Utilization of the AISC Steel Sculpture for an Introductory Construction Plan Reading Course

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This paper explains how the American Institute of Steel Construction (AISC) Steel Sculpture can be used to enhance construction education. There are over 135 AISC Steel sculptures located on college campuses across the country, however, the educational material available to date has been primarily focused on advanced structural steel design. This paper provides one example of how the steel sculpture may be incorporated into other areas of a construction curriculum, in this case in an introductory construction plan reading course. The sculpture may be used to illustrate concepts discussed in a lecture on steel drawings and steel construction, and the sculpture may also be used in a laboratory session to provide students with a "hands on" appreciation of steel construction, with concepts illustrated in three-dimensions. Instructor assessment of the utility of the steel sculpture to illustrate construction concepts was positive, as was feedback from students who participated in the laboratory exercise. This paper is of general interest to construction educators that teach in undergraduate programs.

Key Words: Steel connections, laboratory learning, undergraduate education, steel sculpture.

Introduction

Structural steel members and structural steel connections are an important component of many large construction projects. Recognizing the importance of students having a first hand appreciation for these construction components, in 1986 Prof. Duane Ellifritt designed a steel sculpture to illustrate most of the steel connections commonly used in construction

Ellifritt developed the concept for the sculpture when he realized that it would be effective to teach students about connections using an actual physical representation. Ellifritt's sculpture allows students to see steel members and steel construction first hand and up close, and learn about steel connections in three-dimensions (Modern Steel, 1999). In Ellifrit's own words, "My eventual solution was to create a steel sculpture that would be an attractive addition to the public art already existing on campus, something that would symbolize engineering in general, and that could also function as a teaching aid." (Modern Steel, 1999)

The American Institute of Steel Construction, Inc. (AISC) recognized the value of Ellifritt's sculpture for educational purposes, and distributes the plans to businesses that are interested in donating a sculpture for educational purposes (AISC, 2008). More than twenty years after Ellifritt's first sculpture was installed, there are now over 135 sculptures at schools across the country (AISC, 2008). A photo of an AISC steel sculpture is shown in Figure 1.

The AISC steel sculpture was originally built to serve as a learning tool for civil engineers who design steel structures and their connections. In fact, AISC has developed a complete text toward this end. "Connections Teaching Toolkit, A Teaching Guide for Structural Steel Connections," (Green, 2008) provides a detailed program for study, targeted toward structural design. This toolkit provides a wealth of technical detail and supporting drawings, and while certainly many lectures have utilized this information, there has been little documentation of lectures and laboratories in the literature. A review of literature identified only one example of a lab developed that uses the AISC steel sculpture. This lab, which is oriented toward steel connection design concepts, was developed for a senior level civil structural course on connections (Liu, 2008). The design concepts illustrated in this lab focus on technical design categories, rather than the physical structural elements commonly referred to in construction.

Construction education typically focuses on physical elements and hands on activities. The students in the introductory plan reading class have all had a computer based drafting class, and are familiar with two-dimensional renderings. In fact, many construction programs utilize sophisticated computer programs for construction plans and details. Construction students often have worked extensively with these computer programs, and may even be familiar with advanced technologies such as computer vision technology applications (Slattery, 2006). Furthermore, computers may also be utilized for computer aided take-offs for structural steel estimating (Bunea, 1991). However, no amount of computer modeling is a substitute for a three-dimensional rendition of actual construction components. Recognizing the value of learning in three-dimensions, many construction programs currently utilize full-scale laboratories for construction education. Students often have a "hands on" appreciation for framing, and thus a more intuitive sense for potential construction issues. This paper outlines how the steel sculpture can be used to provide an analogous "hands on" appreciation for steel beams and connections.

Objective

This paper presents one method in which the AISC sculpture can be used in a construction program, based on a lecture and laboratory conducted in a sophomore level plan reading class. The exercise was deemed a success, based on student feedback and based on instructor assessment of students meeting learning objectives. The laboratory was also considered successful because it gave the students a three-dimensional learning tool that familiarized them with steel members and connections that they will see in the future on actual construction projects. Additional details about the utilization of the AISC steel sculpture are provided in the following section.

Sample Exercise Utilizing AISC Steel Sculpture

The AISC steel sculpture was introduced as a teaching aid in a basic plan reading class. The teaching strategies included a lecture component which laid the foundation for a laboratory component. The lecture introduced basic concepts regarding steel members and steel connections, and more detailed exploration of the topic was provided through a laboratory exercise. The laboratory exercise facilitated student comprehension of basic steel construction issues including plan reading, steel member naming conventions, steel connections, welding and fabrication issues.

