# Project-Based Learning: Field Inspection of a Truss Bridge

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**Abstract** – The focus of this paper is to present student assessments of a sophomore level engineering statics course with a real truss bridge project integrated into the curriculum. Students are required to work in teams and perform a preliminary physical field inspection of a steel truss bridge. This is a unique hands-on approach to project-based learning where students actively participate by working in the field on an existing structure.

*Keywords:* Bridge inspection, project-based learning, and student assessment.

## INTRODUCTION

In recent years, there has been a growing trend in engineering education to include project-based learning in the classroom. Numerous engineering projects have been incorporated into the classroom including the egg drop catcher and the balsa wood bridge projects to name a couple [1]. The general purpose of these projects was to demonstrate what is learned in the classroom and to encourage creativity and teamwork. Most of the projects attempt to simulate a development, design and analysis experience. While there is value to this approach, there is a greater need to expose students to real life engineering projects rather than a simulated project. Unfortunately, real life engineering projects are typically left to the senior capstone course [2]. However, engineering students upon entering college need exposure to real life projects to better prepare themselves as future engineering practitioners [3].

Practice based projects should be a part of engineering courses. This approach relates basic engineering concepts taught in the classroom to real life engineering problems faced in practice. It is important for engineering students to understand that the study of engineering by nature is both academic and practice based. In the past several decades, greater emphasis has been place on academic studies [4].

Students in an academic setting typically have ample opportunity to become proficient in the pencil and paper rigor of engineering problem solving. However, there is a disconnect between academia and engineering practice [5]. The classroom learning environment is typically a passive experience such as in a lecture hall (with the exception of the laboratory courses), whereas engineering practice is an active experience. Real life engineering projects encouraging active participation and physical exposure to real structures such as buildings and bridges can significantly improve student understanding of the applied principles of engineering mechanics and help bridge the gap between engineering education and practice.

## THE PROJECT

Students actively participated in a class project involving a preliminary inspection of a local steel truss bridge. A dead load analysis of the truss superstructure based on as-built conditions was performed. At the end of the project, students were required to evaluate the project in context with the course.

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**College Street Bridge**

College Street Bridge is a four-span, steel, truss structure which crosses the Barren River in Bowling Green, Kentucky (see Figures 1 and 2). Spans 1 through 3 are through trusses, and span 4 is a pony truss. The historic bridge was built in 1915 and presently serves as a pedestrian bridge. The top chord truss members and the vertical truss members of the through trusses are made of built-up riveted steel sections. The lower chord truss members and the diagonal compression members of the through trusses are steel eyebars which connect to steel pins at the joints. The slender tension diagonals are steel bars with a circular cross-section. The members of the pony truss are built-up riveted steel sections.

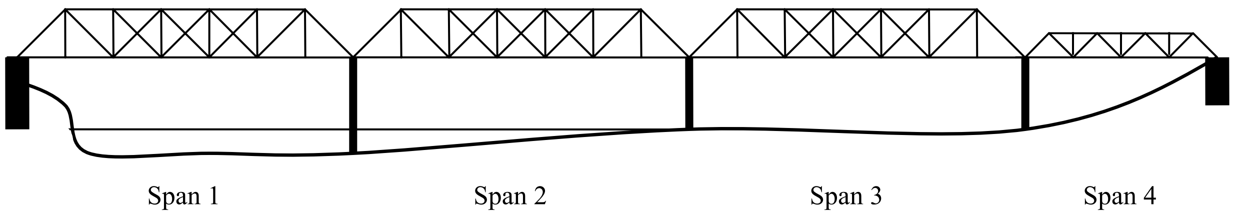



Figure 1: Elevation of College Street Bridge

Figure 2: College Street Bridge

**Purpose of the Project**

The purpose of the project was to give students an opportunity to work hands-on on a real engineering structure, to see and feel members and joints of a real bridge. Students were required to perform a preliminary inspection of the truss superstructure, spans 1 through 3. This involved three components: basic bridge geometry (since plans of the structure do not exist), member properties, and locating notable areas of deterioration. Basic bridge geometry included length of truss (lower cord), distance between panel points, lengths of vertical, diagonal and bottom chord members, transverse distance between trusses (centerline to centerline), and roadway width. Member properties included size and shape as well as cross-sectional area. Notable areas of deterioration included pitting losses and impacted rust.

