****

CIVE 467 - REINFORCED CONCRETE DESIGN

****

Fall 2007 **Civil Engineering Department** **Colorado State University**

CLASS DESCRIPTION: CIVE 467 - 03(3-0-0) - Design of Reinforced Concrete Structures
Design and behavior of reinforced concrete structural members.
(from the 2007-2008 Colorado State General Catalog).

TIME & PLACE: Lecture -- 12:00 – 12:50 pm Monday, Wednesday & Friday 120 Engineering

INSTRUCTOR: Marvin E. Criswell, Professor of Civil Engineering
Office: A201 Engineering ***Telephone:*** 491-6697
Office Hours: 2:00-3:00p Monday & Wednesday, 9:30-10:30a Friday
Grader: Balaji Mahalingam ***Office Hours:*** **9 to 11 a.m. Thursday, Room A6 Engineering**

TEXTS:
REQUIRED:

1. **Building Code Requirements for Reinforced Concrete (ACI 318-05) and Commentary on Building Code Requirements for Reinforced Concrete (ACI 318R-05),**
American Concrete Institute, Farmington Hills (Detroit area), MI, 460 pages

The combined ACI Code and Commentary can be obtained at the beginning of the CE 467 class semester through a student order and a special ACI student price for much less cost than through a bookstore: **$57.00 basic price plus shipping = $ 60.00 -- payable to ASCE Student Chapter** – do not include CSU in the "Pay to the order of" line. Your price if, as a non-ACI member, you order this from ACI would be the $162.50 (plus shipping) list price; this also would be the Bookstore price, as their "wholesale" cost would be based on the $ 162.50 list price. ACI member price is $98 (plus shipping)

It is quite necessary that each CE 467 student have his/her own copy of the ACI Code for use in exams, etc. By the end of class on August 23th, please either purchase a copy (see above) or tell the instructor you are not planning to because you will obtain access to a copy via another way.

A combined order for ACI Code will be sent in Friday, August 24th, soon after class.

2. **Class handout notes will be provided**.

RECOMMENDED:

"Design of Concrete Structures, 13th Edition" by Arthur Nilson, David Darwin, and Charles Dolan, McGraw-Hill, 2004

This text is recommended for those wanting a "second source" and/or a traditional textbook. It is intended that the class notes plus the ACI Code will be sufficient for most students. The lectures will make reference to the recommended text, but will be tied to the class notes.

This class is tied closely to the latest edition of the ACI Building Code Requirements, the source document for most design of reinforced concrete (R/C) in the U.S. and the IBC (International Building Code) provisions. The 2002 ACI Code contained the most substantial changes in the Code since way back in 1956. These changes were both in some design procedures and in the values for some design factors – as a consequence, at least the numbers changes in most all of the example problems. Most of the more widely-used U.S. texts on reinforced concrete (R/C) lagged these changes by a couple of years, at least one has not yet to be revised. The latest ACI Code was published in Spring 2005; this revision has few technical changes and major notation changes from the previous 2002 ACI Code. The draft of the 2008 ACI Code is out for public comments and will be released sometime in Spring 2008. It has relatively few major changes other than in some of the seismic design provisions.

COURSE OBJECTIVES: The class objectives include to

1. Present the **methods of providing structural safety and specifying design loads** as used in reinforced concrete (R/C) strength design and in other design methods.

2. Present the **procedures, steps and professional responsibilities involved in structural design** in general and their application to the design of R/C structures.

3. Examine **the relevant material properties**, including the time-dependent concrete properties, and **their effects** on member strength and behavior.

4. Thoroughly present the **basic assumptions of the strength design method** now used for the design of most reinforced concrete members.

5. Examine the **roles of structural analysis and structural continuity** in reinforced concrete design.

6. **Examine the behavior and methods for design and review of the basic reinforced concrete members, especially beams loaded in flexure and shear, columns and beam-columns (including slenderness effects).**

   Expanding on Objective 6*: This can be considered as the primary objective of the class. *The most successful/effective designers have acquired an excellent sense of how the structure and its elements will behave under various conditions and loads. They have a structural sense and understanding.

7. **Introduce some R/C design topics which cannot be covered in detail** within a first course – torsion, special shear conditions, long columns in unbraced frames, seismic requirements, anchorage and inserts.

