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Safety and Organization: An EPICS Partnership With Habitat for Humanity

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SAFETY AND ORGANIZATION:

An EPICS Partnership With Habitat for Humanity

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ABSTRACT

The student authors of this essay are a group of eight participating in the Engineering Projects in Community Service (EPICS) program on the Habitat for Humanity (HFH) team. In this article, they describe how they have improved the working conditions within the loft space of the local Habitat for Humanity office in Lafayette, Indiana. Their work is intended to permanently improve the safety conditions of the loft, as well as the organization of the equipment within the loft. The specific safety concerns addressed by the HFH team include horizontal steel trusses at head level and an unprotected access opening in the railing of the loft. The organizational change includes the installation of two units to organize signs used for construction sites and events.

KEYWORDS

Habitat for Humanity, safety, organization, Engineering Projects in Community Service, EPICS, HFH

INTRODUCTION

Habitat for Humanity International was founded in 1976 by Linda and Millard Fuller, and it has since expanded to include more than 1,400 domestic affiliates, including a branch in Lafayette, Indiana (Habitat for Humanity, n.d.). The purpose of Habitat for Humanity is to give low-income families a chance at homeownership, and it pursues this goal by providing partner families with zero-percent interest mortgages on their new homes. Partner families are required to volunteer 100 hours of their time to the construction of their own home and then an additional 150 hours to Habitat for Humanity services, which can include volunteering at Habitat ReStores, volunteering on deconstruction projects, joining neighborhood revitalization efforts, assisting with Habitat-sponsored events, or further continuing construction on their own homes.

The Engineering Projects in Community Service (EPICS) program at Purdue University is designed to connect students of all majors to nonprofit organizations to provide engineering services under the advising of faculty members and through service-learning experiences. Students participating in the EPICS program take EPICS as a course and earn either one or two credits for the semester, depending on the time commitment desired, in addition to meeting for two hours every week with their advisor(s) to discuss the progress, issues, and goals of the past and upcoming weeks. In the spring 2017 semester, the EPICS program consisted of 46 teams.

The Habitat for Humanity (HFH) team has partnered with the Lafayette affiliate of Habitat for Humanity. The faculty advisors for the HFH team for the spring 2017 semester were Dulcy Abraham (professor of civil engineering) and Jorge Martinez (EPICS lab manager). The primary contacts for the project included Sue Hunter (construction volunteer for the family support committee), Ryan Wellner (Construction Coordinator), Neal Porter (repair program coordinator), and Doug Taylor (executive director of Habitat for Humanity–Lafayette).

Since 2015, the HFH team has primarily been involved in work aimed at assessing the organizational needs of Habitat for Humanity.

For the spring 2017 semester, the team devoted its attention toward safety and organizational concerns within the loft space of the Lafayette office of Habitat for Humanity. This space is a designated storage location for large power tools, buckets, seasonal equipment, construction site signs, and other construction equipment and must be accessed by a staircase. After the team's arrival to the site and tour of the loft, there were safety concerns related to low trusses used to support the ceiling and an open gap within the railing. The organizational concern that the team was asked to address was the long-term storage of signs.

DESCRIPTION

Horizontal Trusses

Upon entering the loft, the immediate safety concern was a set of four horizontal steel trusses at, or in some cases below, head level; an example is shown in Figure 1. These trusses are large metal structures made from several steel beams welded and bolted together. They are designed to support the weight of the roof and run horizontally through the loft space from one side of the building to the other, a span of 40 feet.

Bubble wrap sheets had previously been wrapped around certain areas of the beams in high-traffic areas to protect employees from head injuries, but the bubble wrap was insufficient, and most other areas of the beams were unpadded. Habitat employees described the need to duck underneath the trusses every time they wanted to reach other areas of the loft space. The most common head injury involved an employee ducking underneath a beam and then standing back up again without the clearance to do so. Many employees would stand back up and hit their heads on the steel trusses, causing headaches and pain in most cases. Poor visibility of the trusses was one of the primary reasons for people striking their heads. Therefore, for a safety solution to be successful in the long-term, it had to be easily visible and capable of preventing injuries to users while they pass underneath the beams.

