

Collaborative solid wood construction case study

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ABSTRACT: This paper describes the design, development and construction of three 600ft² summer cabins completed in July 2014 by faculty in the University of Utah College of Architecture + Planning's Integrated Technology in Architecture Center (ITAC) for the Girl Scouts of Utah's Trefoil Ranch Camp near Provo, Utah. This multifaceted project integrated material and off-site fabrication research, community design services, outreach and education to an underserved population, and provided applied learning opportunities for architecture students.

The organizing team took an integrated, multidisciplinary design and development approach in which stakeholders, architecture faculty, general contractor and fabricator, engineers, the building department, Girl Scouts, and architecture students were involved. The predominantly utilized building material was Interlocking Cross-Laminated Timber (ICLT), which is a panelized wooden construction material relatively new to the US construction marketplace. This paper reports on the participatory, interdisciplinary development process of the project.

KEYWORDS: Collaborative Design, Women in Architecture, Sustainable Design, Architecture and Education, Interlocking Cross-Laminated Timber

INTRODUCTION

Project: ARCHITECTURE is a new partnership between the Girl Scouts of Utah (GSU) and the School of Architecture (SoA) at the University of Utah, to raise awareness of careers in the built environment for women and to provide opportunities for architecture students to actively engage in service and creative projects. The inaugural project for this partnership was the design and construction of three cabins for the Girl Scout's Trefoil Ranch Camp near Provo, Utah.

As an important part of the participatory design process, the authors hosted a yearlong series of outreach events to expose Girl Scouts directly to women practitioners, to provide female student mentors in design-related programs, and to offer opportunities to visit architecture firms and construction sites, as well as providing the girls a first opportunity to engage with an institution of higher education.

1.0 DESIGN DEVELOPMENT

1.1. Context

The Trefoil Ranch Camp is located on a wooded site at the upper end of Provo Canyon at an elevation of 6,040', which is within the Utah Cold Climate Zone. Due to the warm, dry summers and cold winters with a heavy annual snow load, the camp's use is restricted to the summer months only when it offers diverse activities during daily, weekend, or weekly camps to the GSU population, which ranges in age from 5 years to 18 years. Thus the cabins are not heated for the winter months, and their utilities are reduced to electricity only with bathhouses, a common kitchen and activity areas, bunkhouse, and meeting and gathering places in the main lodge and existing facilities providing additional services.

1.2. Building material

Interlocking Cross-Laminated Timber (ICLT) was the primary building and construction material used for the cabins. Originally developed in Europe, Cross-Laminated Timber (CLT) uses adhesives or mechanical fasteners to assemble solid softwood timber stock into structurally sound, cross-laminated building components and panels. ICLT is a similar, prefabricated cross-laminated solid softwood wall, floor, or roof panel that is fabricated from two to seven layers of alternating direction pine stock milled from waste or beetle-killed pine wood using a robust, CNC-controlled process. Binding the CO₂ content of already dead wood into this long lasting, low maintenance product, ICLT has a low environmental impact over the project's life-cycle and eliminates the use of VOCs by removing adhesives from the assembly. The cabins were built in collaboration with industry partner Euclid Timber Frame PC, a company focusing on natural building methods using no glues, binders, adhesives, or products with VOCs. Euclid Timber with research support from the University of Utah's Integrated Technology in Architecture Center (ITAC) has developed ICLT as an

innovative and highly-sustainable material to incorporate locally-sourced wood damaged by pine beetle infestation prevalent in the American West.

Simple dovetail joints connect the pine stock elements, utilizing no fasteners and no adhesives within each panel. This system reduces overall capital cost typically incurred by either stainless fastener purchase and install or press purchase and set up associated with glue lamination [Smith 2010, 2011]. Mechanical fasteners were used for the assemblage of the panels on site, which means that capital cost can be reduced by increasing the size of each component to the point where size is limited by the access to the construction site, availability of equipment, and transportation restrictions. In case of the GSU summer cabins, the assembly method of choice for certain components was adjusted during the design process and through collaboration with the structural engineers. Due to dead, live, and snow load requirements, the thicker horizontal floor and sloped roof panels were assembled in Brettstapel construction, in which softwood timber boards are connected in parallel with hardwood dowels. After pressing those into place, the dowels absorb the moisture of the soft wood and swell, thus creating a very strong, force-fit connection [Greve 2014].