8. **Introduce the use of design aids and programs for** member analysis, some design, design checks.

   Expanding on Objective 8: With the very extensive use in practice of computer software for structural design in today=s consulting/design community, an increasingly important overall task of the CE 467 class is to ***prepare students to be informed, intelligent users of appropriate software***. This includes their having an ability to properly describe design problems, select relevant software and design program features, and to detect erroneous results that can result with even the best software due to input and other errors.

   There are many important design decisions software cannot make and many design details and messy" geometries that software cannot or cannot easily handle.

9. Present the **basic concepts and design principles for several reinforced concrete structural systems**, including reinforced concrete slabs, prestressed (both pretensioned and post-tensioned) concrete members, foundations and retaining walls, along with information on new projects and design concepts and issues.

10. Present the **behavior of reinforced concrete building systems** and the general concerns and procedures for building design (this is an important overall objective, but one hard to include in exams).

The student successfully completing this first course reinforced concrete will be able to:

1. Know and understand the methods of providing structural safety and selection of design loads, especially as used in U.S. practice.

2. Understand the procedures, steps and professional responsibilities involved in structural design in general and their application to the analysis and design of reinforced concrete structures and members.

3. Understand how the relevant material properties, including time effects for concrete, influence member strength and behavior.

4. Know the basic assumptions and procedures for the strength design method now used for most reinforced concrete design.

5. Understand the role of analysis within design.

6. Be able to design and review the basic reinforced concrete members, especially beams loaded in flexure and shear, columns and beam-columns, for both strength and serviceability.

7. Have some experience in using applicable design aids and software.

8. Have a basic understanding of more advanced members and systems, including two-way slabs, torsion, and prestressed concrete.

9. Have the necessary background and intellectual curiosity to facilitate further study, either formally or through self-study, of R/C, and a awareness that further learning and practice is needed for independent structural engineering practice and any practice at a high technical level, and

10. Have acquired a sense of judgment and an appreciation of needed member proportions so to be able to quickly identify possible problem areas, gross inadequacies and overdesign, and to effectively interact in project teams involved in the design and/or construction of R/C structures.

CLASS FORMAT:

The CE 467 class has a three-lectures per week format. Until several years ago, it was set up with two lectures plus a three-hour problem lab. Although this format has been retained for the companion structural design course, CE 466, there are practical challenges in having a three-hour problem lab with the current large class size.

EVALUATION (i.e. grading):

Problem sets ----------25%
Hour Exams (3 @ 15%) ---------- 45% (Wednesday of Weeks 6, 10, & 14 – Sept 26, Oct 24, Nov. 28)
Final Exam ---------- 30% (Final will be comprehensive, may have a closed book portion)

FINAL EXAM TIME: The standard time for Fall 2007 12-MWF classes is 3:40 – 5:40 pm,, Thursday, Dec 13th.

GRADING SCALE: The class grading does not follow a strict "90 – 100 = A, 80 – 89.99 = B, etc." scale.

The solution sheet for each examination will include the A,B,C, etc. grade range for that examination. For Problems sets, A = 88 – 100%, B = 77-88%, C = 66-77%, and D = 55-66%.

The overall conversion of numerical to alphabetical grades will utilize a scale constructed from the individual scales. For example, if the division between B and C for the individual examinations are as follows:

Exam #1 – 78%, Exam #2 – 68%, Exam #3 – 73% and Final Examination – 71%,

then the division between B & C for the overall class grades will be:

Problem Sets: 0.25(77%) = 19.25%
Hour Exams: 0.15(78% + 68% + 73%) = 32.85%
Final Examination: 0.30(71%) = 21.30% SUM EQUALS 73.40% = "BC" Grade Division

Plus/minus grading will be used, with about 20% of the class grades expected to be "+ plus" grades and another 20% expected to be "- minus" grades.

PROBLEM SETS:

The primary purpose of the problem sets is to help you learn and understand the course content. Problem sets and your associated ability to formulate solutions efficiently are vital parts of the learning process in a class such as CE 467. The performance of previous CE 467 classes shows a very high correlation between individual student problem set grades and grades earned on the exams, especially for the students in the highest and lowest quartiles of the class.

