AC 2011-590: A MODEL FOR THE POST-BACHELOR'S DEGREE EDUCATION OF STRUCTURAL ENGINEERS THROUGH A COLLABORATION BETWEEN INDUSTRY AND ACADEMIA

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A Model for the Post-Bachelor's Degree Education of Structural Engineers Through a Collaborative Effort Between Industry and Academia

Abstract

There has been much discussion in the engineering community on the challenges of suitably covering the ever-expanding engineering knowledge base within a four-year curriculum. This has in turn led to arguments for a requirement for additional post-Bachelor's degree coursework such as the M/30 (Master's Degree or equivalent) requirement proposed by the American Society of Civil Engineers. A comparable general concern exists in Canada that after four years of education, university graduates are not well-prepared with sufficient knowledge for working in structural design offices.

This paper presents a model developed in British Columbia, Canada, for preparing structural engineers for practice, especially in consulting firms, through a series of courses organized and offered through a collaborative effort between local practicing engineers and university faculty members. Courses are offered on a part-time studies basis, and are delivered by instructors drawn from local practicing engineers and nearby universities. Students taking the courses are a mixture of recent graduates, experienced practicing engineers, and recent immigrants looking to learn about local codes and practices. A certificate is awarded upon completion of sufficient core and optional courses. The model has been implemented in the development of twenty-five courses, delivered to over 2,100 course registrants over a ten year period.

The development and format of the program are described, along with some lessons learned by the organizing body in the process of operating and improving the program over its history. This model for post-Bachelor's degree education could also be applied to other sub-disciplines of Civil Engineering as well as other engineering disciplines in general.

Introduction

In this paper an alternative model to the traditional Master's degree education of structural engineers is examined. While the focus is on the Western Canadian context in which the model was developed and applied, the discussion is also framed by a brief comparison to U.S. structural and civil engineering educational needs. An initial discussion of the need for another means of structural engineering education beyond the traditional university bachelor's degree model examines both industry employer as well as individual employee educational needs. The model development process and resulting structure and organization are then described. Key outcomes of the program are presented, followed by a series of observations and lessons learnt.

Program Need

In Canada, as in the United States, undergraduate education in the field of structural engineering is usually offered as a subset of studies in a civil engineering program. A typical undergraduate engineering educational experience consists of four years of university culminating in the award of a Bachelor's degree. A survey of selected Canadian civil engineering programs conducted in 2008 showed that the percentage of core courses (specifically prescribed as part of the undergraduate curriculum) in terms of credit hours in these programs ranged from 74.0% to 89.8%[1]. Core courses make up 89.8% of the credit hour requirements at the University of British Columbia (UBC), which until 2010 was the only institution in British Columbia (B.C.) to offer an accredited program in Civil Engineering. There is therefore limited opportunity to take specialized and advanced optional technical structural engineering courses in the typical Canadian undergraduate civil engineering program and in B.C. specifically.

The practice of Professional Engineering in Canada is self-regulated by Provincial and Territorial associations. Each of the associations' Code of Ethics are modeled on those of Engineers Canada, which contains an expectation that engineers keep current on the latest advances in technology, materials, standards and practices, and only undertake work for which they are fully competent. Currently, minimum levels of acceptable professional development activity and reporting are required in six of the twelve jurisdictions[2,3]. In B.C., a new continuing professional development guideline is being developed after a September 2009 bylaw vote to make compliance with the previous guidelines mandatory fell 9% short of the two-thirds majority required for passage[4]. Presumably then it is just a matter of time before the current voluntary continuing professional development guidelines become mandatory. Practicing structural engineers are therefore in need of continuing professional development opportunities.

In addition, consistent with the area's multicultural population, a significant portion of the engineering workforce in the Metro Vancouver region consists of out-of-province and foreign-trained professionals. These engineers typically need to learn more about local practices and issues such as seismic design, since Western B.C. is a seismically active area.

As a result of the above reasons, there continues to be a desire on the part of practitioners to improve their structural engineering skills. In addition to this demand from potential 'students', there has been a demand from industry employers for employee training, as many firms have limited resources to provide training for new hires. For many years, employers have expressed concern that University graduates were not adequately prepared with sufficient practical knowledge for working in structural design offices[5].

