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 Tuesday & Wednesday, 9:30-10:30a Friday
Grader: Karthik Rudraprasad Office Hours: 9 to 11 a.m. Thursday (tentative), Room A6 Engineering
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 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: $58.00 basic price plus shipping = $ 63.00 -- 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 $167.00 (plus shipping) list price; this also would be the Bookstore price, as their “wholesale” cost would be based on the $ 167.00 list price. ACI member price is $101.00 (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 Friday, August 29th, 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 29th, soon after class.

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

RECOMMENDED:

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 for the IBC (International Building Code) provisions. The 2002 ACI Code contained the most substantial changes in the Code since way back in 1963. 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 ACI Code edition published in Spring 2005 had had few technical changes and major notation changes from the previous 2002 ACI Code. The 2008 ACI Code has relatively few major changes in most chapters, exceptions being in the provisions for seismic design and in some of the appendices.
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 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.**

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 26, Oct 24, Nov. 28)
Final Exam -------------------------------- 30% (Final will be comprehensive, may have a closed book portion)

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 may be used during hour exams; no calculators with programmable features will be allowed. Use of cell phones and other electronic devices during a CIVE 467 examination is also not allowed.

FINAL EXAM TIME: The standard time for Fall 2008 12-MWF classes is 9:10 – 11:10 a.m. Tuesday, Dec 16th.

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 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 24 will be partial problem set since many of the CIVE 467 students will be taking the Fundamentals of Engineering Examination on Saturday, October 25th.

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 because the solution sheet may come out before the graded problem sets are returned.

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.

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 and/or spreadsheets need to include enough critical intermediate answers that the procedures and input used, along with your 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 digits are adequate for non-integer answers, with 4 needed 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 you report 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 (this technique is sometimes 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 and marked 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.). 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 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 into 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 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!

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**CLASS SCHEDULE FOR CIVE 467, FALL 2008  (tentative)**

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<thead>
<tr>
<th>Period</th>
<th>Date</th>
<th>Topic</th>
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<tbody>
<tr>
<td>1</td>
<td>Mon 25 Aug</td>
<td>Introduction, course overview</td>
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<tr>
<td>2</td>
<td>Wed 27</td>
<td>Design concepts &amp; codes, history of R/C, gravity loads</td>
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<td>2</td>
<td>Fri 29</td>
<td>Loads, safety, design methodologies, load combinations, materials - steel and concrete</td>
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<td>4</td>
<td>Mon 1 Sept</td>
<td>************************ LABOR DAY HOLIDAY, NO CLASSES *************************</td>
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<tr>
<td>5</td>
<td>Wed 3</td>
<td>Design process, determination of member loads, pattern loads, analysis examples</td>
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<td>6</td>
<td>Fri 5</td>
<td>Material properties and their consideration in R/C behavior and design</td>
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<td>7</td>
<td>Mon 8 Sept</td>
<td>Flexural members – basic behavior and preview of the ACI Code methods</td>
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<td>8</td>
<td>Wed 10</td>
<td>Materials, effects of material time dependent behavior, approximate analyses, concrete quality</td>
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<tr>
<td>9</td>
<td>Fri 12</td>
<td>Modeling and analysis of singly reinforced beams</td>
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<tr>
<td>10</td>
<td>Mon 15 Sept</td>
<td>Flexural members - balanced conditions, calculation of reinforcement strain and ductility</td>
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<td>11</td>
<td>Wed 17</td>
<td>Flexural members – limits of flexural reinforcement amounts</td>
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<td>12</td>
<td>Fri 19</td>
<td>Flexural analysis of general shaped members</td>
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<td>13</td>
<td>Mon 22 Sept</td>
<td>Design of singly reinforced beams for flexure – general procedures</td>
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<td>14</td>
<td>Wed 24</td>
<td>Examples -- flexural analysis and design</td>
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<td>15</td>
<td>Fri 26</td>
<td>Flexural design – continued; cover, spacings, other restrictions on reinforcement placement</td>
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<td>16</td>
<td>Mon 29 Sept</td>
<td>Flexural crack control, reinforcement details</td>
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<td>17</td>
<td>Wed 1 Oct</td>
<td>*** EXAM I --- through material of Lecture 14</td>
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<td>18</td>
<td>Fri 3</td>
<td>Doubly reinforced beams &amp; details of T-beams</td>
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19 Mon 6 Oct R/C beam behavior in flexural shear
20 Wed 8 Design of shear reinforcement in usual beams
21 Fri 10 Columns – behavior, general requirements

22 Mon 13 Oct Columns with bending, interaction diagrams
23 Wed 15 Examples -- flexural shear, construction of interaction diagrams
24 Fri 17 Columns design and introduction to design aids

25 Mon 20 Oct Examples -- columns
26 Wed 22 Column length effects
27 Fri 24 Singly and doubly reinforced beams with reinforcement without a definite yield point

************ FE Examination Saturday, October 22, 2008 ************

28 Mon 27 Oct Flexure - alternate design (elastic analysis)
29 Wed 29 Deflections of R/C beams
30 Fri 31 Moment redistribution, one-way slabs

31 Mon 3 Nov Examples – deflections, alternate design, etc.
32 Wed 5 *** EXAM II – through material of Lecture 27 ***
33 Fri 7 *** Engineering Professional Learning Institute (PLI) Day ?? ***

34 Mon 10 Nov Development of reinforcement
35 Wed 12 Code requirements for reinforcement bar lengths and cutoffs, and for splices of rebar
36 Fri 14 Reinforcement bar lengths, detailing

37 Mon 17 Nov Torsion and torsion reinforcement
38 Wed 19 Torsion examples
39 Mon 21 Footings and walls

************ THANKSGIVING BREAK ----- WEEK OF NOVEMBER 24 - 28, 2008

40 Mon 1 Dec Deep beams, shear friction, corbels
41 Wed 3 *** EXAM III --- through material of Lecture 38
42 Fri 5 Introduction to prestressed concrete

43 Mon 8 Dec Introduction to 2-way slabs
44 Wed 10 Examples -- long columns, miscellaneous topics
45 Fri 12 Seismic design details, Review

FINAL: For 12 MWF classes, Fall 2008 final exam time is 9:10 – 11:10 a.m., Tuesday, December 16, 2008.