One of the major advantages of utilization of ICLT and Brettstapel was its time-savings potential: the building components were pre-manufactured in the contractor's controlled environment, utilizing a construction sequence that involved a highly-detailed computer model from which the solid wood wall components were then milled on a CNC router. The individual pieces were joined together in 'chunks' in the shop to form manageable modules that were delivered to the site where they were assembled and fastened together. In parallel, the site and foundation work was prepared and finished to allow for relatively short assembly phases on site. Thus construction time and costs were reduced, and a higher level of quality was maintained. Transportation cost and impact onto the site were also minimized, with the third cabin being erected in just a few weeks.

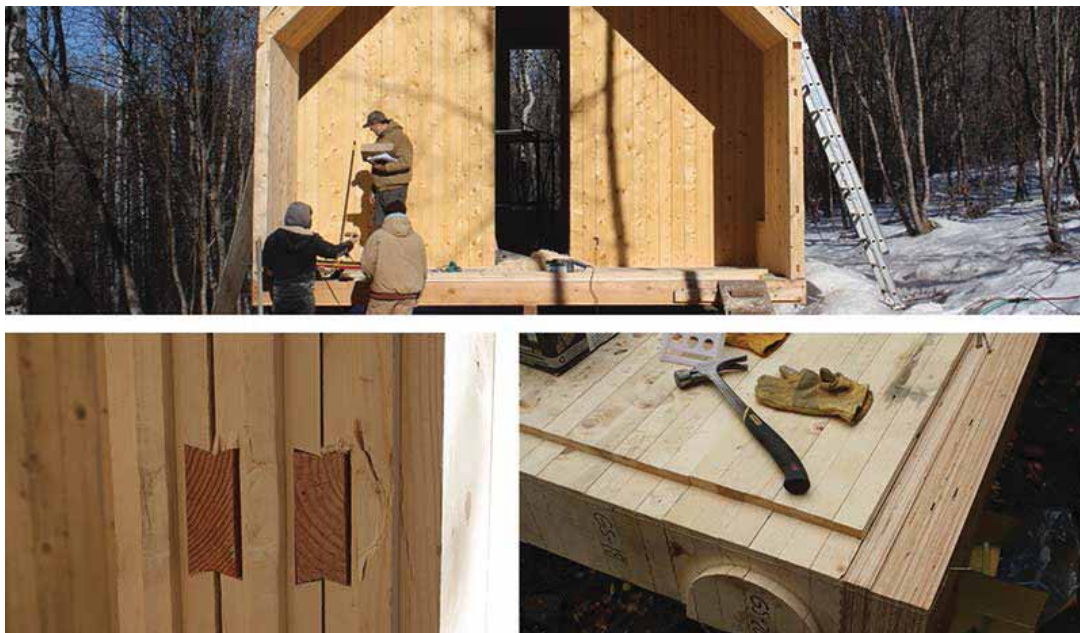


Figure 1: ICLT and Brettstapel Component and Panel Assembly. (Authors 2013)

The ICLT system presents a new approach in construction technology, material process, and assembly methodologies. Binding the CO₂ content of already dead wood into this long lasting, low to no maintenance highly sustainable wood product, the panels have a low environmental impact over the project's entire life-cycle, including a high ratio of renewable energy to fossil energy in construction through very low embodied energy in the material. The cabins provide long-lasting, healthy, and useful buildings that conserve finite resources and fossil energy by using this extremely durable, recyclable, and renewable natural material. Utilization of this material puts the project at the forefront of sustainable construction with findings expected to influence the construction market along the Wasatch Front and beyond.

