CIV_ENV 455
Plasticity and Limit Analysis
Winter Quarter 2023

Instructor
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Office: Tech A122
Office hours: Mon 12:00-1:30pm; Wed 12:00-1:30pm; by appointment
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Class Times
Monday and Wednesday, 8:00-9:50am

Location
Technological Institute L170

Class Website
Northwestern Course Management System (Canvas)
http://www.it.northwestern.edu/education/login.html

Required Textbook
None

Suggested Reading

Prerequisites
Familiarity with elementary mechanics, including the concepts of stress, strain, and equilibrium
Familiarity with linear algebra and basic programming

Course Objectives

• Introduce fundamental theory of plasticity, including the concepts of yielding and plastic flow in materials and, by extension, the concepts of limit (collapse) loads and collapse mechanisms in boundary value problems
• Introduce the various techniques available for computing limit loads, including the slip-line method (method of characteristics), limit equilibrium, analytical and numerical limit analysis, and the finite element method*
• Understand and apply limit analysis as a method for evaluating rigorous bounds on limit loads for stability problems in engineering
• Understand key components of finite element limit analysis (FELA) and apply commercial code
• Introduce advanced concepts

* The course Civ_ENV 456 Computational Geotechnics addresses the implementation of plasticity, and aspects of material nonlinearity, in the displacement-based finite element method.
Course Outline

1. Introductions and course overview
2. Stress; Stress-traction relationship; Equilibrium
3. Motion and displacement; Strain
4. Mechanical properties of soils and solids
5. Preliminary Project Presentation, tentatively due Wednesday, January 25th
6. Perfect plasticity
7. Stress invariants; Principal stress space
8. Yield condition
9. Yield condition
10. Plastic flow rule
11. Boundary value problems
12. Limit equilibrium; slip-line method (method of characteristics); limit analysis; finite element method
13. Project Progress Reports tentatively due Wednesday, February 15th
14. Limit theorems
15. Lower bound limit analysis
16. Upper bound limit analysis
17. Possibilities and limitations of plasticity theory and limit analysis; non-associated flow
18. Advanced topics: generalized forces, steady-state flow problems, etc.
19. Final Project Presentation, tentatively due Wednesday, March 18th

Course Assessment

Grades are determined based on the following components, weighted as indicated:

- 15% Class participation (attendance, completion of in-class activities and quizzes, etc.)
- 15% Homework
- 15% Preliminary Project Presentation
- 20% Progress Report
- 35% Final Project Presentation

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within the first two weeks of the term, so we can work together to implement your disability accommodations. Disability information, including academic accommodations, is confidential under the Family Educational Rights and Privacy Act.

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This class or portions of this class will be recorded by the instructor for educational purpose and available to the class during the quarter. Your instructor will communicate how you can access the recordings. Portions of the course that contain images, questions or commentary/discussion by students will be edited out of any recordings that are saved beyond the current term.

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