Missouri University of Science and Technology

Scholars' Mine

International Specialty Conference on Cold-Formed Steel Structures

(2004) - 17th International Specialty Conference on Cold-Formed Steel Structures

Oct 26th, 12:00 AM

Report on the Development of a Cold-formed Steel Design Course At Kansas State University

V. J. Kircher

Sutton F. Stephens

Follow this and additional works at: https://scholarsmine.mst.edu/isccss

Part of the Structural Engineering Commons

Recommended Citation

Kircher, V. J. and Stephens, Sutton F., "Report on the Development of a Cold-formed Steel Design Course At Kansas State University" (2006). *International Specialty Conference on Cold-Formed Steel Structures*. 3.
https://scholarsmine.mst.edu/isccss/17iccfss/17iccfss-session6/3

This Article - Conference proceedings is brought to you for free and open access by Scholars' Mine. It has been accepted for inclusion in International Specialty Conference on Cold-Formed Steel Structures by an authorized administrator of Scholars' Mine. This work is protected by U. S. Copyright Law. Unauthorized use including reproduction for redistribution requires the permission of the copyright holder. For more information, please contact scholarsmine@mst.edu.

Seventeenth International Specialty Conference on Cold-Formed Steel Structures
Orlando, Florida, U.S.A, November 4-5, 2004

Report On The Development Of A Cold-Formed Steel Design Course At Kansas State University

V. J. Kircher[1] and S. F. Stephens[2]

Abstract

Construction using cold-formed steel as the main framing system or partial framing systems continues to increase in the United State and abroad. As more and more structures are designed using cold-formed steel, it would naturally be assumed that opportunities for higher education in cold-formed steel design would be in demand. This paper presents documentation on the development and implementation of a two credit hour course in the design of cold-formed steel members in the Department of Architectural Engineering and Construction Science at Kansas State University. A description of the course goals, content and how the course was developed are addressed. An informal survey of structural engineers practicing mainly in the Kansas and Missouri area on the need for a university level design course for engineering students planning to graduate with an emphasis in structural engineering was conducted and results are presented. An assessment of the course by those students who took it is also included. Based on these results, recommendations for the continued development of the course are proposed.

1.0 Introduction

The Architectural Engineering and Construction Science (ARE/CNS) Department at Kansas State University (KSU) endeavors to include up-to-date information regarding current industry p[1]ractices and codes in its courses and curriculum. In a recent review of the structural courses offered in the department, a deficiency was identified. The required steel design courses, ARE 524: Theory of Structures II for architectural engineers and CNS 524: Steel Construction for construction science majors, currently taught in the department mainly cover the design and construction methods for hot rolled steel shapes.

[1] Engineer in Training, Page McNaghten Associates, Fairway, Kansas
[2] Assistant Professor, Department of Architectural Engineering and Construction Science, Kansas State University, Manhattan, Kansas

Instruction in the design of cold-formed steel (CFS) shapes is limited to floor and roof deck. Another course taught in the ARE/CNS department; CNS 644: Pre-Engineered Metal Building Industry covers in depth the construction methods of pre-engineered metal buildings. However, CNS 644 does not cover the design, behavior or construction of individual CFS members. Since CFS construction makes up forty-five percent of steel construction in the United States, students interested in structural building design would benefit from a course in CFS design and construction (AISI website).

This report examines the current curriculum and education options for CFS design instruction for engineering students and practicing engineers and explores the need for a CFS course in the ARE/CNS department through review of current trends in CFS construction. Information gathered from professional structural engineers shows that students graduating from an engineering curriculum with an emphasis in structures would benefit from knowledge of cold-formed steel design and construction.

Information for this study consists of online articles and research reports data compiled from the AISI Specification, manufactures' websites and literature, industry literature and journal articles. Current practices and needs within industry were accumulated through a survey of practicing professionals in both design and construction fields.