Problem sets are assigned 25% in the overall class evaluation algorithm. Although you cannot earn a high course grade by only doing well on the problems sets, you can drop one or two letter grades if problems sets are poor or missing. Remember, in addition to the weight directly assigned to them, these sets are also very important in helping you learn the class material and to perform well on the exams!

Problem sets will generally be assigned once per week, either Friday or Monday, with sets generally due at the **start** of class on Friday. By Wednesday's class, you should have at least examined all the assigned problems and what they require. There will be no problem set due 26 Oct 2007 (Exam on 24 Oct and FE for many on Oct 27th!)

Problem Format and Guidelines: Problems are to be worked (mechanical pencil with 0.5mm HB lead recommended) on one side (the "plain" side) only of engineering paper (white preferred). Leave an appreciable space (>1 inch) between problems or (preferred) start each problem on a new page. Letter (i.e. print), not longhand (script) write, the word/text information involved in your solution.

Include the class number, due date, and your name on the first page, with your name in the upper right corner. On other pages, include at least your last name in the upper right of each page, and number the pages.

You need not hand in the assignment sheet with your solution – indeed, it is preferred that you do not. If the solution sheet comes out before the graded problem sets are returned, it is best that you have the problem sheet.

Organization and neatness of your work will be considered in grading, along with procedures and final answer. Show enough equations, sources of information, assumptions and intermediate steps so that your work can be followed both by a grader and by you when you latter use your problem sets for review in CE 467 and possibly also several years from now as a reference.

If you seek full credit for your homework solution, you must give more than only the final answer from your calculator or computer. Unless software/listings are provided in class, solutions achieved through programs/spreadsheets need to include enough critical intermediate answers that the procedures/thought processes are documented. In all cases, input values must be given.

Include only a **reasonable number of significant digits** in your final answers - usually 3 or 4 are adequate, with 4 if the lead digit is a 1, 2 or 3 (this precision of 1 part per several hundred or a few thousand can be described as "slide rule accuracy"). Round or do not round intermediate answers as you see fit. Underline, box, or otherwise clearly identify your answers. Always include units with your answers. When appropriate, draw a neat and at least approximately to-scale sketches to explain and/or display your work. Use a straight edge, pocket template, etc., unless your freehand sketching skills are unusually good. Regarding significant digits for intermediate answers -- in most cases, you will be using intermediate answers available to you from within your calculator, and thus you are using the precision inherent within your calculator. Your task is to document enough intermediate answers in your work that your procedure and possible locations of numerical errors can be found.

Unless instructions clearly state otherwise, each student is expected to **independently** formulate a problem solution, carry out the calculations and prepare his/her problem set solution. **You are encouraged to consult with (but NOT copy from) other class members** about general aspects and approaches to the problems, when difficulties arise in doing the homework problems), and to check with others on whether your solution appears to be correct. (Different and more restrictive rules exist for exams!!)

The proper use of student interactions can be a very effective, efficient learning technique (also called Collaborative Learning), and most engineering jobs in practice involve group work with each person contributing. If after you have independently approached a problem and put forth a reasonable effort, you find you are absolutely stuck or strongly suspect that your approach is wrong, seek help from the instructor or a classmate rather than

"spinning your wheels". ***Remember that the primary purpose of homework is to facilitate learning, not just to produce a solution as the end result.***

Grading of Problem Sets: Because solution sheets will be handed out, problem sets will not be graded in great detail. It is expected that you will individually check you solutions with the solution sheet for all problems.

Late homework will be penalized 15% if handed after the due time (usually start of class) on the due date (i.e. a multiplier of 0.85 will be applied), plus 10% for each additional week day it is late (i.e. if due Friday, -15% if it comes in on Friday at the end of class or later in the day, -25% if it comes in on Monday, etc.). Homework handed in after the solution sheet for that problem set is released to the class will not be graded for credit.

Homework submitted via e-mail will not be accepted.

Identical solutions and solutions obviously copied from another student will be noted and penalized. Solutions so similar that they reasonably can be judged as being from a single source, whether from students working together "line-by-line" on a single solution or from copying a solution previously completed by another class member (sometime it is obvious which student's work is the source!) fall in this category. The first time such "single source" solutions are identified, the grade will be divided among the papers submitted. The second (or more) time a student submits problem sets nominally identical to another student's work, the work will be returned ungraded.

