Handout No. 1 **Northwestern University**
CIV ENG 495—Computational Inelasticity **Spring 2007**

INSTRUCTOR:

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COURSE DESCRIPTION:

Computational inelasticity deals with the basic components of elasto-(visco)plastic constitutive models for material behavior. In particular, the theory of plasticity will be presented, covering classical and advanced plasticity models as well as the numerical implementation of these models. We will also discuss shear band-type instability problems and loss of uniqueness of the field equations.

COURSE OBJECTIVES:

To develop an understanding for the basic ingredients involved in the theory of plasticity in the infinitesimal strain regime and to be able to develop efficient and robust integration algorithms for advanced plasticity models to be used within the framework of finite element procedures.

GRADING:

- Homework and computing assignments: 30%
- In-class midterm examination: 30%
- Take-home final examination: 40%

REFERENCES:

[1] Y. C. Fung, *A First Course in Continuum Mechanics*, Second Edition, Prentice-Hall, 1977.

[2] R. Hill, *The Mathematical Theory of Plasticity*, Claredon Press, Oxford Classic Series, 1998.

[3] J. C. Simo and T. J. R. Hughes, *Computational Inelasticity*, Springer-Verlag, 1998.

[4] C. S. Desai and H. J. Siriwardane, *Constitutive Laws for Engineering Materials*, Prentice-Hall, 1984.

[5] R. I. Borja, *Plasticity Modeling and Computation*, Stanford University Lecture Notes, 2006.

COURSE OUTLINE

1. **Introduction**
   The big picture; structure of a nonlinear FE program.

2. **Plasticity and visco-plasticity in 1D**
   One-dimensional non-linear problems; basic numerical solution procedures; notion of isotropic and kinematic hardening in one dimension.

3. **Plasticity I**
   Deviatoric (J2) plasticity; flow rule; isotropic, kinematic, and combined hardening; plastic dissipation.

4. **Integration Algorithm**
   Radial return mapping; consistent tangent operator; introduction to general return mapping algorithm.

   Midterm Examination – April 27

5. **Plasticity II**
   Mohr-Coulomb, Drucker-Prager, cap models, critical state models; nested yield surface and bounding surface models; three invariant models; return mapping in principal directions; spectral representation of tangent operators.

6. **Material Instability**
   Limitations of classical plasticity models; length scale; viscoplastic regularization.

7. **Bifurcation Theory**
   Deformation bands: shear, compaction and dilation bands; strain localization; static liquefaction.

   Take-Home Final Examination – June 5