# Steel Frame Sculpture for Teaching Purposes

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## Abstract:

Steel Design is an important structural engineering course which is taught widely in most of the universities in the United States. One important aspect of teaching this course is getting students familiar with the steel frame and common connections which are used in the construction of a frame. This paper presents the construction of a steel frame sculpture with detailed beam to column and column to footing connections. This frame was constructed as a student project completely on campus. American Institute of Steel Construction (AISC) motivates faculties and students nationally to design and built a steel sculpture for their universities by providing construction plans for them. Although the authors used AISC's idea to build the steel sculpture, the sculpture presented in this poster is not built the plan provided by AISC. A tree shaped sculpture was drafted in SketchUp and the sculpture was constructed based on the drawings. This sculpture is made up of multiple steel I beam pieces which are welded and bolted to each other, to demonstrate different beam to column and beam to beam connections. A concrete footing is designed and built for this sculpture to demonstrate the column to footing connection. The sculpture is placed on the floor of Civil Engineering department and is used for teaching various courses including Structural Steel Design. Construction of this steel frame structure and application as a classroom demonstration is described in this paper.


## Introduction:

According to American Institute of Steel Sculpture (AISC) website the use of steel sculptures for teaching Civil Engineering was first introduced by Duane Ellifritt, Ph.D., PE, Professor Emeritus of Civil Engineering at University of Florida. Since then, more than 170 universities such as Polytechnique University of Puerto Rico, University of Alaska Anchorage, and North Dakota University constructed a steel frame sculpture for the purpose of teaching. The construction plan of many of these sculptures are provided by American Institute of Steel Construction (AISC) [1]. Figure 1 presents the sculptures constructed for University of Maine, ME.

Following the idea of steel sculpture by AISC, a semester long independent study project was defined for a senior civil engineering student at Author's university. The purpose of this project was to develop a better understanding of structural connection types by designing and building a steel sculpture. The structure demonstrates various connections used to join different steel shapes at intersections. The structure is displayed in the hallway of the civil engineering department and used as a teaching aid for courses such as Structural Steel Design, Civil Engineering Material and Introduction to Engineering courses.

Figure 1: Steel Frame Sculpture in University of Maine, ME.

**Design and Construction:**

A group of three faculty, one student and one laboratory technician were involved in the project. The design and construction team decided on not using the available frame plans by AISC. A 3-Dimensional drawing of a desired sculpture which was drafted using a Sketchup software is shown in Figure 2. It should be noted that some members of the initial drawing shown in Figure 2 were subjected to change in final project during the process of construction.

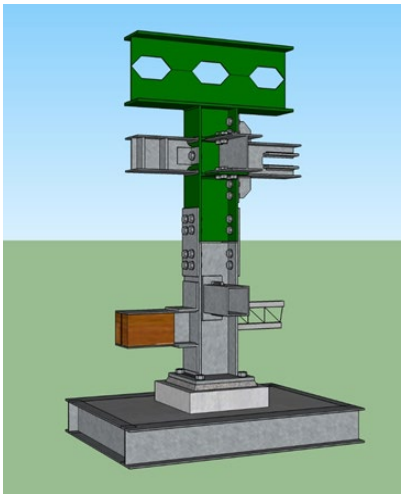


Figure 2: Initial drawing of the sculpture using Sketchup software

The materials for the project were chosen and immediately cut down to length. Figure 3 presents the process of cutting the steel members.

Figure 2: The process of cutting steel pieces to desired sizes

The connections contain mixes of bolts and welding. Two welding methods, Shielded Metal Arc Welding (SMAW) and Metal Inert Gas (MIG), were utilized throughout the project. Figure 3 shows the sculpture during the construction process.

Figure 3: The sculpture during the construction process.

A 3 foot by 4-foot steel frame mold was constructed for the base. The frame was connected to the steel frame and a concrete was poured to demonstrate the footing. Approximately 20% of the base was kept open to show the connection of the sculpture to the footing. Figure 4 presents the sculpture connected to the steel mold, prior to pouring the concrete.

Before pouring the concrete, the sculpture was sent to a shop outside of campus for sand blasting and painting. All steps of design and construction of the sculpture, other than sand blasting and painting, were done on campus.

Figure 4: Steel frame sculpture ready to pour the concrete.

The final product is shown in figure 5. The sculpture is approximately 5 feet tall and 4 feet wide. The sculpture is displayed in the civil engineering department's hallway.