2.0 Current Educational Options

Three methods currently exist for engineers and contractors to learn about CFS design and construction: college courses, short seminars, or self-teaching on the job. While researching for this paper, four universities in the U.S. with on-going research in CFS design were identified. The Civil Engineering program at the University of Missouri-Rolla (UMR), with the Center for Cold Formed Steel Structures and the civil engineering programs at Cornell University, Johns Hopkins University (JHU), Santa Clara University (SCU) and the Virginia Polytechnic Institute are also involved in CFS research and testing. Of these five schools, only UMR and SCU list CFS courses in their line schedule or course catalog.

Although a course in just CFS structures is not offered at JHU, assistant professor Dr. Ben Schafer does include some CFS design in an undergraduate steel course and several weeks of thin-walled theory in a graduate structural stability course.

The second method for engineers and contractors to learn about CFS design and construction is short courses and seminars offered at various locations throughout the year. Short courses are historically one to three day seminars and recently have been designed as webcasts. Most seminars on CFS design are conducted by the Center for Cold Formed Steel Structures (CCFSS) at UMR in conjunction with the American Iron and Steel Institute (AISI) or are sponsored by the Light Gauge Steel Engineers Association (LGSEA). The UMR website lists one short course for 2003 and the LGSEA website lists four at various locations throughout the U.S. According to their website, the UMR short course content "deals with the fundamentals of cold-formed steel design and is intended to provide engineers and others with a better understanding of the basic principles used in the current design methods." The course objectives list both member and connection design. The course topics offered by LGSEA for 2003 include CFS shear wall and truss design, as well as, two courses on load bearing wall design.

Self-taught design and on-site observations are the way many engineers and contractors learn about CFS, as shown by the survey results. Yet another method of education that may be available but was not researched for this study is continuing education courses at universities.

3.0 Industry Need for Course

Courses in CFS design are not offered in many engineering curriculums and most schools that do offer such courses offer them as graduate level courses only. Based on their observations and professional structural design experience, the faculty of the Architectural Engineering and Construction Science Department at Kansas State believe that a CFS course should be offered to students. To determine if CFS construction is prevalent enough in the building industry to justify a CFS course, a survey of professionals in the industry was conducted. Surveys were distributed to contractors and professional engineers to help determine if a course in CFS design and construction would be useful to students graduating from the ARE/CNS curriculum. Since the bulk of students graduating from the ARE/CNS Department take jobs in Kansas and Missouri, the surveys were distributed to individuals and companies within these states. The surveys were distributed with the aid of professors in the ARE/CNS

Department and the Structural Engineering Association of Kansas and Missouri (SEAKM).

Twenty-eight engineers returned the Engineers' Questionnaire. The surveys were completed by engineers with as many as thirty years and as few as one year of experience in industry. The following graphs and information reflect the survey findings.

Of the engineers surveyed, only 32 percent have received any formal education in CFS design, as detailed in Figure 1. For the purposes of this study, formal education is defined as a college course or a short course or seminar. The engineers described the short courses taken as 1 to 2 day seminars in various cities presented by the University of Missouri-Rolla's Center for Cold-Formed Steel Structures or the Steel Network. Other short courses were described as "brown-bag" lunch presentation given in-office by manufacturers' representatives. All of the engineers who replied that they had taken a college course indicated that the course was CE 426: Advanced Design in Steel and Lightweight Structures taught at the University of Missouri-Rolla. Several of the engineers who responded to the survey indicated a desire for CFS short courses in their area. Figures 2 and 3 show statistics on the number of engineers who have taken short courses or college courses in CFS design.