A similar demand by both employees and employers for additional educational opportunities likely also exists in the United States. Sparling[1] noted that it appears that the Canadian Civil Engineering programs considered in his survey all provide significantly more content than their American counterparts. To address concerns over

the academic preparation of civil engineers in the United States, the American Society of Civil Engineers (ASCE) has adopted Policy Statement 465, which among other reforms endorses mandatory post-Bachelor's degree education in the form of a Master's degree or approximately 30 coordinated graduate or upper level undergraduate credits as one prerequisite to licensure (in addition to more focused pre-licensure experience and a more comprehensive licensure examination) for the professional practice of Civil Engineering[6]. There are currently no plans to move to a Master's degree or equivalent requirement for potential licensees in Canada, although Engineers Canada is reviewing the situation since this seems to be a worldwide movement[7]. For sake of comparison to American licensure requirements, licensure as a Professional Engineer (P.Eng.) in B.C. (which is generally similar to other Canadian Provinces and Territories) requires the following: 1. A Bachelor's Degree in Engineering from an accredited Canadian University program; 2. Citizenship Citizenship/Permanent Resident Status, English language proficiency, and suitable character; 3. A minimum of four years of satisfactory engineering experience; 4. Completion of a Law and Ethics seminar; and 5. Completion of the Professional Practice Examination.

Program Development

Recognizing the demand for post-Bachelor's professional development opportunities by practicing structural engineers and employers, a model for a program of courses on practical skills and knowledge was initially developed in the late 1990s in Vancouver and started in the fall of 2000 . The organizing committee consisted of both industry practitioners and representatives of local universities. The Department of Civil Engineering at UBC was a co-sponsor of the program and contributed significantly to its development.

This program – named the SEABC/UBC Certificate in Structural Engineering (CSE) Program – differs significantly from the common/typical type of courses offered by North American universities. Table 1 below summarizes some of the key aspects of the program and compares them to those commonly found in university settings. Further discussion of certain aspects is presented below. The CSE program seems to be unique, as the authors are not aware of any other comparable programs in existence.

The CSE Program is delivered in a part-time studies format, usually with four courses offered per four month term. The full suite of courses that have been developed is listed below in Table 2. Students must complete a total of twelve courses (including a minimum of six 'core' courses) in order to receive a Certificate in Structural Engineering. All of the courses were developed with the goal of providing a healthy mix of reinforcing the engineering principles learned in undergraduate studies along with teaching practical approaches to problem solving. Due to the uniqueness of the courses no opportunity is currently provided for students to obtain prior course credit from other institutions.

Table 1: Comparison Between CSE Program and Common University Courses*

Item	University Courses*	CSE Courses
Lecturer	University Faculty Member	Mixture of University Faculty Members, Industry Practitioners
Number of Lecturers per Course	One (typically). Some courses may involve several lecturers	Varies: team teaching commonly used
Class Timing & Frequency	Daytime; 2 or 3 one-hour lectures per week	Evenings; 1 two-hour lecture per week
Availability of Webcasting	Not common	Yes
Course Location	University Campus	Downtown Core Location
Typical Student	Full-time student	Upgrading professional
Evaluation	Homework assignments, exams, projects, other	Homework assignments, exams, other
Course Duration	Varies: often 4 months in duration: 36 lectures	Usually 4 months in duration: 12 lectures
Course Funding	Student tuition plus government contribution	Student tuition only (non-profit)

* - University Course formats can vary greatly, but the most commonly occurring formats are listed here for sake of comparison and contrast to the CSE program.

All of the courses require significant effort on the behalf of the student in terms of assignments and exams, and a course grade of 68% is required to earn course credit.

An option of taking the courses via webcast delivery was added in 2005. Webcast registrants watch lectures live over the internet, can participate actively during the lecture, and must complete the same assignments and exams as in-class students.

Table 2: Certificate Program Course Listing.

Course #	Course Title
Core Courses	
C1	Analytical Methods in Structural Engineering
C2	Effective Structural Modeling
C3	Topics in Practical Structural Design
C4	Earthquake Engineering and Seismicity
C5	Conceptual Structural Design
C6	Dynamic Analysis of Structural Systems
C7**	Analysis and Design of Buildings with Hybrid Systems
C8	Geotechnical Aspects of Foundation Design
C9*	Computer Structural Analysis
C10*	Design of Earth-Supported Structures

Table 2: Certificate Program Course Listing – Cont'd

Course #	Course Title
Elective Courses**	
E1	Masonry Design of Buildings
E2	Timber Design of Light Residential and Commercial Buildings
E3	Reinforced Concrete Design 1
E4	Structural Steel Design for Buildings
E5	Seismic Aspects of Reinforced Concrete Design
E7	Seismic Strengthening of Existing Structures
E9	Design of Tilt-up Concrete Buildings
E10*	Structural Analysis Fundamentals: A Refresher
E11*	National Building Code (NBC) Part 4 – Structural Design
E12*	Seismic Design of Steel Structures
E13*	Computer Software Applications in Structural Engineering
E14*	Design of Prestressed and Post-tensioned Concrete Structures
E15*	Applications of Dynamic Analysis for Seismic Design of Structures
E16*	Introduction to Cables and Cable Systems
E17*	Time Histories and Response Spectra – Fundamentals and Practical Uses of Discrete Ground Motion Data

* - Courses added after the initial program development.
** - C7 has been developed but not yet been offered. E6 and E8 were removed from the program prior to offering.