The EPICS–HFH team understood the importance of safety in the workplace and chose to investigate different methods of padding the steel beams. An effective padding solution would absorb the force of a person's head pressing against the beam and thus prevent injury. Several options were considered to pad the beams, including pool noodles, column protectors, different types of bubble wrap, and foam padding sheets. The EPICS team

Figure 1. Example of a horizontal steel truss in the loft used to support the roof.

used a design matrix to compare the effectiveness of each option for protecting people, as well as the cost for each option, the ease of installation, the long-term maintenance required, and the ability to replace damaged pieces if needed. The decision was made to use pool noodles to pad the beams because of their availability, effectiveness, and low price.

Once the EPICS–HFH team had decided upon pool noodles, they took the opportunity to address the visibility concerns of the beams. Instead of adding brightly colored caution tape or paint to the padding, an easier solution would be to make the padding itself brightly colored. The beams would then always be visible and protected simultaneously without the need to replace old tape, use new paint, or update existing measures. The pool noodles were available in a variety of colors and could be purchased in bulk from HonorTraders©. The EPICS–HFH team decided to use yellow noodles to mimic the look of black and yellow caution signs that would commonly be seen on construction sites.

On January 26, 2017, the EPICS–HFH team installed its pool noodle solution on all the trusses in the loft space and donated the remaining pool noodles to the Lafayette affiliate of Habitat for Humanity in case any become damaged and need to be replaced. The final installation is displayed in Figure 2.

Figure 2. The truss of Figure 1 with pool noodles attached to it.

Opening in Railing

The loft is a second-story area with safety railings on all sides of it to prevent people from falling if they trip or lose their footing. However, the railings in the loft space have an opening in one location designed for use as an access point for moving long objects that could not easily be taken up the staircase and underneath the steel trusses. Additionally, for long objects being built in the loft space, the opening in the railing serves as a point where the object can overhang out of the loft a bit if needed. Figure 3 displays this opening.

Figure 3. The opening in the railing (picture taken from ground level).

Since the opening in the railing is functional, walling it off was not a viable option. Thus, the opening needed to be handled in a way that would not jeopardize its functionality but would still address the safety concern. The team referenced the OSHA regulations in place for railings as a guide to ensure that the safety measures would be sufficient and compliant by recommended standards. OSHA regulations for safety railings mandate that a railing can support 200 pounds of horizontal force at the top and is at least 42 inches tall. The design solution to this gap would serve as an extension to the in-place railing. Therefore, the design solution could only be successful if it complied with OSHA regulations for safety railings and still preserved the functionality of the space.

The HFH team searched for viable options among swinging doors, gates, sliding doors, latches, and removable pieces and then turned to a design matrix to select the proper solution. With the results of the design matrix and input from Ryan Wellner, the construction coordinator, the HFH team decided to pursue a removable beam solution that would not impede the available space surrounding the railing opening. (Any swinging door would require unblocked clearance to swing outward fully.)

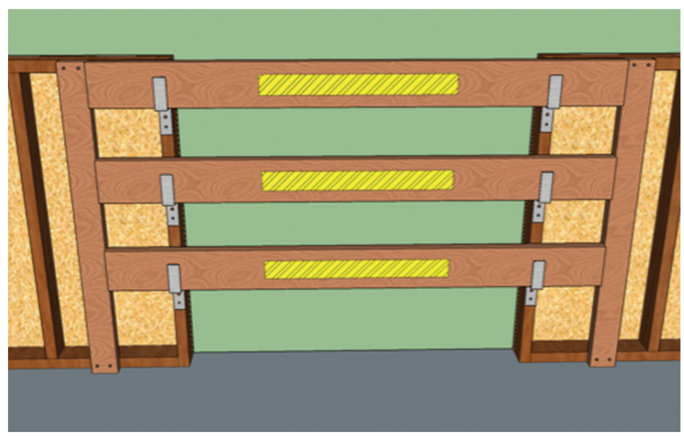

Figure 4. Railing gap solution (image constructed using SketchUp 16.1 3D modelling software).