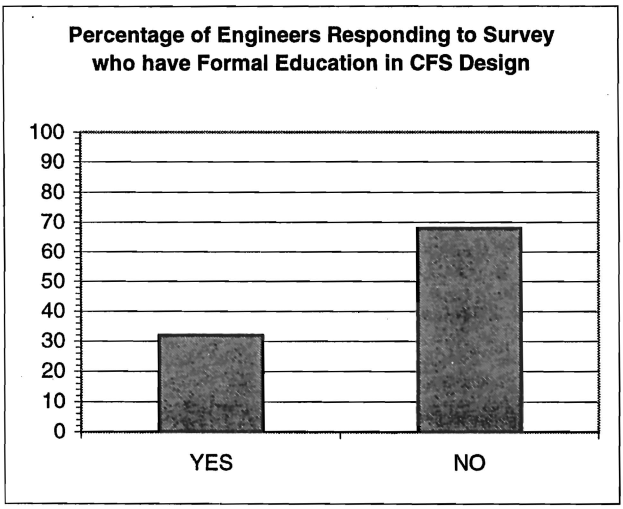

Figure 1: 32.1 percent of the engineers who responded to the survey have had formal education, either a college or short course, in CFS design.

Although only 32 percent of the completed surveys indicated any formal education in CFS design, only fifty percent of the total respondents indicated that they believe they need further education in CFS design. Five of the engineers who refuted the need for further education in CFS design had already received formal education. One of the remaining respondents indicated that he/she "would not design a CFS building because he/she "was not aware of a demand for CFS buildings." The percentage of engineers who believe that they could benefit from further CFS education is detailed in Figure 4. Another Engineer indicated that he/she could design CFS components, but not an entire structure. This engineer also stated that, "I would not personally seek to learn more because my firm does not need more

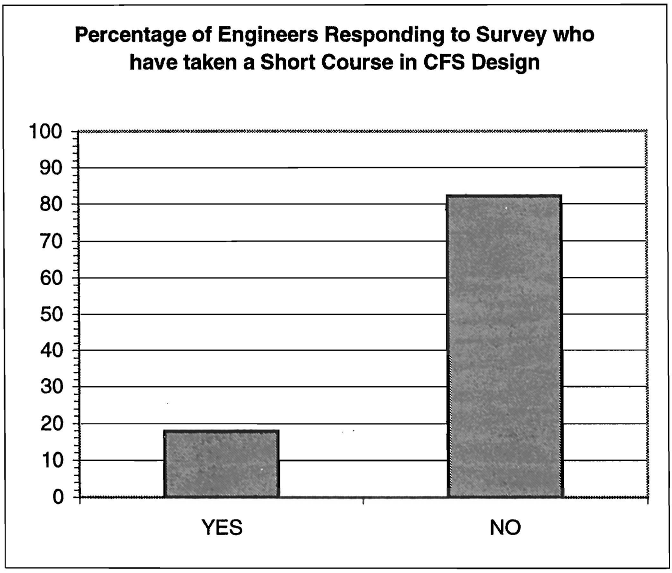

Figure 2: 17.9 percent of the engineers who responded to the survey have taken a short course or seminar in CFS design.

capability." Yet another engineer replied that he/she is comfortable with CFS design having "taught myself CFS design." Several of the engineers who indicated that further education would benefit them listed connections and construction methods as areas they would like to focus on. Others listed learning about the updated code as an area of interest. Still another engineer listed details and bearing wall systems as topics he/she could benefit from learning.

Another question on the survey asked if engineers believed that students or new graduates would benefit from a course in CFS design. Of the respondents, 89 percent believe that a CFS course would be beneficial to students, 7 percent did not believe that such a course would aid students and one claimed to not have enough prior information about CFS design to respond. One engineer who deemed a CFS course to be helpful to recent graduates wrote, "If they ever intend to design or specify it [CFS] as the Engineer of Record, then it would be required that they fully understand its strengths and weaknesses." Another engineer wrote, "I believe that new/recent graduates should know CFS design, and not just be able to pick a stud out of a chart."

