CIV_ENV 495
Plasticity and Limit Analysis
Spring Quarter 2017

Instructor
Prof. James P. Hambleton
Office: Tech A122
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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

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