Results

The program started course offerings in the fall of 2000. Courses were initially offered in three terms commencing in January, April, and September, but the April term was discontinued in 2003. The main reason for this reduction was due to limited availability of suitable instructors at the time and to allow the program coordinators more time to plan and organize upcoming courses. Annual student registration levels are graphically displayed in Fig. 1, and provide a breakdown between the individual terms. As of December 2010, there had been 2,113 course registrants in 34 core course offerings and 46 elective course offerings. A total of 746 people have registered in the program, including 86 people who have registered in webcast courses. To date, four people have completed all of the requirements and received a Certificate in Structural Engineering.

Consistent with the reasoning described previously for the demand for such a program of structural engineering courses, student enrolment has consisted of a mixture of professionals looking to advance in their careers, those unemployed and looking to strengthen their abilities and resume, and immigrants wanting to learn how to integrate into the structural engineering profession in Canada.

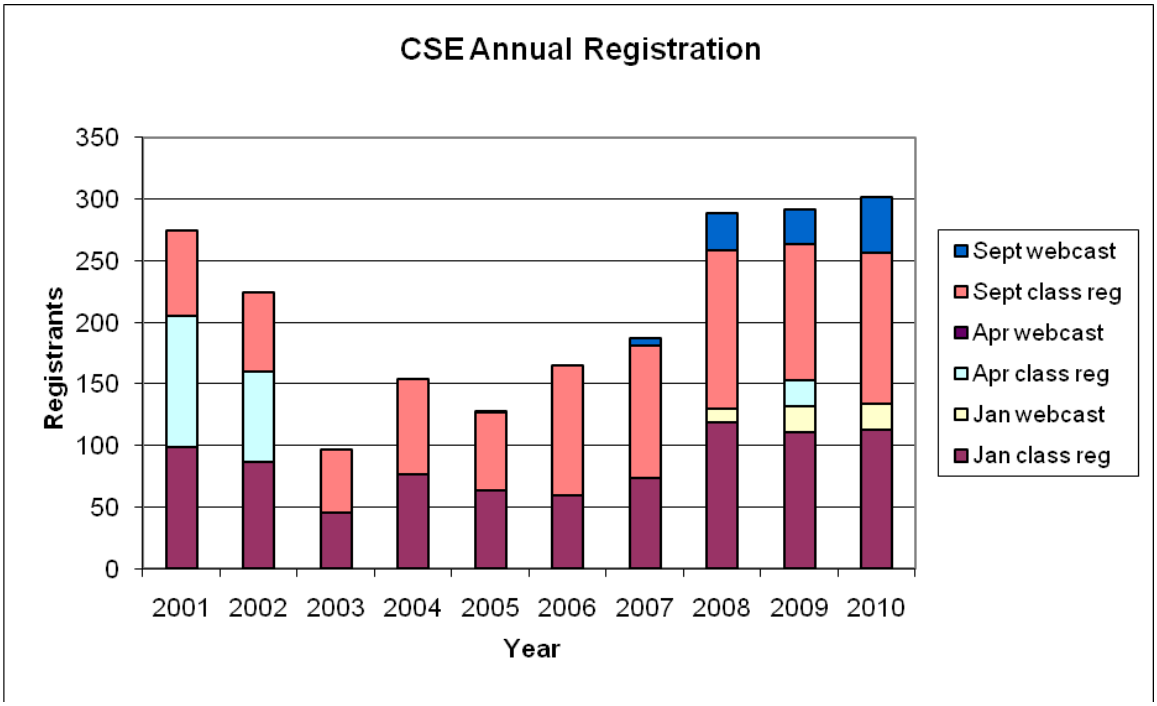

Fig. 1: CSE Program Annual Registration Levels

Table 3 below illustrates the extensive involvement of industry professionals in both the coordination as well as the delivery of core and elective courses. 58% of the courses were delivered in a team-teaching format, in which two or more lecturers were involved in delivering the course material (Table 4). However, each course was assigned only one course coordinator, who was ultimately responsible for the course operation. A handbook was developed to clarify coordinator and instructor expectations.