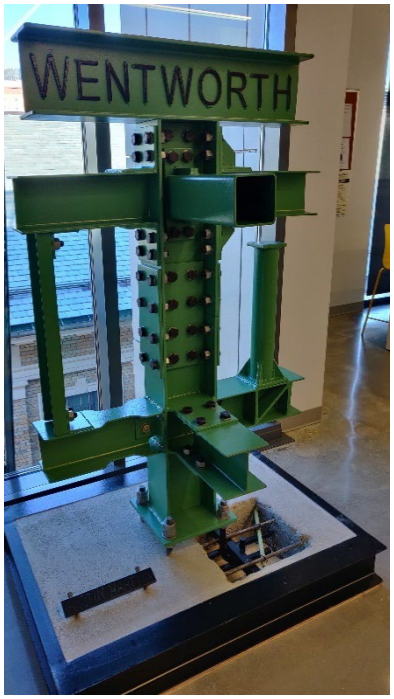
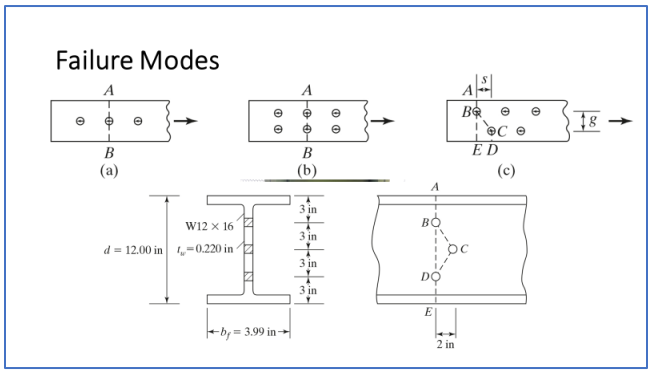
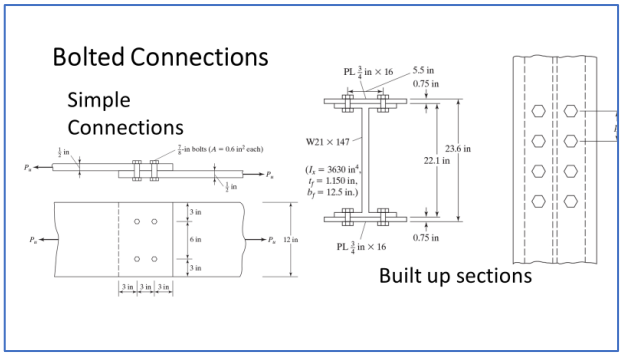



Figure 5: The sculpture is displayed in the civil engineering department hallway

**Application in teaching civil engineering courses:**

In addition to be an excellent undergraduate independent study project for a Senior in Civil Engineering and a beautiful addition to the Civil Engineering Floor, this sculpture is a practical teaching aid. It is used in a variety of courses from the Introduction to Engineering course in the first year to the Structural Steel Design course in the senior year. A brief description of application in each course is given below.



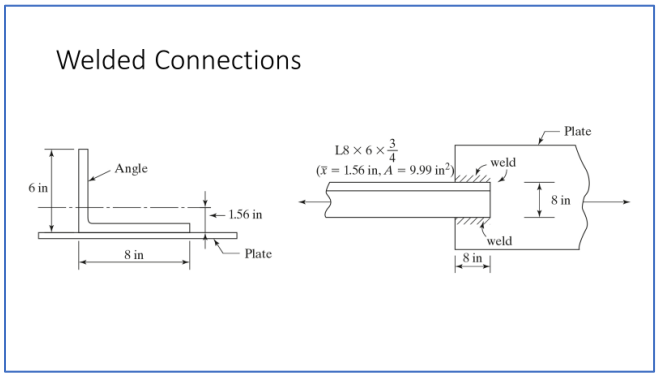




Figure 6 Lecture slides for Steel Design Course and corresponding parts of the sculpture

***Structural Steel Design Course*:** This sculpture was mainly constructed to aid the lectures in the Structural Steel Design course, which is a Civil Engineering elective course the author's

university. The sculpture is used for teaching various topics including tension members, compression members, torsion, lateral torsion buckling, and connections. Examples of the lecture slides used in class are presented in Figure 6. The slides explain the failure modes, bolted connections and welded connections. The students get a demonstration using the sculpture.

Structural Steel Design is offered in Summer in the author's university. This sculpture was built last summer. The students in the Steel Design class were shown parts of the sculpture. The students commented that they had a better understanding after looking at the joints than before. Almost all students agreed that looking at the connections made a difference to their understanding of the course. The sculpture was finished and mounted in its current spot in Fall 2019 and will now be used as a regular demonstration in the Structural Steel Design course.

***Civil Engineering Materials Course*:** The sculpture is useful in teaching Civil Engineering Materials, which is a required sophomore level course in the Civil Engineering curriculum, where the students learn about the different types of rebars, including the epoxy coated rebars which are demonstrated in this sculpture. The part of the sculpture shown in Figure 7 is also helpful during the lecture on mix design while learning about the maximum aggregate size. The PowerPoint lecture slides used for this topic are also given in the figure.