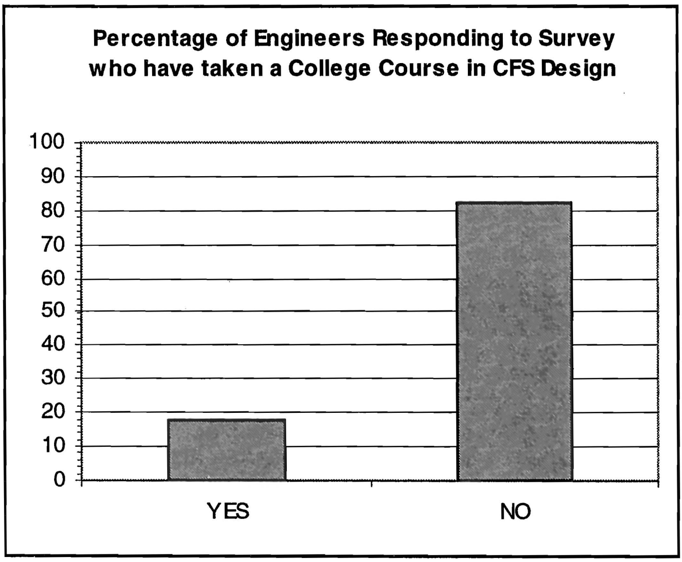

Figure 3: 17.9 percent of the engineers who responded to the survey have taken a college course in CFS design

Another reason practicing engineers believe that knowledge of CFS design will aid students and new graduates, is that many engineers have noticed an increase in CFS construction. Fifty-seven percent of the survey's respondents reported noticing an increase in the amount of CFS design and construction in their practice. Twenty-five percent of the respondents did not notice an increase in the amount of CFS design they performed while eighteen percent did not have enough knowledge of CFS to make an observation either way.

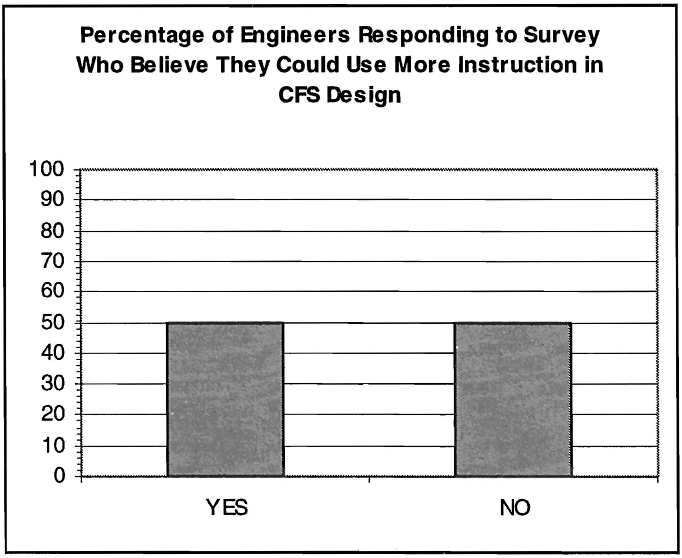

Figure 4: Fifty percent of the engineers who responded to the survey believe that they could use more instruction in designing CFS components or buildings.

The basic trend of the information contained in the returned engineers' surveys indicates that a CFS course would aid students in a structural engineering curriculum.

Unfortunately, only three contractors completed and returned the Contactors' Survey, prior to the writing of this report. Although these three respondents do not provide a wide enough pool of information from which to draw conclusions, the trends of these three surveys are briefly overviewed here. None of the contractors reported any formal training in CFS construction or design. Instead, they reported learning about CFS construction on the job. Two of the surveys noted that the architect or engineer of record generally provided performance specifications for the contractor to follow in designing the CFS members, while the third observed that the contractor is responsible for CFS members. Only one of the three surveys reported noticing an increase in CFS construction, the survey observed that CFS construction seemed to begin increasing about 12 years ago. Both of the other surveys noted that CFS members have been used in almost every commercial building that the contractor has worked on but they have not noticed an increase in CFS construction. All three surveys reported that CFS members are a good building material to work with in the field. Each survey also reported that knowledge of CFS would be beneficial to recent graduates, with one contractor writing, "it would be better to have a course in CFS than wood structures if the student is going into commercial construction." The consensus of the surveys returned by contractors indicates that a course in cold-formed steel would aid students after graduation.