The team took measurements of the opening and developed a 3-D model of the selected solution, which is shown in Figure 4. Three beams, each 2-inch by 6-inch studs, would block the opening to prevent anybody from falling through it. Pressure-treated ground contact lumber was selected over the cheaper kiln-dried variety because it offers greater strength and weather resistance over time, and any situation involving the safety of individuals should call for the best resources and safest possible design considerations whenever possible. The three beams each sit horizontally on top of metal brackets with alignment studs at the sides to keep them in place. The beams can each individually be removed from their brackets by lifting up and then out. All beams are labelled on both sides with reflective caution tape to ensure that they are visible when removed and can easily be identified and separated from other 2-inch by 6-inch studs in the loft. The final design was approved by Ryan Wellner on March 9th, 2017. Materials were purchased on March 22, 2017 and the final installation occurred on April 19, 2017.

Sign Storage

The primary organizational concern the EPICS–HFH team was asked to address was the storage of a variety of signs used on build sites and for special events. These signs ranged in size from 1-foot by 1-foot squares to 4-feet by 4-feet squares with a variety of rectangular shapes between. In total, 54 signs needed to be stored, and Habitat employees anticipated adding more signs to the collection in the future.

The signs were originally stored in a corner of the loft space on the floor, leaning against each other in a stack (as displayed in Figure 5). This location proved difficult to access due to the presence of the aforementioned horizontal trusses in the loft. Removing a sign from the stack proved difficult because it involved pulling away all of the other signs leaning against it first. This difficulty in removing signs also caused difficulty in putting signs back into place. For this, it was easier to simply add the sign back onto the edge of the stack, which

Figure 5. The stack of event and build signs we needed to organize.

eliminated any kind of organizational basis. Taking signs back underneath the horizontal trusses in the loft also involved uncomfortable and awkward maneuvering that jeopardized employee safety by exposing them to greater risks of striking their heads against the trusses.

The EPICS team worked with Ryan Wellner and Sue Hunter to develop a two-part solution to the accessibility and organizational issues. The first part of the solution involved moving the storage location of the sign sorter to an area away from all steel trusses. With this location change, there is direct access to the sign collection from the loft staircase and nobody needs to move underneath a truss with a sign. The second part of the solution involved the construction of a sign sorter unit catered toward accessibility and organization. The sign sorter unit would need to store 54 signs in a way that would allow for simple retrieval and return and could keep signs organized over time.

The inspiration for the sign sorter came from shopping carts at hardware and construction stores. Some shopping carts are designed with metal rails to create slots for holding oriented strand board (OSB) sheets, plywood, plastic sheets, doors, windows, or studs for construction. The EPICS team decided to use wooden studs as rails to create slots that could separate signs according to size and purpose. These same rails would then bear the weight of the signs so that they do not lean upon each other, thus making it easier to remove a desired sign.

The EPICS team took a full inventory of the sign collection within the loft, organized them into groups based on size, and then adjusted the width of each slot to fit the sign groups. Early designs of the sign sorter were far too large to fit within the loft space and would have needed to be constructed in their final location because of the inability to easily move them. Feedback from the project partners and recommendations from the advisors led the team to pursue modular designs that could easily be moved around once brought into the loft space and could be dynamic enough to store signs in the future that do not exist now. As a result, a once large and bulky design too enormous to fit within the loft became a compact, two-unit design with expandable components capable of creating room for extra signs in the future. The team made every attempt possible to keep the sign sorter compact without reducing the number of signs it could hold. Figure 6 displays the final design for the sorter.

The smaller unit of the sign sorter stores rectangular signs up to 3 feet by 2 feet in size, as well as a variety of banners, tarps, a picket sign, and small components such as bolts and wingnuts related to the assembly of other signs. The larger unit stores signs up to 4 feet by 4 feet in size in its leftmost slots. However, the larger unit also features an expandable slot on the right side, which can expand up to 2 additional feet outward to make room for the large signs that Habitat for Humanity anticipates purchasing in the future. The final sign sorter design (Figure 6) was approved for construction by Ryan Wellner. Materials were purchased on March 22, 2017 and the sign sorter was constructed in small, flat pieces throughout the week of March 27, 2017 to make transportation more manageable. Delivery occurred on April 19.

