Spring 2013

CVEN 6525

Call # 14135

ECCR 118; T-Th 3:30-4:45

Nonlinear Analysis of Framed Structures; Theory and Applications

Prof. Saouma

Instructors

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Four lectures will be given by Prof. Keith Porter.

Course web page: http://civil.colorado.edu/~saouma/6525

Description

No structural system behaves as a perfectly elastic structure. Even though structural design is mostly based on linear elastic analysis, a rational design philosophy should account for the basic sources of nonlinearity. Concrete cracking or column buckling are two examples we are all familiar with.

Recent emphasis on Performance Based Engineering (FEMA 273/356 and ASCE 41), where the performance of the building must be evaluated at several levels of load excitation, has brought the nonlinear static and dynamic analysis techniques to the forefront. Accordingly, nonlinear structural analysis is becoming increasingly important.

Accordingly, linear elastic analysis is no longer sufficient, and engineers need to be properly equipped to undertake nonlinear ones through: a) understanding of modern computational techniques for the nonlinear analysis of frame structures (which constitute the vast majority of structures investigated by Civil Engineers); and b) application of those techniques in the context of actual design/safety assessment and regulations.

Whereas nonlinear analysis of structure has been traditionally confined to solid elements, this course will focus exclusively on frame structures which are by far more relevant to civil engineers.

Few institutions offer such a course (which coverage is greatly facilitated by an extensive set of notes and a Matlab based program: Mercury) which should be recommended to all graduate students and professional engineers.

Objectives

The objective of this course is to provide student with the proper theoretical underpinning of nonlinear static and dynamic analysis of framed structures, exposure to the corresponding programming techniques in (Matlab); applications to actual engineering problems.

Tentative Coverage (2013)

MODIFIED DUE TO HESITANT AND OOR ENROLLMENT

Tentative Schedule

Lecture	Week	Date			Coverage	
1	1	Jan.	T	15	Intro, Organization; Intro to Nonlinear Analysis;	PART I; Fundamentals
2			Th	17	Geometric Nonlinearity, geometric stiffness matrix, nonlinear analysis	
3	2		T	22		
4			Th	24		
5	3		T	29		
6			Th	31	Intro to Performance Based Engineering 1 and 2 (Prof. Porter)	
7	4	Feb	T	5	Advanced Matlab; Functions; Cell Arrays; data structures; Object Oriented	
8			Th	7	Plasticity 1; Materials; Mechanics	
9	5		T	12		
10			Th	14	Plasticity 2; X-Sections: Lumped plasticity vs Layered Sections	
			T	19		
11	6		T	21	Plasticity 3; Structures: Limit State Theorems	
12			Th	26	Plasticity 3; Structures: Limit State Theorems; Part II	
13	7		T	28	Event-to-Event; Newton Methods; Relations to Nonlinear Structural Analysis	
14			Th	5	Saouma Presentation to nonlinear analysis research	PART II; Numerical Models
15	8	Mar	T	12	No Class	
16			Th	14	Exam	
17	9		T	19	Element Formulation; State Determination; (EF-SD) Stiffness	
18			Th	21	Element Formulation; State Determination; (EF-SD) Stiffness	
19	10		T	26	**Spring Break**	
20			Th	28		
			T	2	EF-Fiber; Zero length; Zero Section	
			Th	4	EF-SD; Fexibility Based Elemens; Const. Model steel	
21	11	Apr.	T	9	Constitutive Models Concrete; Constitutive driver	
22			Th	11	Simulations of Response vectors from Limited # of Analysis (Prof. Porter)	Part III; Applications
23	12		T	16	Buffer	
24			Th	18	Buffer	
25	13		T	23	dynamic, Intro, Euler Methods;	
26			Th	25	Dynamic; Time Integration	
27	14		T	30	Derivation of Fragility Functions (Prof. Porter)	
28			Th	25	PBEE-2 End-to-End Illustration (Prof. Porter)	
29	15		T	30	Modeling with Mercury ++	
30		May	Th	2	Final Exam	

Prerequisites

- Strong interest in Nonlinear Structural Analysis; Prior exposure to CVEN4525/5525 (Matrix structural Analysis or Finite Element analysis) or equivalent.

- Proficiency in Matlab programming.

Benefits

This course will not only help you in the nonlinear analysis, but will also be of great value for nonlinear design of structures.

Textbooks

There are no assigned textbooks, lecture notes will be provided,

Reference texts include:

- McGuire, W., Gallagher, R., Zieman, R. (1999) *Matrix Structural Analysis*, 2nd Edition.
- Bathe, K.-J. (2007). *Finite Element Procedures*. Prentice-Hall, Englewood Cliffs, New Jersey.
- Crisfield, M.A. (1991). *Non-linear Finite Element Analysis of Solids and Structures*. John Wiley & Sons, Chichester, England.
- Yang, Y.-B., and Kuo, S.-R. (1994). *Theory and Analysis of Nonlinear Framed Structures*. Prentice Hall, Englewood Cliffs, New Jersey.

Computer Assignments

You will be

- Expected to be familiar with Matlab, and will be modifying existing Matlab codes;
- Using a newly developed code Mercury http://civil.colorado.edu/~saouma/Mercury

Grades; Examinations

Grades will be based on: 30% Homeworks; 50% Exams; and 20% Project

There will be one Mid-Term and one Final exam.