

CIVE 467 - REINFORCED CONCRETE DESIGN

Fall 2009 Civil and Environmental 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 2008-2009 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

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Office Hours 2:00-3:00p Monday, Wednesday, and Thursday; 9:30-10:30a Friday

Grader: Karthik Rudraprasad *e-mail:* rkrechan@lamar.colostate.edu

TEXTS:

REQUIRED:

1. **Building Code Requirements for Reinforced Concrete (ACI 318-08) and Commentary on Building Code Requirements for Reinforced Concrete (ACI 318R-08)**, American Concrete Institute, Farmington Hills (Detroit area), MI, 465 pages

The combined ACI Code and Commentary (the two are in a single volume and cannot be gotten separately) can be obtained at the beginning of the CIVE 467 class semester through a student order and a special ACI student price for much less cost than through a bookstore: **\$60.00 basic price plus shipping = \$ 65.00 -- payable to ASCE** – do **not** include CSU in the “Pay to the order of” line; also not needed – “Student Chapter”. The list price of this publication is \$174.50 (plus shipping) list price; this also would be the Bookstore retail price, as their “wholesale” cost would be based on the \$ 174.50 list price

It is quite necessary that each CE 467 student have his/her own copy of the ACI Code for use in exams, etc., as the CIVE 467 course is tied closely to the latest edition of the ACI Building Code Requirements, which is the source document for most design of reinforced concrete (R/C) in the U.S. and for the IBC (International Building Code) provisions.

By the end of class on Friday, August 28th, 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 by phone on Friday, August 28th, soon after class. A new ACI policy starting this fall is that the 318 Codes will not be shipped until ACI receives payment!

2. Numerous class handout notes will be provided (Suggested – get a large 3-ring binder).

RECOMMENDED:

“Design of Concrete Structures, 14th Edition” by Arthur Nilson, David Darwin, and Charles Dolan, McGraw-Hill, 2010. 795 pages. ISBN 978-0-07-329349-3.

Retail \$188.25 new (according to publisher) or \$170.85 (at CSU Book Store) or \$160.60 (at Amazon), too new for used books to be available, CSU Library: TA683.2.N55 for previous edition (2004). Coverage in the 13th Edition has been little changed in the 14th Edition on the topics covered in CIVE 467. Used 13th Edition available (Amazon) from \$48, new 13th in paperback (14th not yet in paperback) available at \$80.95.

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.

COURSE OBJECTIVES: The objectives of the CIVE 467 course include to

1. Present the **methods of providing structural safety and specifying design loads** as used in reinforced concrete (R/C) strength design in other design methods for many other structural materials.
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** 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 CIVE 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, understand R/C design well enough to select appropriate software and design program features, use correct input, and to detect erroneous results that can result with even the best software due to input and other errors.
Also, there are many important design decisions software cannot make and many design details and messy geometries that software cannot or cannot easily handle. Most software has little creativity!
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 the larger topic of 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.
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 CIVE 467 class has a three-lectures per week format.

EVALUATION (i.e. grading):

Problem sets -----25%

Hour Exams (3 @ 15%) ----- 45% (Wednesday of Weeks 6, 10, & 14 – Sept 30, Oct 28, Dec 2)

Final Exam ----- 30% (Final will be comprehensive, it may have a closed book portion)

The standard time for Fall 2009 12-MWF classes is 11:20 a.m.– 1:20 p.m. on Thursday, Dec 17th.

FORMAT FOR EXAMS: The format of an examination will be announced at least a week before the exam; exams are typically open book/Code. **Only FE-eligible calculators (Casio fx-115, HP 33s and 35s, and TI-30X and 36X) may be used** during hour exams; no calculators with programmable features will be allowed. Use of cell phones, other electronic devices, and web resources during a CIVE 467 examination is also not allowed.

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%.

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. As of Fall 2008, the permissible grading scale at Colorado State University when plus/minus grading is used no longer includes grades of C-, D+, and D-.

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 CIVE 467. The performance of previous CIVE 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. The problem set due October 23 will be partial problem set since many of the CIVE 467 students will be taking the Fundamentals of Engineering Examination on Saturday, October 24th.

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.

