

CIV_ENV 455
Plasticity and Limit Analysis
Winter Quarter 2023

Instructor	Prof. James P. Hambleton Office: Tech A122 Office hours: Mon 12:00-1:30pm; Wed 12:00-1:30pm; by appointment Phone: (847)491-4858 Email: jphambleton@northwestern.edu
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	Chen, W.-F. (1975). <i>Limit Analysis and Soil Plasticity</i> . Elsevier. Chen, W.-F., and Han, D. J. (1978). <i>Plasticity for Structural Engineers</i> . Springer-Verlag. Calladine, C. R. (1985). <i>Plasticity for Engineers</i> . Ellis Horwood. Lubliner, J. (2008). <i>Plasticity Theory</i> . Dover. Yu, H. S. (2007). <i>Plasticity and Geotechnics</i> . Springer. Davis, R. O., and Selvadurai, A. P. S. (2005). <i>Plasticity and Geomechanics</i> . Cambridge University Press. Jirásek, M., and Bažant, Z. P. (2002). <i>Inelastic Analysis of Structures</i> . Wiley.
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

Inclusivity in CEE 455 – Plasticity and Limit Analysis

The instructor and Northwestern University are committed to creating an inclusive environment in which all students are respected and valued. We will not tolerate disrespectful language or behavior on the basis of age, ability, color/ethnicity/race, gender identity/expression, marital/parental status, military/veteran's status, national origin, political affiliation, religious/spiritual beliefs, sex, sexual orientation, socioeconomic status or other visible or non-visible differences.

Accessibility Statement

Northwestern University is committed to providing the most accessible learning environment as possible for students with disabilities. Should you anticipate or experience disability-related barriers in the academic setting, please contact AccessibleNU to move forward with the university's established accommodation process (e: accessiblenu@northwestern.edu; p: 847-467-5530). If you already have established accommodations with AccessibleNU, please let me know as soon as possible, preferably

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.

Recording of Synchronous Remote Class Sessions

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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