ALWAYS EXAMINE YOUR ANSWERS FOR REASONABLENESS!!! If an answer you get does not look reasonable, investigate if you can find an explanation, verification, or error. Try to learn from your investment in producing a solution – ask how does the member behave? What effect does a change in input produce in the answer? What is the estimated answer using some "back-of-the-envelope" approximate solutions? Try to sharpen your "structural sense" of what looks right and your ability to predict what is reasonable. If no errors are found, but the answer still looks unreasonable, note your concerns (especially on exams where you may not have time to do a thorough investigation). Do not automatically accept calculator answers - no magic assures they are correct and the calculator cannot compensate for wrong assumptions, keystroke errors, and wrong input numbers. Remember the abbreviation **GIFGO** as it applies to computers - garbage in, **fabulous** garbage (wrong to 12-place precision?) out!

CLASS SCHEDULE FOR CIVE 467, FALL 2007 (tentative)

Period		Date	Topic
1	Mon	20 Aug	Introduction, course overview
2	Wed	22	Design concepts & codes, history of R/C, gravity loads
2	Fri	24	Loads, safety, design methodologies, load combinations, materials - steel and concrete
4	Mon	27 Aug	Design process, determination of member loads, pattern loads, analysis examples
5	Wed	29	Material properties and their consideration in R./C behavior and design
6	Fri	31	Flexural members – basic behavior, Preview of ACI Code
7	Mon	3 Sept	********** LABOR DAY HOLIDAY, NO CLASSES **********
8	Wed	5	Materials, effects of material time dependent behavior, approximate analyses, concrete quality
9	Fri	7	Modeling and analysis of singly reinforced beams
10	Mon	10 Sept	Flexural members - balanced conditions, calculation of reinforcement strain and ductility
11	Wed	12	Flexural members – limits of flexural reinforcement amounts
12	Fri	14	Flexural analysis of general shaped members
13	Mon	17 Sept	Design of singly reinforced beams for flexure – general procedures
14	Wed	19	Examples -- flexural analysis and design
15	Fri	21	Flexural design – continued; cover, spacings, other restrictions on reinforcement placement
16	Mon	24 Sept	Flexural crack control, reinforcement details
17	Wed	26	***** EXAM I** --- through material of Lecture 14
18	Fri	28	Doubly reinforced beams & details of T-beams

19	Mon	1 Oct	R/C beam behavior in flexural shear
20	Wed	3	Design of shear reinforcement in usual beams
21	Fri	5	Columns – behavior, general requirements
22	Mon	8 Oct	Columns with bending, interaction diagrams
23	Wed	10	Examples -- flexural shear, construction of interaction diagrams
24	Fri	12	Columns design and introduction to design aids
25	Mon	15 Oct	Examples -- columns
26	Wed	17	Column length effects
27	Fri	19	Singly and doubly reinforced beams with reinforcement without a definite yield point
28	Mon	22 Oct	Flexure - alternate design (elastic analysis)
29	Wed	24	***** EXAM II** --- through material of Lecture 26
30	Fri	26	Deflections of R/C beams

********** **FE Examination – Saturday, October 27, 2007 ********

31	Mon	29 Oct	Moment redistribution, one-way slabs
32	Wed	31	Examples - deflections, alternate design, etc.
33	Fri	2 Nov	***** Engineering Field Trip/Professional Development Day *********
34	Mon	5 Nov	Development of reinforcement
35	Wed	7	Code requirements for reinforcement bar lengths and cutoffs, and for splices of rebar
36	Fri	9	Reinforcement bar lengths, detailing
37	Mon	12 Nov	Torsion and torsion reinforcement
38	Wed	14	Torsion examples
39	Mon	16	Footings and walls

**********THANKSGIVING BREAK ----- WEEK OF NOVEMBER 19 – 23, 2007

40	Mon	26 Nov	Deep beams, shear friction, corbels
41	Wed	28	****** EXAM III** --- through material of Lecture 38
42	Fri	30	Introduction to prestressed concrete
43	Mon	3 Dec	Introduction to 2-way slabs
44	Wed	5	Examples -- long columns, miscellaneous topics
45	Fri	7	Seismic design details, Review

FINAL: For 12 MWF classes, Fall 2007 final exam time is 3:40 – 5:40 pm, Thursday, December 13, 2007.