4.0 Course Goals

Based on their belief that knowledge of CFS design and construction would benefit students graduating from an engineering or a building sciences curriculum, the faculty of the Architectural Engineering and Construction Science Department designed a 2 credit hour course that was taught during the August 2003 intersession. The course can be taken for 2 hours of graduate or undergraduate credit. The description of the class listed in the course catalog reads:

> This course will cover the behavior and design of cold-formed steel structural members, connections and systems. Design will include framing members for walls, floors and roofs. AISI Standards for Cold-Formed Steel Framing, manufactures' literature and design guides and freely available analysis and design software will be utilized.

The comprehensive goal of the course was "to have the content be theory based but with practical information for design engineers." As shown in the previous section, many design engineers learn CFS design methods at short courses and seminars or by simply reading and teaching themselves. An ojective of this course was to give students entering the work force the tools to be confident designing with CFS and the background knowledge to learn more about the theory and design of CFS structures. Upon completion of the CFS course, students would have a basic understanding of the theory behind the behavior of CFS members and design and be able to use the design equations and tables from the AISI Standard (2001a, 2001b, 2001c) and AISI Specification, as well as, tables from manufacturers' literature (North, 2001).

Another objective for the CFS course was to introduce students to some of the construction aspects of CFS design. Reviewing how a building is put together, the tools needed to construct a CFS structure, problems that can be encountered with CFS construction, and the advantages and limitations of CFS construction encompass the topics relating to the construction of CFS were included in the course.

5.0 Development of Course Content

The structure of the course, ARE 720: Cold Formed Steel Design was developed around the AISI Specification (North, 2001) and the *International Building Code 2000* (IBC 2000). The sections of the course followed the subjects of the chapters of the AISI Specification with the exception of the final three sections of the course.

The truss section of the course was developed from the AISI *Standard for Cold-Formed Steel Framing – Truss Design* (AISI *2001b)* and from the Alpine TrusSteel literature. Information from these sources was used to teach the requirements for designing trusses, how to specify trusses and to provide examples of typical truss details. The *International Building Code 2000* (IBC 2000) was used to develop the shear wall design portion of the course. The 2000 IBC references the AISI Specification for all CFS design except shear walls, which are covered in IBC section 2211. The material on construction mainly came from the Prescriptive Method for Residential Cold-Formed Steel Framing (2000).

The Clark Steel Framing Systems manual and website were used as a resource to find the appropriate studs, joists and other sections used in design examples and homework. A number of photographs of a CFS building under construction supplemented the technical information in the course. These photographs were taken at St. Joseph's Senior Center in Manhattan, Kansas by the permission of the Law Company.

Microsoft PowerPoint slides were used to present the notes for this course. The notes were presented in this manner to show tables and figures that describe CFS and to easily display photographs of a CFS building. Examples problems were presented using both slides and the more traditional use of the chalkboard. Homework was assigned regularly in the form of design exercises. The take-home final exam was also in the form of design exercises.

6.0 Course Assessment

Upon completion of the first session of ARE 720: Topics in Architectural Engineering: Cold-Formed Steel Design, the course was reviewed by both students and faculty. An appraisal was done to determine if the course goals were met, if the course should continue to be offered, and if it met student and faculty expectations. The students evaluated the course by completing a survey after the course was completed. The faculty assessment of the course was determined in interviews with those instructors who aided in the development of the course.

6.1 Student Assessment

The students enrolled in the first offering of the CFS course were given a survey to fill out and return after completing their final examination.

Eleven students completed the ARE 720 course offered during the August 2003 Intersession. All of the students had completed at least three years of the Architectural Engineering or Construction Science Program and five were enrolled in the class for graduate credit. Nine of the students are architectural engineering majors and 2 are construction science majors. Eight of the eleven students had already completed an introductory course in hot rolled steel design. Eight of the 11 students completed and returned the student surveys.

