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Development And Integration Of A New Course In Structural Loads & Systems In A Civil Engineering Technology Program

Abi Aghayere
Rochester Institute of Technology

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Abi Aghayere
College of Applied Science and Technology
Rochester Institute of Technology

Abstract

One of the Civil criteria in ABET TC2K[1] is that programs "apply current knowledge and adapt to emerging applications of technology," such as, changes in the building codes. Structural design firms also have the expectation that Civil Engineering Technology (CET) graduates should be able to apply current codes to determine structural loads, required for the analysis and design of structures. While most CET programs expose their students to structural analysis and design using instructor or textbook-prescribed loads, few expose students to the detailed calculation of actual structural loads using current codes.

Many jurisdictions in the United States, including New York State, have recently adopted the International Building Code (IBC) [2], which contains the latest provisions on structural loads, including wind and seismic loads for buildings. Prior to 2002, in New York State, the building code only required buildings to be designed for wind loads using a very simple tabular method. Seismic loads were not considered. Under that dispensation, it was possible and feasible to integrate the topic of structural loads, dead, live, snow and wind load, into any one of the structural design courses, all-be-it at an elementary level. However, with the adoption of building codes, such as the IBC 2000, the calculation of structural loads has become complex and time consuming.

In order to meet the changing needs in this subject area of the CET curriculum, a new stand-alone course in structural loads and systems has become a necessity. This paper discusses the development and integration of a 2-credit hour required course in structural loads and systems that is offered to 3rd year students in the CET program at Rochester Institute of Technology (RIT). The topics discussed include: impetus for developing the course, course structure and syllabus, integration into the curriculum, intended learning outcomes, course text development (no available structured textbook exists), typical homework assignments, summary and conclusions.

Introduction

As the loads section of the major building codes has become more complex, the need for a separate structural loads course has become more apparent[1, 2], especially now with many jurisdictions in the United States, including New York State, adopting the International Building Codes (IBC 2000). The IBC 2000 Code[2] is considerably more detailed and complex than the previous New York State Code, especially with regards to wind and seismic load calculations,

and includes a chapter on structural loads (Chapter16). Due to the sheer volume of this new body of knowledge and the time required to cover the material in sufficient detail, it is no longer feasible to adequately cover all structural loads, dead, live, snow – including drift and sliding snow, wind and seismic, within existing structural design or analysis course. In fact, a review of the course websites of civil engineering/civil engineering technology programs in the United States reveals that only a few offer a stand-alone course in structural loads.[3, 4] Most programs [5, 6, 7, 8, 9, 10, 11, 12] provide a cursory treatment of structural loads within the structural analysis course, and to the author's knowledge, no civil or structural engineering technology program offers a stand-alone course in structural loads.

To solicit input from the Industry on the need for this course, the letter shown in Appendix 1 was sent to ten structural engineers within the Rochester, New York area, one of whom is on our Advisory Board. Six responses were received and sample comments received from these engineers in support of the development of this course include the following:

- Course content looks good. I'm not sure how in depth you get into seismic but how a building is categorized seems to have a big effect on the layout of the lateral systems and the design of the moment connections

- The homework assignments seem adequate. A short homework section on wind/snow exposure categories may add to the course. That is one area where engineering judgments can have a large impact on the loads, and the code can be confusing. If you could have the students visit a site and work out the exposure categories it may prove enlightening.

- The assignments are presented well. I didn't see any assignments that dealt with braced or moment frames – maybe a simple braced or moment frame could be thrown in.

- I assume that this will be a prerequisite for the design courses? That would make teaching the design course a little easier. I can tell you that I was not able to get to seismic in the on-line Timber class. As far as content goes, you seem to have all of the basics covered.

- Make sure discussion includes load path and load combinations to some depth and is not just brushed upon. Can you expand to include some discussion on bridge/traffic loadings or are you sticking strictly to buildings? Glad to see the Excel spreadsheet requirement. Overall it looks very good – keep up the good work!

Some additional topics suggested by these practicing structural engineers are as follows:

- Efficiency in applying live loadings to floors. For instance if there are corridors (100 psf) and office space (50 psf) on a floor you may want to consider designing the entire area for 100 psf.
- Load paths from primary to secondary framing systems all the way to the foundations.
- Impact loadings, Rain Loads, Ice loads

- Effect of Uplift loads on roof members
- Seismic Component forces—Architectural & Mechanical components, IBC section 1621

Based on the input from Industry, we concluded that a separate course in structural loads is indeed desirable for the CET program at RIT to enable us continue to produce well prepared graduates who have up-to-date knowledge and skills and are ready to the "hit the ground running" with minimal additional on-the-job training.