Lecture Components

Basic information about steel construction was presented in the lecture. This information included reviewing the various types of I beams and the associated naming conventions such as S sections and W sections. Other information included different types of connections for steel structures and illustrations detailing how steel members and steel connections are represented in drawings. The lecture also provided the opportunity to present information on how steel components are used, for example how shear studs are used in conjunction with metal decking and a concrete floor slab.

Issues appropriate for discussion in the lecture included highlighting the importance of connections for structural integrity, and mentioning case studies in which poor connections result in failure, sometimes catastrophic. A discussion of gusset plates and the Interstate 35 bridge collapse in Minnesota provided a vivid example of how steel plates are used to reinforce a steel joint. The importance of strong steel connections provides a good opportunity to introduce proper welding techniques, and identify fabrication issues and standard procedures, such as factory welding for half the connection and field welding to complete the connection.

Sample Laboratory Components

The laboratory component allowed students to gain an appreciation for how the three-dimensional steel members and connections in the AISC steel sculpture were represented in two-dimensions in typical construction drawings. This relationship was emphasized by having students find members and connections on the steel structure that were shown on construction plans, identify specific beams and channels, and draw members and connections for items on the steel structure.

For example, the elevation shown in Figure 2 was provided, and students were required to find and identify elements such as open web joists, shear studs, and gusset plates. Detailed shop drawings (see Figure 3) can also be incorporated into the lab and can be used to identify components. All of the concepts explored in the lab were initially presented in the lecture. This made a strong connection between pictures of steel items shown in the lecture presentation, renderings on construction drawings, and the actual three-dimensional component. Sample lab questions are provided in Figure 4.

During the lab, the students were provided tape measures, standard dimensional shape tables for steel elements, and elevations of the steel sculpture. Lab activities included measuring the steel members (including S sections, W sections, channels and angles), identifying steel members based on their measurements and the standard dimensional shape tables, and recognizing the relationship between designation by size and weight per foot.

The stand alone nature of the sculpture presented benefits, as well. Although a finished construction product, the structural components and connections remain visible. Some students had questions with the very basic elements of plan reading, for example: "Does the north elevation refer to the side facing north, or the side that I see when I am facing north?" This illustrates that issues beyond steel construction were addressed, as well.

This lab was conducted early in the semester and provided a good opportunity to compare a two-dimensional set of drawings to a three-dimensional structure. The majority of the labs in the class are based on reading two-dimensional drawings. It would be possible to visit a construction site with steel construction to gain an appreciation of steel construction issues; however, there are practical concerns such as transportation and student safety that may prevent such a field trip. Moreover, even if such a field trip were arranged, it would not be possible to see the range of steel members and connections at such a close proximity, and compare the steel members and connections to the drawings side by side.

Discussion

Utilization of the AISC steel sculpture provided a good opportunity to illustrate important concepts in steel construction. Although the AISC steel sculpture was less than a quarter of a mile from the building construction department, the majority of students did not know it was on campus. None of the handful of students that had seen the sculpture realized that it was designed to illustrate steel members and connections. Feedback from the students was generally positive, and lab scores indicated that after the lab the students had a good appreciation of steel construction elements. Questions from students during the lab made it clear that many students did not understand some of the basic concepts of steel members and connections, which made their satisfactory scores on the final lab more meaningful.

When asked for constructive feedback on the lab, the majority of students indicated that they thought the lab was a worthwhile activity. One student suggestion that may be incorporated in the future is the requirement to draw one complete elevation (north, south, east or west) as a lab or homework activity.

For schools that do not have a AISC steel sculpture, there is a virtual steel sculpture available on-line (Chou, 2008). An on-line interactive version of the steel tree was created for civil engineering schools that either did not have a steel tree or schools in developing countries that did not have the resources for a steel tree. Although this lacks the advantages of a "hands on" experience, it does provide a helpful tool for understanding steel connections.

Recommendations and Conclusions

The AISC steel sculpture was successfully used to demonstrate steel building components and steel connections. The steel sculpture was also useful to reaffirm basic construction drawings standards, and illustrate how two-dimensional drawings convey three-dimensional objects. Although the sculpture was particularly informative for students in beginning level construction plan reading classes, it may also be useful in other building construction management classes. This laboratory can be used anywhere there is an AISC steel sculpture. In cases where the AISC steel sculpture is not available, it may be possible to modify the laboratory to utilize components of other structures, or use in conjunction with a field trip to a construction site with steel construction. Future research is

recommended to document the pedagogical impact of incorporating the AISC steel sculpture into an undergraduate construction program.