Table 3: University Faculty vs. Industry Practitioner Involvement in Course Delivery

Course Type	**Course Coordinators**		**Lecturers**	
	University Faculty	Industry Practitioners	University Faculty	Industry Practitioners
Core Courses (C1 – C10)	33%	67%	17%	83%
Elective Courses (E1-E16)	29%	71%	28%	72%
TOTAL	**31%**	**69%**	**24%**	**76%**

Table 4: Number of Instructors Per Course

Instructors Per Course	Frequency	Percentage
1	10	42%
2-3	7	29%
4 or more	7	29%

Course evaluations are conducted at the conclusion of each course, using a standard evaluation form that has been developed by the organizing committee. The majority of the questions relate to the individual instructor delivery and course material. Two questions, however, relate to the program as a whole: students are asked 1.whether there is a need for this program in industry, and 2. whether the courses are useful in the industry. Response to these two questions has been uniformly affirmative, and the author could not find a single instance of disagreement after reviewing all of the hundreds of evaluation forms that were available. While caution should be made in extrapolating these results to the structural engineering profession as a whole due to the sampling of only students who have taken the CSE courses, when combined with the significant numbers of course registrants it is safe to say that at a minimum there is a significant amount of support for the program within the local structural engineering community.

Observations and Recommendations

While it has been possible to come to certain conclusions using the hard data presented above, the authors feel that it is also valuable to provide their own views and opinions on certain other aspects of the program for consideration by any other group that is considering implementing any variation of the program described in this paper.

From the beginning the program has involved a rare combination of industry and academia as committee members. The initial idea of this program was developed at UBC and presented to the structural engineering community of BC in 1998. The structural engineering community reacted positively to this idea and started working immediately with UBC in the development and implementation of the program. To date nine separate faculty members have been involved in teaching all or part of the courses. Two other faculty members from the nearby British Columbia Institute of Technology (BCIT) have also contributed as organizing committee members, course coordinators, and lecturers. The involvement of local structural engineering faculty, combined with the extensive involvement of industry practitioners described above has provided legitimacy, recognition and acceptance of the courses by local structural engineers and structural engineering firms. The Association of Professional Engineers and Geoscientists of British Columbia has referred foreign-trained engineers to the program for upgrading, especially in the area of seismic design. In addition, the University of British Columbia is currently investigating incorporating courses from the CSE Program into a Professional

Master's degree program in Structural Engineering at the University[9]. This program is scheduled to commence in the fall of 2012.

To date, four students have completed the course requirements to receive a Certificate in Civil Engineering. In comparison, over 740 students have taken courses in the ten year history of the program, averaging 2.8 courses per person. It does seem, therefore, that the majority of students are taking individual courses rather than pursuing award of the full Certificate.

The organizing committee has stayed relatively constant in size at between four to seven members, and one administrative assistant is hired on a part-time basis. Over half of the committee has been involved since the program inception. Formal committee meetings are held only three or four times per year, with much of the necessary debates and discussions between committee members conducted in an ad-hoc manner via e-mail or over the phone. The committee's small size and member continuity have allowed for a flexibility and efficiency in developing, evolving and improving the program.

Based on feedback to the Organizing Committee, it is apparent that many Instructors involved in the program participate more out of a sense of responsibility and enjoyment than for monetary gain. A number of new courses have been added to the program since its original development at the suggestion of instructors keen to share their knowledge. However, recruiting instructors is probably the program's biggest challenge, largely due to the time commitment required. The use of team-teaching has reduced the time commitment onus on individuals, and the process of only offering four courses per term allows for a cycling of courses such that instructors are able to have some time off between course offerings if they wish. The introduction of webcast delivery of the courses has increased access beyond the Vancouver lower mainland area. Students have registered from seven Provinces or Territories outside of British Columbia as well as the United Kingdom, New Zealand, Qatar, and Nigeria. Webcasting was originally started with a single student in one course but has grown to the point where the majority of courses are offered both in-class and via webcasting. The ability to reach beyond the classroom to remote locations has been a positive outcome but has required significant effort on behalf of the organizing committee to address quality, equipment, and logistical issues, and significant effort by instructors who must adjust their teaching methods to suit webcasting.

Conclusions

The proposed model addresses an observed need on the behalf of both individual engineers and employers for continuing education beyond the Bachelor's degree level. The model differs from the traditional university master's degree course offering in the degree of partnership between industry practitioners and university faculty, as well as its emphasis on preparing students for engineering practice. It has been successfully implemented in the delivery of structural engineering courses over a ten year period. While the emphasis in this paper has been on continuing education of structural

engineers, the model could also be applied to other sub-disciplines of civil engineering and other engineering disciplines in general. In addition, while the program was developed within a Canadian context (in which there are currently no plans to move to a Master's degree or equivalent for licensure), the authors believe that with only minor modification the courses could be used to satisfy the equivalent requirement of 30 coordinated graduate or upper level undergraduate credits contained in ASCE Policy Statement 465.

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