Course Structure

The Structural Loads and Systems course is a 2-credit hour required course with two 50-minute lectures each week for ten weeks. The prerequisite for this course are statics and strengths of materials. The course includes one mid-term and final exam, and a total of six homework assignments. A detailed treatment of gravity and lateral loads, load paths, and gravity and lateral load resisting systems is included in the course. The course is delivered to on-campus students in a lecture format using the transparencies of the notes developed for the course. It is intended to also offer this course to online distance students in the near future; currently, the on-campus version of the course is web-based using the course management software, Prometheus. The course web site has the follow sections: Syllabus, Grade Book, Files, Messages, Discussions, and Utilities. The use of the discussion forums in Prometheus fosters additional student-to-student and student-to-instructor interactions outside of the classroom environment. The detailed course outline, and the percentage of time spent on each topic is shown below:

1. Introduction to structural loading and load combinations (5 %)
2. Dead loads; tributary width and tributary areas; gravity and lateral load path (10 %)
3. Live loads: Roof live loads; Snow loads -- Balanced, Drifting, and Sliding snow loads; Floor live loads (20 %)
4. Lateral loads on buildings: Cause and effects (5 %)
5. Lateral Load Resisting Systems: Rigid and Flexible diaphragms; Shear walls, Braced frames, Moment frames (10 %)
6. Wind loads: Analytical Method; Simplified Method; Main Wind Force Resisting System (MWFRS); Components and Cladding (C&C) (20 %)
7. Seismic loads: Primary system; Parts and Components (25%)
8. Mid-term exam (5 %)

Most of the feedback from industry has already been incorporated into the above course outline except for the suggested additional topics such as impact loads, rain loads, ice loads, and seismic component forces. The author plans to incorporate as many of these additional topics into the new offering of the course as time would allow in this 2-credit hour course. In any event, these additional topics will be included in the next version of the course notes so that students can at least have access to the information.

Integration into the CET Curriculum

Students in the Baccalaureate program in CET at RIT have previously been required to take a 4-credit course in technical programming, and a 2-credit hour course in computer applications. In recent years, the technical programming course consisted of C++ programming taught by the electrical engineering technology faculty. The computer applications course consisted of 5 weeks of structural computer applications software (STAADPro) and 5 weeks of land development computer applications software (AutoCad). Alumni surveys have revealed that very few graduates use C++ or FORTRAN programming in their day-to-day work; most of them use civil engineering application software such as STAAD Pro and Auto Cad in addition to Microsoft application software. Student course evaluations have also consistently pointed to the need to provide more time to cover the materials for both the STAAD Pro and Land Desk sections of the computer applications course.

The CET curriculum committee reached a conclusion based on instructor input and student course evaluations that more time was needed to cover the materials in both the structural and civil applications sections of the existing computer applications course, and that this couldn't be achieved within the existing course structure. Since the technical programming course had become superfluous for the students in the CET program, it was decided to eliminate the technical programming course and the computer applications course resulting in 6 available credit hours. In order to maintain the same number of credit hours required for graduation, the available 6 credit hours were replaced with three new 2-credit hour required courses as follows: Land Development Computer Applications (0608-303), Structural Loads & Systems (0608-304), and Structural Computer Applications (0608-305). As a result, the requirements of the New York State Department of Educations and ABET were maintained while keeping the courses in the CET program current and abreast of emerging technologies.

Intended Learning Outcomes

The basic goal of the Structural Loads course is to give our students the necessary tools to calculate gravity and lateral loads acting on building structures and to introduce the concept of load path, gravity and lateral load resisting systems, in preparation for the structural analysis and design courses that the students will take later in the program. The Intended Learning Outcomes (ILOs) as listed in the course syllabus are as follows:

After completing this course, you will be able to:

1. Calculate dead, live, snow, wind and seismic loads acting on building structures and components using the NYS 2002, IBC 2000 and ASCE 7-02 Codes.

2. Calculate the distribution of lateral forces to lateral load-resisting systems in building structures

3. Select appropriate structural systems for resisting gravity and lateral loads in building structures

Course Materials

There are few available structured texts that treat the topic of structural loads in sufficient detail. The major reference used in the course is the ASCE 7-02 publication[13]. The one or two textbook available are not concise and contain a lot of extraneous information, and are therefore not very suitable for this 2–credit hour undergraduate course. As a result of the paucity of adequate texts for the course, the instructor developed a set of concise and succinct notes that is practice-oriented with many example problems from the instructor's current consulting experience. Each student in the course is given a bound set of the course notes. The instructor uses the transparencies of these notes in the lectures. Practice-oriented homework assignments from the instructor's consulting activities are assigned in this course.