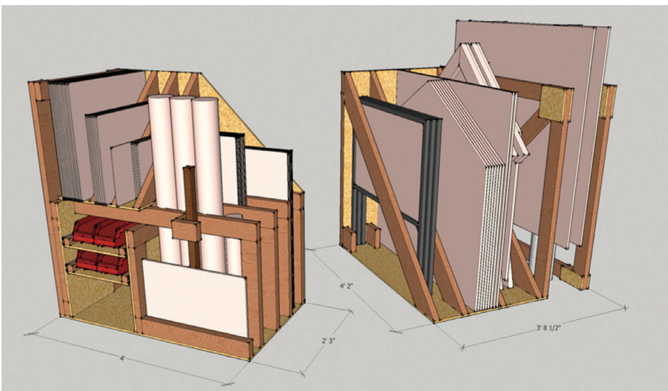

Figure 6. The final design for the sign sorter (image constructed using SketchUp 16.1 3D modelling software).

COMMUNITY IMPACT

For the pool noodle safety solution to be successful in the long-term, it had to be easily visible and capable of preventing injuries to users while they pass underneath the beams. During the installation of the pool noodles on the horizontal steel trusses, already-installed pool noodles prevented at least five head injuries of students moving underneath the beams. Since installing the pool noodles on January 26, 2017, Habitat employees have offered several testimonies describing the effectiveness of the pool noodles and how several head injuries have been prevented since their installation, as well as how much easier it is to see the trusses when the lights are turned off in the loft. This means that the pool noodles have been tested in actual collision situations and performed as anticipated, thus making them an effective solution to the safety concern brought about by the steel trusses.

As for the railing gap, a design solution could only be successful if it complied with OSHA regulations for safety railings and still preserved the functionality of the space. All safety railings must be at least 42 inches tall in order to comply with these standards. In this case, the railing was already 42 inches tall, so the top beam was placed flush with the top of the existing railings to continue the 42-inch height across the span of the gap. In addition, the beams had to be capable of withstanding 200 pounds of horizontal force. After installation was completed, a test was performed to see if the beams could support the force, and each of the beams passed. In addition to meeting OSHA regulations, the solution to the railing gap only involves a few beams and no maintenance. Should the lumber ever become damaged, Habitat only needs to acquire new 2-inch by 6-inch beams, a material that the organization already purchases by the thousands. This solution complies with OSHA standards and still preserves the functionality of the railing gap, which means the solution can therefore be considered successful.

A successful sign sorter design would need to store 54 signs in a way that could keep signs organized over time. The constructed sign sorter can store all 54 signs in the loft space in its compact setup and potentially up to 62 signs in its expanded setup. Slots can be labelled according to size or sign purpose and can be reorganized to fit different groups of signs if desired. The goal of the sign storage project was a system that would work effectively and would be easy to use for Habitat employees. The sign sorter meets all of its requirements, so that goal has been achieved and the sign sorter can be considered a successful design.

The Lafayette affiliate of Habitat for Humanity has collaborated with the Purdue EPICS program for several years, and the staff were well prepared to work with the students. The goals of the project were well defined from the start, and the students were offered access to all areas of the headquarters and local facilities. This trust in the students made collecting dimensions, counting signs, testing prototypes, and installing design solutions much easier. Finding times when all the students could meet proved difficult throughout the semester, and the available times for the EPICS team did not always fall within standard business hours. Beyond that, Habitat staff were regularly busy with the houses they were constructing and their availability fluctuated as well. Had the Habitat staff not been so welcoming and trusting of the students to work on their own, the project likely would have experienced significant delays.

During the spring 2017 semester, the EPICS–HFH team aimed to provide improved safety measures to the steel trusses in the loft, close a gap in the safety railings with a removable barrier, and develop an improved system to organizing the signs in the loft. The team gave its final design presentation on April 20, 2017, after the delivery of the projects, and they sought the input of Habitat staff in attendance. The Habitat staff explained that the projects met all of the expectations in place and that all of the design solutions were effective and needed no alterations. Together the students, academic advisors, and Habitat staff agreed that the spring 2017 projects were complete and that new projects would be identified for the fall 2017 semester.

STUDENT IMPACT

The EPICS program has provided this team with a learning experience unlike any other. Most educational systems consist of classroom coursework and textbook theory. It is unusual to find a program like EPICS that allows students to perform actual engineering work as early as their first semester of college. With this exposure to real engineering so early, every member of this team has acquired a skillset and knowledge base that they would not have acquired otherwise. Every member of this team feels better prepared to perform as an engineer in the workforce after graduation and now has the experience to be competitive in the job market for internships and full-time career opportunities.