**Project Phases**

The project was divided up into phases: general information, bridge geometry, bridge inspection, and a dead load analysis of the truss superstructure. In the first phase, students were only given the name and the location of the bridge and were required to individually visit the structure several times to gather information such as information from bridge plagues. In addition, students gathered information from the internet to learn more about the structure. During this time, topics relating to simple trusses such as truss rigidity, zero force members, compression members, tension members, methods of joints and sections were discussed in the classroom and related to the bridge. The second phase involved going to the bridge as a class and working in teams of 3 or 4 students to determine structure specific information including bridge geometry and member properties. Member deterioration of the truss superstructure was noted. The fourth phase involved a dead load truss analysis of the structure. For each site specific task, two independent groups were assigned so that one group could check the other and vice versa.

## STUDENT HANDS-ON WORK

Students performed a preliminary hands-on inspection of the College Street Bridge, spans 1 through 3. Inspection was performed from complete access to the top of deck. Top cord members were visually inspected from the top of deck. Field measurements were taken to determine member geometry as shown in Figures 3 and 4. Truss nomenclature for spans 1 through 3 is shown in Figure 5. From the measurements, cross-sectional area for each member was calculated and is shown in Table 1 with the respective member length. In the field, minor areas of member deterioration due to pitting losses and impacted rust were found.

Using the method of sections and joints, students computed member forces for selected members. Calculating the weight of the truss members and approximating the weight of the floorbeams, stringers, bracing members and deck, students performed a dead load truss analysis of the structure for selected members to determine the corresponding member stresses. Selected member stresses are shown in Table 2.

Figure 3: Engineering Students Measuring the Vertical Height of the Truss.

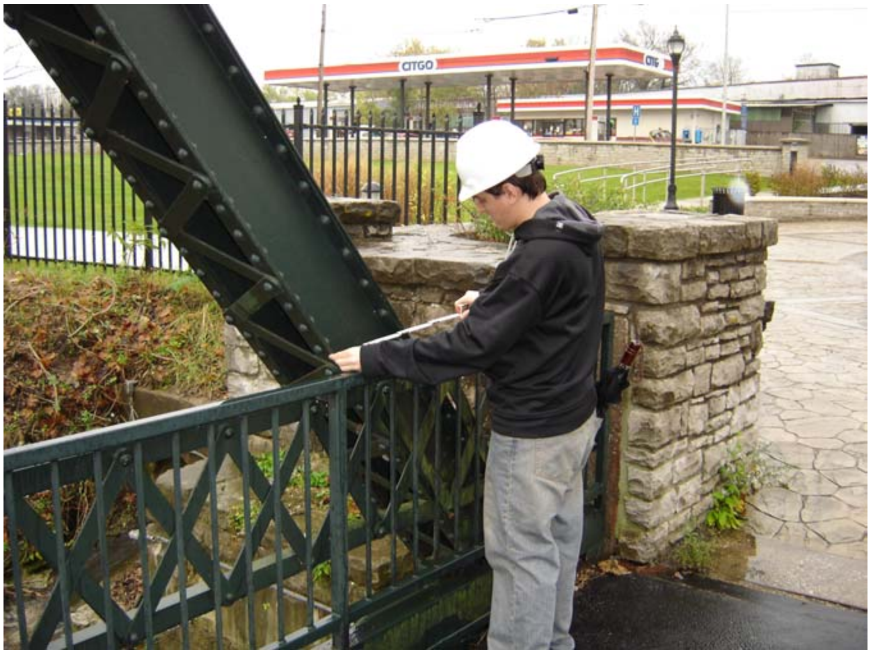



Figure 4: Engineering Student Measuring Section Properties of a Truss Diagonal

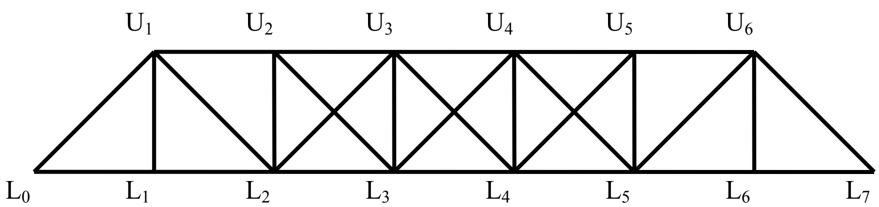



Figure 5: Truss Nomenclature for Spans 1, 2, and 3.