Eighty-seven percent of the students responded that the course met or exceeded their expectations. One student who indicated the course exceeded his/her expectations explained by citing that "both theoretical and practical aspects of CFS design" were taught in the course.

Although most of the students' comments were positive, they did have some suggestions to improve the course. A recommendation made by several students was to work all examples on the board as opposed to having the solutions already presented in the Microsoft Power Point presentations. The students believed that this would help to keep them more involved and actively learning during the lectures. One student suggested more hands on experience. Bringing in more examples of CFS members could do this or, if possible, by taking the students to a job site of a building that is using cold-formed steel members.

6.2 Faculty Assessment

Faculty assessment of the course was that the students enrolled in the course left with a basic knowledge of cold-formed steel and its assets and drawbacks as a building material. They also had a grasp of how to design CFS members and structures using the AISI Specification (North 2001) and the International Building Code 2000 (IBC 2000).

Although the faculty of the Architectural Engineering and Construction Science Department assessed the first session of the CFS course as a success, they believe improvements could be made. The first change that should help to improve the course will be to require all students to have completed an introductory steels course, either ARE 524 or CNS 524, thus increasing the scope of material that can be covered during the course. Because three engineering students in the initial course had not yet taken a course in steel design, it was necessary to spend time discussing some basic principals such as k-values for compression members and slenderness in greater detail than just as a review.

By eliminating the need to review basic principals such as these, more time can be spent discussing the theory behind CFS design. One area that Stephens would like the students to explore further is effective section properties. Specifically, he would have the students work exercises to find the effective section properties and then relate the section properties to how buckling behavior applies to flexural and compression members. In future courses Stephens would also like to expand the material covered on shear wall design. Time allowed students to cover only two examples in class and no time to look at an example of an entire building and follow the load paths for wind and seismic forces. Following the load path through the building would allow students to gain a greater understanding of how shear walls and diaphragms function.

9.0 Conclusions

A limited number of options currently exist for cold-formed steel education. Very few of these include college courses. As CFS construction becomes more prevalent, engineers are finding themselves designing more and more CFS members and buildings, usually with no formal education to guide them in their design process. Many engineers currently practicing structural design believe that knowing the basics of CFS design will aid students when they graduate and join the work force.

To give students an introduction to CFS design, a CFS course was designed to be taught during intersessions. The first offering of the course followed the format of the AISI Specification. Also included in the course content was information on CFS trusses, shear walls, and construction considerations. The course used the AISI Specification, as well as, current industry literature and other codes to teach the basics of CFS design.

The assessments of the first course showed that while most of the students felt they gained knowledge that would aid them in both their academic and future careers, some changes to the course structure should be made for future offerings of the course. These changes include adding a prerequisite of either ARE 524 or CNS 524. Another change that should be implemented for future classes is creating a more interactive learning environment in the classroom. While most students found the photographs and charts displayed by the Microsoft PowerPoint slides helpful, the also found it more difficult to concentrate when they were not taking notes.

BIBLIOGRAPHY

AISI Standards, Standard for Cold-Formed Steel Framing – General Provisions American Iron and Steel Institute. June 2001.

AISI Standards, Standard for Cold-Formed Steel Framing – Header Design. American Iron and Steel Institute. June 2001.

AISI Standards, Standard for Cold-Formed Steel Framing -- Truss Design. American Iron and Steel Institute. June 2001.

American Iron and Steel Institute (2001a), *Standard for Cold-Formed Steel Framing – General Provision*, Washington, D.C.

American Iron and Steel Institute (2001b), *Standard for Cold-Formed Steel Framing – Truss Design*, D.C.

American Iron and Steel Institute (2001c), *Standard for Cold-Formed Steel Framing – Header Design*, Washington, D.C.

International Building Code 2000. International Code Council. March 2000.

North American Specification for the Design of Cold-Formed SteelStructural Members, 2001, American Iron and Steel Institute, Washington, D.C.

Prescriptive Method for Residential Cold-Formed Steel Framing (2000), North American Steel Framing Alliance, Washington, D.C.