanics.* Cambridge university press.

Additional References:

- Schofield, A. N. (2005). *Disturbed soil properties and geotechnical design.* Thomas Telford.
- Pietruszczak, S. (2010). *Fundamentals of plasticity in geomechanics.* Boca Raton, FL: Crc Press.
- Chen, W.F. and Han, D. J. (2007). *Plasticity for Structural Engineers* . J. Ross Publishing.
- Puzrin, A. (2012). *Constitutive modelling in geomechanics: introduction.* Springer Science.
- Borja, R. I. (2013). *Plasticity.* (Vol. 2, p. 1). Berlin: Springer.

Prerequisites: An undergraduate-level understanding of mechanics of materials and basic geotechnical engineering is assumed.

Grading Policy: Home assignments/ term paper (20%), Quiz 1 (20%), Quiz 2 (20%), Final exam (40%).

Important Dates:

Quiz #1	February 19, 2020
Quiz #2	March 18, 2020
Final Exam	May 04, 2020

Course Policy:

- Please sign up for Moodle at IITM. I will confirm your enrollment for the course, then you will be able to see the course page.

Class Policy:

- Regular attendance is essential and expected.
- At the end of each class, list out the concepts you have understood and aspects that need further explanation.
- Interactive learning is deeply appreciated.

Term paper: Please submit before April 15:

- Bolton, M.D., 1986. Strength and dilatancy of sands. Geotechnique, 36(1), pp.65-78.
- Rowe, P.W., 1962. The stress-dilatancy relation for static equilibrium of an assembly of particles in contact. Proceedings of the Royal Society of London. Series A. Mathematical and Physical Sciences, 269(1339), pp.500-527.

Academic Honesty: Lack of knowledge of the academic honesty policy is not a reasonable explanation for a violation.