Figure 1: Photo of AISC Steel Sculpture

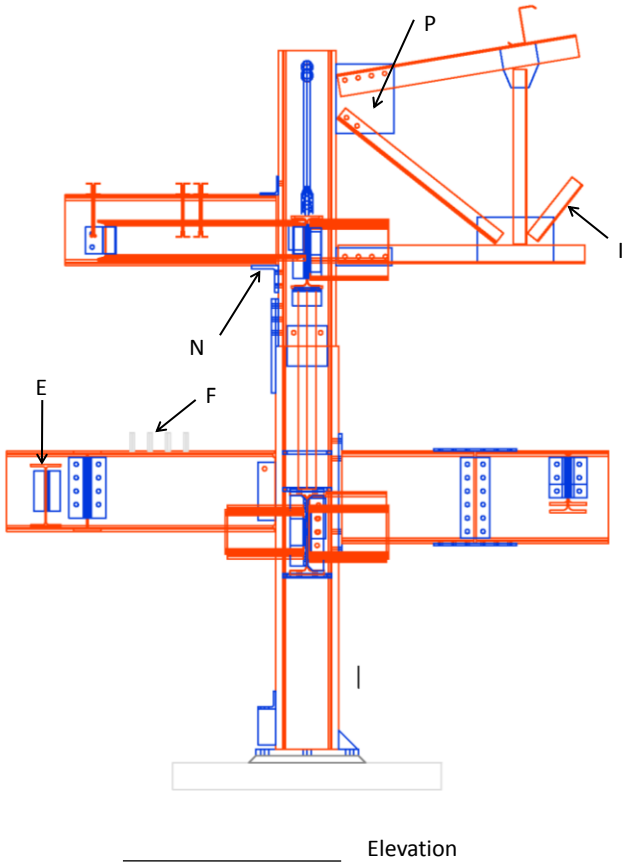

Figure 2. Drawing of North Elevation for AISC Steel Sculpture

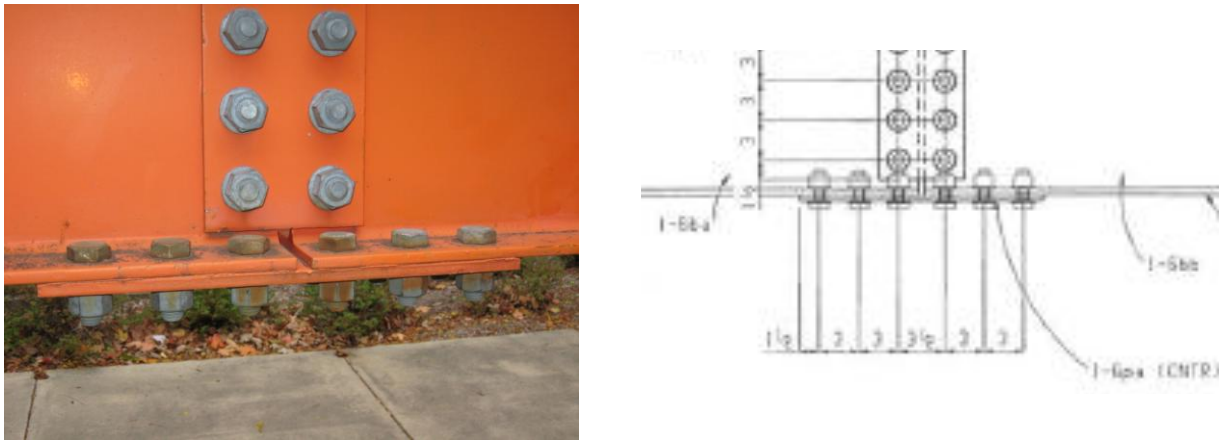

Figure 3: Photo and Detail of Steel Connection as Represented in Drawing for for the North Elevation of AISC Steel Sculpture

All questions pertain to the AISC steel sculpture:

1. Label the drawing elevations using a North, South, East, West convention.

2. For the following structural elements please provide the designation:

   A _____

   B _____

   C _____

   D _____

3. What letter denotes the gusset plate? _____

4. What letter denotes the open web joist? _____

5. How is the open web joist attached?

6. What letter denotes the shear studs _____

7. What are two attachment techniques used to connect the main column at the splice?

8. What letter denotes the clevis? _____

9. What letter is the pipe bracing column? _____

Figure 4: Sample Lab Questions Utilizing AISC Steel Tree Sculpture

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