Table 1: Truss Member Geometry for Spans 1, 2, and 3.

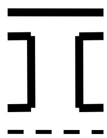
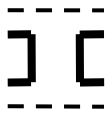
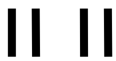
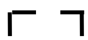
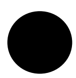
| Member | Schematic Cross-Section | Cross-Sectional Area ($mm^2$) | Length (m) |
|---|---|---|---|
| $L_0$-$U_1$, $U_1$-$U_2$, $U_2$-$U_3$, $U_3$-$U_4$, $U_4$-$U_5$, $U_5$-$U_6$, $U_6$-$L_7$ |  | 14,030 | $L_0$-$U_1$, $U_6$-$L_7$ = 8.00<br>All others: 5.18 |
| $U_2$-$L_2$, $U_3$-L3, $U_4$-$L_4$, $U_5$-$L_5$ |  | 4,350 | 6.10 |
| $U_1$-$L_2$, $U_6$-$L_5$, $U_2$-$L_3$, $U_5$-$L_4$, $L_0$-$L_1$, $L_1$-$L_2$, $L_5$-$L_6$, $L_6$-$L_7$, |  | 3,870 | $U_1$-$L_2$, $U_6$-$L_5$, $U_2$-$L_3$, $U_5$-$L_4$ = 8.00<br>All others: 5.18 |
| $L_2$-$L_3$, $L_3$-$L_4$, $L_4$-$L_5$ |  | 7,740 | 5.18 |
| $U_1$-$L_1$, $U_6$-$L_6$ |  | 1,855 | 6.10 |
| $L_2$-$U_3$, $L_5$-$U_4$ |  | 792 | 8.00 |
| $L_3$-$U_4$, $L_4$-$U_3$ |  | 1,555 | 8.00 |

Table 2: Selected Member Forces and Stresses

| Member | Force† (kN) | Stress† (MPa) |
|---|---|---|
| $L_0$-$U_1$ | -245 | -17.48 |
| $U_1$-$L_2$ | 163 | 42.24 |
| $U_1$-$U_2$ | -265 | -18.86 |
| $L_1$-$L_2$ | 159 | 41.04 |

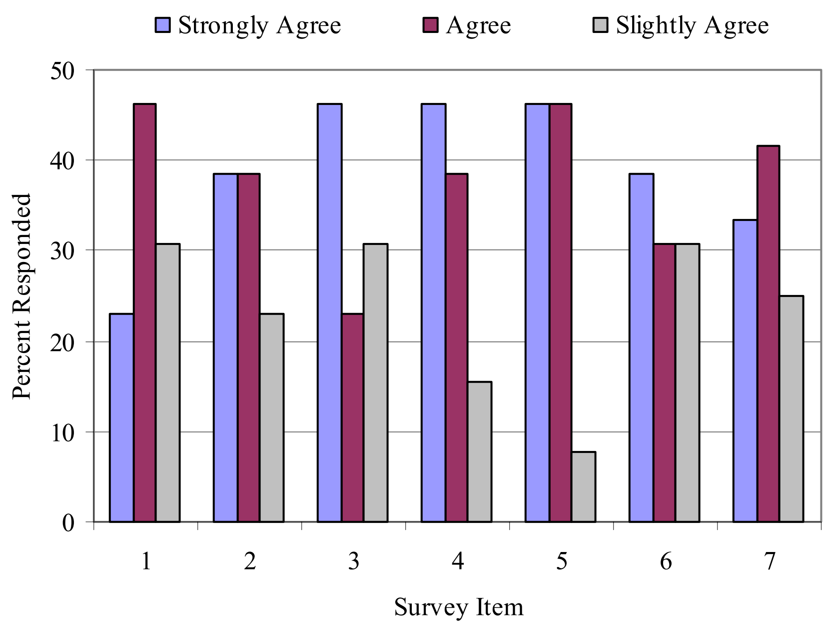
†A positive value denotes tension, and a negative value denotes compression.

## STUDENT ASSESSMENT OF THE PROJECT

Students were given the opportunity to answer a detailed survey about the project. The results are shown in Figures 5 and 6.

