CIV_ENV 495
Plasticity and Limit Analysis
Spring Quarter 2017

Instructor	Prof. James P. Hambleton Office: Tech A122 Office hours: Tuesday, 2:00-3:00; By appointment Phone: (847)491-4858 Email: jphambleton@northwestern.edu
Class Times	Tuesday and Thursday, 12:00-1:50pm
Location	Tech MG28
Class Website	Northwestern Course Management System (Canvas) http://www.it.northwestern.edu/education/login.html
Required Textbook	None
Suggested Reading	Chen, W.-F. (1975). *Limit Analysis and Soil Plasticity*. Elsevier, Amsterdam. Chen, W.-F., and Han, D.J. (1978). *Plasticity for Structural Engineers*. Springer-Verlag, New York. Calladine, C.R. (1985). *Plasticity for Engineers*. Ellis Horwood Limited, Chichester, UK. Davis, R. O., and Selvadurai, A. P. S. (2005). *Plasticity and Geomechanics*. Cambridge University Press, Cambridge.
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
- Program basic finite element limit analysis (FELA) codes
- Introduce advanced concepts

Course Outline

Week 1		
Lecture 1	Tue, 3/28	Stress and equilibrium
Lecture 2	Wed, 3/30	Strain and strain rates
Week 2		
Lecture 3	Mon, 4/4	Mechanical properties of soils and solids; perfect plasticity
Lecture 4	Tue, 4/6	Yield conditions and flow rules
Week 3		
Lecture 5	Mon, 4/11	Slip-line method
Lecture 6	Tue, 4/13	Limit theorems
Week 4		
Lecture 7	Mon, 4/18	Lower bound limit analysis: concepts
Lecture 8	Tue, 4/20	Lower bound limit analysis: analytical solutions
Week 5		
Lecture 9	Mon, 4/25	Lower bound finite element limit analysis (FELA); **Project #1 Assigned**
Lecture 10	Tue, 4/27	Mathematical optimization: linear programming
Week 6		
Lecture 11	Mon, 5/2	Programming lower bound FELA
Lecture 12	Tue, 5/4	Upper bound limit analysis: concepts
Week 7		
Lecture 13	Mon, 5/9	Upper bound limit analysis: analytical solutions
Lecture 14	Tue, 5/11	Programming upper bound FELA; **Project #2 Assigned**
Week 8		
Lecture 15	Mon, 5/16	Limit analysis versus limit equilibrium
Lecture 16	Tue, 5/18	Selected applications: bearing capacity
Week 9		
Lecture 17	Mon, 5/23	Selected applications: slope stability; **Project #3 Assigned**
Lecture 18	Tue, 5/25	Possibilities and limitations of limit analysis
Week 10		
Lecture 19	Mon, 5/30	Advanced topics
Lecture 20	Tue, 6/1	Advanced topics

Course Assessment

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

- 25% Homework
- 25% Project #1: Programming a *lower bound* finite element limit analysis code
- 25% Project #2: Programming an *upper bound* finite element limit analysis code
- 25% Project #3: Applications and comparison with commercially available software