Student Feedback

The feedback from students has been very positive as indicated by the very high ratings and comments from the course evaluations. The average rating for the course was 4.37 out of a maximum of 5.0. On the question of how much the students learned in the course, the average rating was 4.68; the course notes were given an average rating of 4.42. Here are some sample student comments from the course evaluations:

"Information is presented in more than one way with lots of opportunities to ask questions. Real world examples."
"His course notes are by far the most comprehensive and thorough."
"The examples were good, as was the fact that he really encouraged questions."
"Course is laid out very well especially this being the first time it was offered."
"Maybe more time [should be spent] on wind and seismic load and less on snow loading"
"Feel that objective on test cannot be achieved due to time constraints."
"This was a lot of work for a 2-credit course."
"Try to have homework assignments follow more closely to corresponding lectures."
"In the examples given in the course notes, the given information would be helpful it it were in the beginning of the problem."
"[Provide] a couple more examples using different style of buildings or criteria."
"More organization of relevant tables and charts [in the code handout]."
"Smaller groups for homework assignments (3 people)."
"Tests are too long for time allotted."

These student comments and suggestions will be taken into account during the next offering of the course in our effort to continuously improve the course.

Summary and Conclusions

In order to keep abreast of the changing building code regulations, with the recent adoption of the IBC 2000[2] in many jurisdictions in the United States, a new 2-credit hour required course in

Structural Loads and Systems was recently developed and offered in the CET program at RIT. This is in line with the ABET TC2K[1] Criterion b that states that graduates of CET programs should have, "an ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering and technology."

The first class of 22 students successfully completed the course during the fall quarter of 2003. Based on the grade distribution (10 A's, 5 B's, 6 C's and 5 D's) and feedback from the students, we can conclude that the course was successfully delivered via a combination of course notes, handouts, and online discussion forums. Based on the input from industry, it is our belief that offering this course to our students gives them the up-to-date tools for calculating structural loads, highlights the importance of adequate load paths in structures, and exposes them to gravity and lateral load resisting systems used in buildings. This knowledge and experience prepares them well for the latter analysis and design courses as well as meeting and exceeding the expectations of the companies that hire our graduates. The author hopes that this paper will be helpful to other CET programs interested in developing a stand-alone course in structural loads in order to keep their students abreast of this ever changing and expanding body of knowledge.

Bibliography

1. ABET Technology Accreditation Commission, Criteria for Accrediting Engineering Technology Programs, http://www.abet.org
2. International Building Code (IBC) 2000, International Conference of Building officials, Whittier, CA , 2000
3. http://www.engr.utk.edu/civil/courses/ce461.htm
4. http://www.cveg.uark.edu/faculty/SelvamPanneer/index.htm
5. http://www.eng.wisc.edu/cee/courses/cee340.html
6. http://www.spsu.edu/catalog/ugrad/courses/cet.html
7. http://www.structures.ucsd.edu/courses/se130b.shtml
8. http://www.civil-tamu.edu/ugrad/structures/undergraduatecourses.asp
9. http://www.dean.usma.edu/cme/courses/ce404+.htm
10. http://www.uhd.edu/academic/colleges/sciences/engineeringtech/sad/degreeplan.htm
11. http://et.nmsu.edu/program/catalogs/bscivil.htm
12. Bissey, Charles R and Wipplinger, Lisa A (1997) "Structural Analysis for Architectural Engineers", Proceedings of the American Society for Engineering Education Annual Conference and Exposition
13. ASCE (2002) "ASCE Standard: Minimum Design Loads for Buildings and other Structures", ASCE 7-02, American Society of Civil Engineers, New York.

ABI AGHAYERE

Abi Aghayere is associate professor of civil engineering technology at Rochester Institute of Technology and the Faculty Associate for Scholarship in CAST. He received a B.S. in Civil Engineering from the University of Lagos, a S.M. in Structural Engineering from MIT, and a Ph.D. in Structural Engineering from the University of Alberta. Dr. Aghayere has over 16 years consulting experience and he is a registered engineer in Ontario, Canada.

Appendix 1

Dear _____

As part of the preparation for the re-accreditation of our program, I'm trying to get some industry feedback on the Structural Loads & Systems course that I recently developed and taught for the first time this quarter. This is a 2-credit course (i.e. two 50-minute lectures per week for 10 weeks) in the Civil Engineering Technology program at RIT that is offered to 3rd year students just before they go out on their first co-op placement.

I have attached the course outline and the homework assignments for your review and comments. When you have some time, could you please give me some feedback? I'm interested in knowing your thoughts on the following:

1. Do you expect fresh graduate engineers to have a grasp of the topics covered in this course?

2. In your years of experience, what percentage (approximately) of fresh graduate engineers that you have worked with has had a grasp of these topics coming out of school?

3. Are there any other topics that you feel should be included in this course?

4. Are the homework assignments sufficient in number and rigorous enough?

5. Please provide any other comments or suggestions that you may have on how to improve this course

Sincerely,