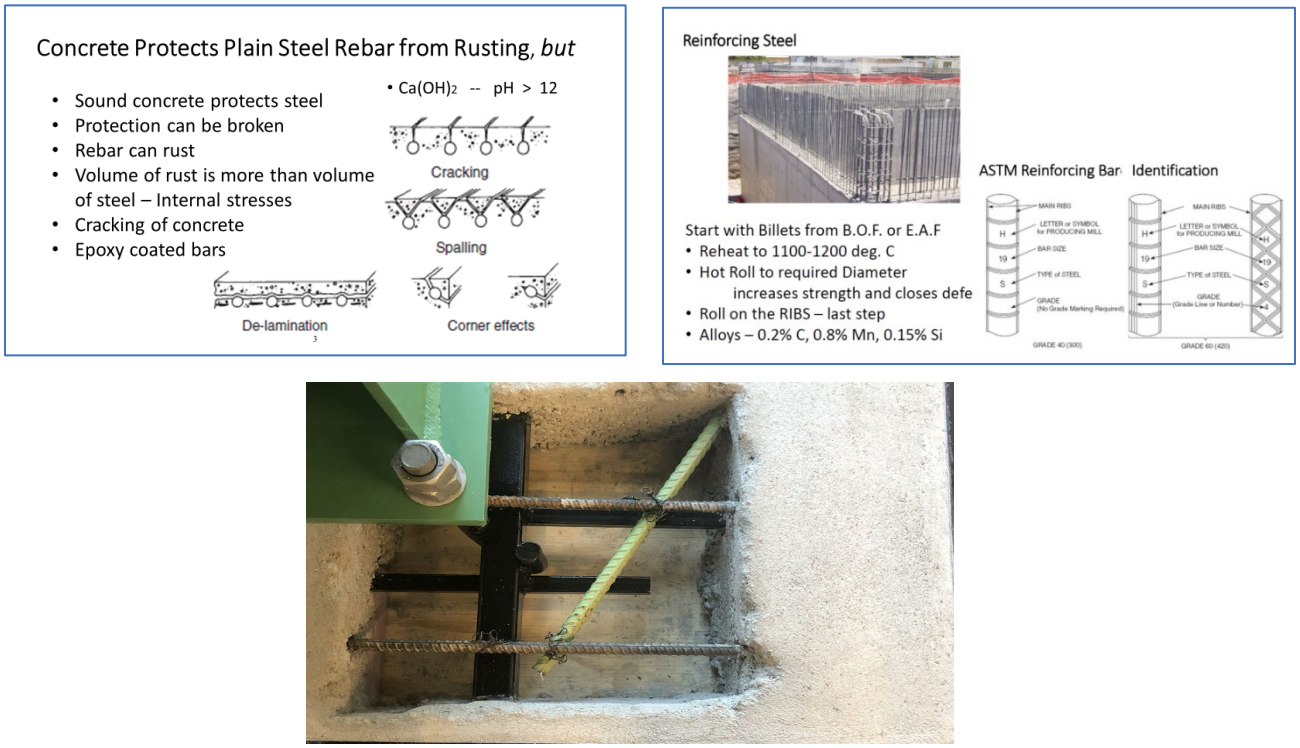



Figure 7: Lecture Slides and the Rebars and Concrete part of the Sculpture

The original intention of this sculpture was to make the steel connections. When the decision was made to mount the sculpture on a concrete foundation, the rebars were added as a bonus feature resulting in another useful classroom demonstration. This unit was a small part of the Civil Engineering Materials course. More demonstrations, slides, study-sheets and quizzes were

implemented. Overall, improvements were observed in the students' understanding and grades. It can however not be co-related to this sculpture alone.

***Introduction to Engineering*:** Another course where this sculpture is regularly used is Introduction to Engineering. This is a required course for all first-year engineering disciplines in their first semester at the author's university. The students rotate between engineering departments and get a taste of all engineering branches. They spend about 3 weeks in each engineering department (Civil, Mechanical, Biomedical and Electrical). During the Civil Engineering department 3 weeks laboratory period, students get a tour of all labs. This sculpture helps to give an idea about steel structures, construction and structural design. The students from disciplines other than civil engineering (electrical, mechanical and biomedical engineering) get a demonstration of this sculpture so that they can appreciate the beauty of the Civil Engineering discipline when they learn through this sculpture.

## Conclusion:

Students learn best by doing. Teaching using demonstration is a significant part of the popular and proven ExCEEd teaching model. The combination of a student independent study, a classroom demonstration and an addition to the decor of the university is hitting a trifecta. The presented project helped a civil engineering student to learn multiple aspects of civil engineering using a hands-on project. In addition, the result of the project is used in multiple civil engineering courses.

## Acknowledgement:

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1. American Institute of Steel Construction (AISC) (https://www.aisc.org/education/university-programs/steel-sculptures/)
2. Salmon, Charles G., et al. *Steel Structures: Design and Behavior: Emphasizing Load and Resistance Factor Design*. Pearson Prentice Hall, 2009