Perhaps the most important lesson learned in the project was the importance of communication. Of all the tools the team used to make decisions, consider designs, and weigh options (design matrices, 3-D models, item inventories, dimensions, OSHA regulations, etc.), the most effective tool was simply communication with the project partner. With constant communication, the team was able to cater its designs to the needs and interests of the Habitat for Humanity staff to ensure that the solution was not just an answer to a problem, but that it was the best answer to the problem.

There were several points throughout the semester when scheduling became difficult. The students always had assignments, activities, midterms, and jobs that made scheduling trips to the loft space difficult, and the Habitat staff were often busy with their own work. A potential way of avoiding this problem for future teams could involve the students finding a day or time when everyone can meet consistently to discuss designs, visit the Habitat headquarters, or make deliveries. The emails and phone calls between students and Habitat staff allowed the projects to keep moving forward on schedule. Transportation would not have been possible without the aid of Ryan Wellner and Neal Porter, and feedback from staff about ideas and designs helped the team understand the priorities of the projects.

As a team of mostly first-year students, most members were still learning the basic skills of engineering and had limited knowledge of design. Habitat staff remained very patient as the first-year students learned the skills that they needed to evaluate their designs. Prior knowledge of construction among certain members of the team offered aid in the design, development, and construction of solutions to the problems. Every member of the team now knows some basics of woodworking and power tool use that can be carried forward in future endeavors.

The Lafayette affiliate of Habitat for Humanity intends to continue partnering with the Purdue EPICS program in the future and has ideas for future projects that could begin as soon as the fall 2017 semester.

CONCLUSION

Partnership with Habitat for Humanity has been a mutually beneficial experience. Students on the HFH team have learned various lessons and skills about engineering and construction, such as how to generate 3-D models, how to use various construction tools, how to plan long-term timelines and schedules, how to plan budgets, how to speak in front of reviewers, and the importance of communication. Beyond that, all EPICS students acquire engineering experience that they can use to apply for internships and full-time jobs. Habitat for Humanity staff are able to work safely and efficiently with safety measures in place and a newly organized sign storage system, which will allow them to devote less of their attention toward organizing materials and more of it toward providing people with new homes.

The EPICS program provides all students with the tools, knowledge, and funding to conceptualize designs, purchase materials, test prototypes, and deliver finished products that serve an actual need in the community. This experience has reassured all of the team members that engineering is what they want to pursue in college and in their future careers. The EPICS program will continue to partner with the Lafayette affiliate of Habitat for Humanity in fall 2017 and in semesters thereafter.

Completing work that makes a difference in the community benefits everyone involved, and this article was written to help encourage students to participate in community service and the EPICS program in the future.

ACKNOWLEDGMENTS

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AUTHOR BIO SKETCHES

Trevor Drouillard, a freshman in first-year engineering, is studying nuclear engineering with plans for involvement in fusion reactor research and development after graduation. He spent about two years volunteering with the Habitat for Humanity.

Logan Quaas, a junior in electric engineering, has an interest in alternative energy and has performed work for the Department of Defense through summer internships in electrical engineering.

Colleen Kelch, a freshman in first-year engineering, studies civil engineering and is interested in sustainable design and alternative energy.

Jeremiah Campbell, a freshman in first-year engineering, studies chemical engineering and is interested in the pharmaceutical industry. He has a deep interest in chemistry and biology and has spent six years volunteering at biology camps for middle and high school students.

Anna Francis is a junior in civil engineering who has been involved with structural design for seismic events and other natural disasters. She regularly participates in campus service organizations.

Connor Moore, a freshman in first-year engineering, studies construction engineering and management and plans to be involved in road construction and design. He has been a volunteer for food banks, assisted living facilities, and memory care facilities.

Jiayin Qi, a junior in electrical engineering, has multidisciplinary interests that span across mechanical and civil engineering. He chose the Habitat for Humanity team as an opportunity to explore those interests to a greater depth while benefiting the local community.

Alyssa Trobl, a construction engineering and management student, hopes to do work related to commercial building and bridge design in her future. She has volunteered for the Purdue University Dance Marathon to raise money for Riley Hospital for Children in Indianapolis.

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