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 CIVE 467 and possibly also several years from now as a reference. Include only a **reasonable number of significant digits** in your **final** answers - usually 3 or 4 digits are adequate for non-integer answers

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

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. ***The proper use of student interactions can be a very effective, efficient learning technique (this technique is sometimes called Collaborative Learning), 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 and marked in great detail. It is expected that you will individually check your 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.). It is not acceptable to work during the lecture class time to complete a problem set due that day!

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. Nominally identical solutions and solutions obviously copied from another student will be noted, penalized, and if not accepted if this behavior is repeated.

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 of study time 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 (“correctly” wrong to 12-place precision?) out!

CLASS SCHEDULE FOR CIVE 467, FALL 2009 (tentative)

Period	Date	Topic
1	Mon 24 Aug	Introduction, course overview
2	Wed 26	Design concepts & codes, history of R/C, gravity loads
3	Fri 28	Loads, safety, design methodologies, load combinations, materials - steel and concrete
4	Mon 30 Aug	Design process, determination of member loads, pattern loads, analysis examples
5	Wed 2 Sept	Material properties and their consideration in R/C behavior and design
6	Fri 4	Flexural members – basic behavior and preview of the ACI Code methods
7	Mon 7 Sept	***** LABOR DAY HOLIDAY, NO CLASSES *****
8	Wed 9	Materials, effects of material time dependent behavior, approximate analyses, concrete quality
9	Fri 11	Modeling and analysis of singly reinforced beams
10	Mon 14 Sept	Flexural members - balanced conditions, calculation of reinforcement strain and ductility
11	Wed 16	Flexural members – limits of flexural reinforcement amounts
12	Fri 18	Flexural analysis of general shaped members
13	Mon 21 Sept	Design of singly reinforced beams for flexure – general procedures
14	Wed 23	Examples -- flexural analysis and design
15	Fri 25	Flexural design – continued; cover, spacings, other restrictions on reinforcement placement
16	Mon 28 Sept	Flexural crack control, reinforcement details
17	Wed 30 Sept	*** EXAM I --- through the material covered on the problem set due September 25th
18	Fri 2 Oct	Doubly reinforced beams & details of T-beams
19	Mon 5 Oct	R/C beam behavior in flexural shear
20	Wed 7	Design of shear reinforcement in usual beams
21	Fri 9	Columns – behavior, general requirements
22	Mon 12 Oct	Columns with bending, interaction diagrams
23	Wed 14	Examples -- flexural shear, construction of interaction diagrams
24	Fri 16	Columns design and introduction to design aids
25	Mon 19 Oct	Examples -- columns
26	Wed 21	Column length effects

27 Fri 23 Singly and doubly reinforced beams with reinforcement without a definite yield point
 ***** FE Examination Saturday, October 24, 2009 *****

28 Mon 26 Oct Flexure - alternate design (elastic analysis)
 29 Wed 28 *** EXAM II – through the material covered on the problem set due October 23rd
 30 Fri 30 Deflections of R/C beams

31 Mon 2 Nov Moment redistribution, one-way slabs
 32 Wed 4 Examples – deflections, alternate design, etc.
 33 Fri 6 *** Engineering Professional Learning Institute (PLI) Day *****

34 Mon 9 Nov Development of reinforcement
 35 Wed 11 Code requirements for reinforcement bar lengths and cutoffs, and for splices of rebar
 36 Fri 13 Reinforcement bar lengths, detailing

37 Mon 16 Nov Torsion and torsion reinforcement
 38 Wed 18 Examples - torsion
 39 Mon 20 Footings and walls

*****THANKSGIVING BREAK ----- WEEK OF NOVEMBER 23 – 27, 2009

40 Mon 30 Nov Deep beams, shear friction, corbels
 41 Wed 2 Dec *** EXAM III --- through the material covered on the problem set due November 20th
 42 Fri 4 Introduction to prestressed concrete

43 Mon 7 Dec Introduction to 2-way slabs
 44 Wed 9 Examples -- long columns, miscellaneous topics
 45 Fri 11 General principles of seismic design for R/C structures, Review

FINAL: For 12 MWF classes, Fall 2009 final exam time is 11:20 a.m. – 1:20 p.m., Thursday, December 17, 2009.