1.3. Design Philosophy

The regionally rooted typology adopted for the cabins is simple, clearly defining the project as highly sustainable from a design as well as a material standpoint. It echoes the regional, functional design of old farm buildings in the canyon as well as the typology of the camp's old wooden tent platforms, which were originally erected on simple CMU piers. The cast in place concrete piers for the new cabins were chosen to minimize construction disturbances while simultaneously maximizing land use efficiency. Clad in mild steel that changes color over time, the cabins already blend well into the site. In addition, the steel has been chosen for its fire resistance properties, allowing for the reduction of wall thicknesses to the structural minimum for material efficiency with the metal cladding providing the code-required fire protection.



Figure 2: Completed Cabins. (Nicholas Steffens 2014)

Each cabin has an inviting, shaded patio that is oriented towards the common gathering, activity, and fire pit area with the cabin to the north also offering additional outdoor seating on its stairs directly adjacent to this outdoor hearth. Access to the cabins is through this communal space, supporting the idea of community and communication among the campers. On the inside, the cabins offer a spacious, day lit, warm, and healthy interior that provides accommodation for up to 10 scouts each. To allow for indoor activities, the bunk beds of each cabin are grouped around large tables, which were designed and digitally manufactured by students at the SoA. A small changing room completes the spatial arrangement. The tall entry door and vertical egress window oppose each other on the short cabin elevation, allowing for a direct visual connection into the woods upon entrance. The four bay windows on the long sides echo the verticality of the trees and offer a small seating bench in each bay; the arrangement of the upper, operable windows allow for cross ventilation. Similar bays without windows, one on each side of the porch, offer views when outside.

The design maximizes the use of on site natural resources, such as sun exposure, wind protection, orientation, and preserves environmental quality with the goal to support the local ecosystem through design with nature. The cabins respond to a socially viable environment and reflect the value of the local community. They provide an outstanding case study for the scouts, raising critical awareness of finite resources and a sensible use and management of an important natural resource. Within its larger context of the GSU, the project creates a space of communal significance and social value.

The collective, integrated design and construction process applied by the team consistently included all stakeholders, building authorities, students, scouts, contractors, and trades. Through the efficiency of the design and the chosen materials, the cabins provide a long-term economic benefit for the users and GSU as a non-profit organization. During construction the team also focused on fulfilling highest ethical standards for

the construction crew, and ensured through continuous visits at the site and the manufacturing plant the high quality of working and product conditions.

For the design development, in which many of the schematic decisions were further explored and finalized, groups of students and Girl Scouts were involved in the decision making process to ensure a functional architecture that would not only be rooted in the local context but would also become the most functional solution for its occupants. During design meetings, number and shape of the beds were discussed and defined, moving from space-consuming single beds to more efficient bunk-beds, which also allowed the team to stay within the given construction budget by reducing the overall cabin size by approximately 25% and introducing a common space for in-cabin activities. The importance of a porch for each cabin was discussed, and the desire for a large table in the center of the cabin emerged. After consultation with stakeholders and the client, all of those measures were successfully implemented into the scope and design of the project.

1.4. Participatory Design Process

Integrated throughout the participatory design process of the cabin project have been outreach activities benefiting both SoA students and the Girl Scouts. Utah's population of female practitioners is well below the national average (women practitioners currently account for only 14% of the population), so recruitment was a primary goal of the project in addition to helping raise the awareness of high quality design in the community. The SoA also has a disproportionately low percentage of female students, so the opportunity for the program to have a significant impact on the local, regional, and state community is high.



Figure 3: Completed cabin interiors with student-designed tables. (Authors 2014)

The GSU involvement in the project was two-fold: there was a Leadership Group of middle- and high-school aged scouts who followed the project through all stages by participating in workshops, site visits, design charrettes, and firm tours, and a broader audience of scouts of all ages who participated in an event in April 2013 that used projects specific to the cabin design to demonstrate general principles about architecture, urban planning, landscape architecture, and multi-disciplinary design. In more detail, the participatory design and development process included participation of SoA students at the Western Mountain Regional/Northwest Pacific Region (WMR/NWPR) Leadership Institute, hosting a booth at the 2012 Girl Fest, organizing a large kickoff event at the SoA, a design charrette, several site visits and tours of Euclid Timber for scouts and students, a consultation meeting for table designs, the design and digital manufacturing of the tables themselves, the day-long educational event for 75 scouts of all ages in April 2013, and a public groundbreaking party shortly after completion of the project. Additionally, SoA students were also involved in construction administration.