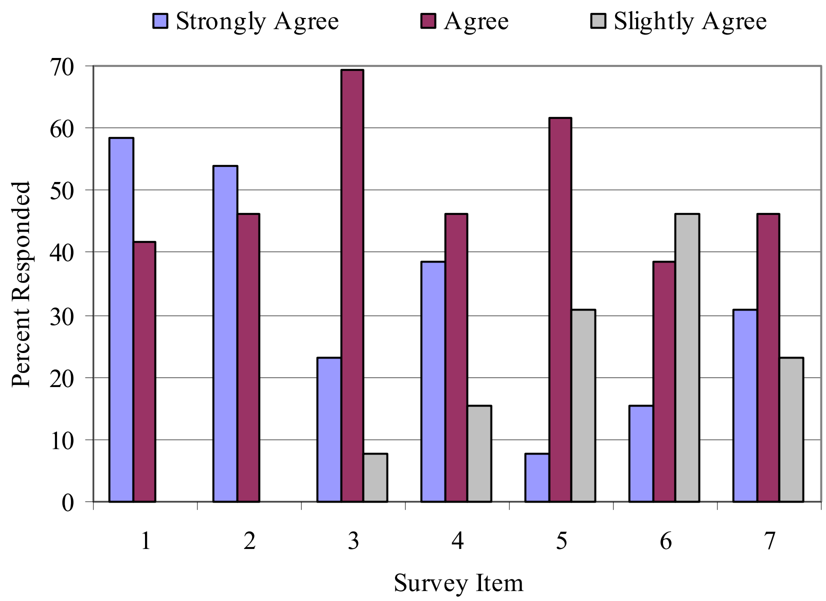
Figure 5 gives the overall student assessment of the project. According to survey item 1, 69 percent of the students either strongly agreed or agreed that the project was enjoyable. In survey item 2, 77 percent of the students either strongly agreed or agreed that the project had a positive influence on their engineering education. In survey item 3, 46 percent of students strongly agreed that the project should be a regular feature of the course. 85 percent of the students either strongly agreed or agreed that the project enhanced their engineering education through a "hands-on" experience (survey item 4), and 92 percent thought the project had a meaningful purpose (survey item 5). Lastly, 75 percent of the students in survey item 7 thought the project made real the concept of static equilibrium.

Figure 6 gives a more detailed student assessment of the project in terms of course content. 100 percent of the students either strongly agreed or agreed that the project improved there understanding of bridges and forces applied to truss type bridges (survey items 1 and 2). 92 percent of the students either strongly agreed or agreed that the project improved their understanding of connections in bridges (survey item 3), and 84 percent either strongly agreed or agreed that the project improved their understanding of simple trusses (survey item 4). 46 percent of the students only slightly agreed that the project improved their understanding of beams (survey item 5). This may have resulted since greater emphasis was placed on the trusses and connections. Finally, 71 and 75 percent of the students either strongly agreed or agreed that the project developed their understanding of engineering mechanics and made real the concept of static equilibrium, respectively (survey items 6 and 7).




The project...
1. was enjoyable.
2. had a positive influence on my engineering education.
3. should be a regular feature of the course.
4. enhanced my engineering education through a "hands-on" experience.
5. had a meaningful purpose.
6. developed my understanding of engineering mechanics.
7. made real the concept of static equilibrium.

Figure 5: Student Survey – Part I.




The project improved my understanding of…
1. bridges.
2. forces applied to bridges.
3. connections in bridges.
4. simple trusses.
5. truss members.
6. beams.
7. floorbeams.

Figure 6: Student Survey – Part II.

## SUMMARY & CONCLUSIONS

Students in an academic setting typically have ample opportunity to become proficient in the pencil and paper rigor of engineering problem solving. However, engineering students need to work on real lift engineering projects that encourage active participation and physical exposure to real structures such as buildings and bridges.

Students in an engineering statics course performed a preliminary inspection of the superstructure of a steel, truss bridge. Truss geometry and member properties were measured in the field. In addition, areas of deterioration were documented. The information was used by the students to perform a dead load truss analysis of the structure for selected members. Upon completion of the project, students were given an opportunity to assess the value of the project.

In general, the students enjoyed the project. The students felt that the project should be a regular feature of the course. Through a hands-on experience, students learned to relate engineering concepts to a real structure.

## REFERENCES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