The authors believe the collaboration was mutually beneficial to both parties and has been successful in achieving its goals as evidenced by the final project outcome. Project: ARCHITECTURE, the first major project to be developed as a result of the partnership, has created opportunities for mentoring relationships at multiple scales amongst the scouts, architecture students, and female practitioners.

2.0 OUTREACH ACTIVITIES

2.1. August 2012, GirlFest

GirlFest is an annual event celebrating the Girl Scout Leadership Experience with activities for scouts to discover new skills and strengths, connect with other girls and their community, and take action to make their neighborhood, community, and the world a better place. School of Architecture students manned a booth at the event in August 2012 to educate girls K-12 about architecture in general and promote the upcoming Project: ARCHITECTURE activities. An activity at the booth where girls decorated laser cut wooden cabins allowed for the younger girls to engage while students shared their knowledge and discussed the program with troop leaders and parents. The event served as a recruitment tool for potential Leadership Group participants.

2.2. October 2012, WMR/NWPR

SoA students and their faculty mentor participated in the Leadership Institute, a two-day workshop conducted in advance of the AIA's Western Mountain Region/Northwest Pacific Region Joint Conference in Tucson, Arizona. Students arrived with proposals that they presented to the group of peers from architecture schools throughout the region. Over the course of two days, students participated in presentations, work sessions, and lectures intended to develop their leadership and advocacy skills and their community-engaged projects. The mission of the program is to provide emerging professionals the opportunity to learn leadership strategies from professionals, to develop leadership skill sets, to establish a forum that will facilitate dialog amongst future leaders, and to advance the next generation of professionals to critical roles in the design and construction of the built environment.

2.3. October 2012, Kickoff meeting

In October 2012, the Leadership Group of scouts met with representatives from the GSU, SoA student mentors, and the authors to discuss the project. The group also reviewed the proposed involvement of the Leadership Group intending to help them become invested in the project activities. Simultaneously, the Leadership Group was introduced to the basics of architectural design, sustainable use of resources and materials, and the educational as well as spatial environment of the architecture school through a series of interactive presentations and exercises. After touring the buildings facilities and talking to students working in the studios, they participated in a discussion about how to make buildings more sustainable and better performing. At the end of the day, they left with a high level of motivation and a suitcase full of impressions, ideas, and encouragement about their power to shape the cabin project going forward.

2.4. November 2012, Site and manufacturer's fabrication shop visit

The Leadership Group along with students and faculty of the SoA visited the site and the fabrication facility to gain a better understanding of the cabin context and to understand the process of designing and manufacturing the ICLT components for the structures. On the cabin site they were able to explore and understand the specific nature of the place, see the challenges of the undulating terrain, and visit the older cabins that had been built using standard construction the year before. The latter was an important lesson in better understanding how ICLT buildings are planned, manufactured, and assembled, which was the major focus when visiting Euclid Timber, the ICLT manufacturer, right after the site visit.

2.5. December 2012, Design charrette

After initial code review and space allocation exercises were conducted by the authors, the GSU, troop leaders, architecture students, and Project: ARCHITECTURE coordinators were invited to take part in a design charrette for the cabins. The scouts provided important input and design ideas that shaped the cabin direction. This was an invaluable experience for students as well in understanding the positive impact a client can have on a design.

2.6. April 2013, Capstone event

The capstone to the service and outreach component of the project was an event on April 20th, 2013 that involved approximately 75 scouts, including the Leadership Group. The event paired architecture students, a female practitioner, and a Leadership Group scout together to develop a series of activity sessions that exposed girls of all ages to the principles of architecture, design, and planning through hands-on activities. In addition, the day started with a panel discussion where female architect-practitioners - including the dean of the College of Architecture + Planning, a senior vice president at the University, the first female fellow of the American Institute of Architects in Utah, and the principle of the AIA Utah Architecture Firm of the Year - spoke about how they became interested in architecture and their experience in practice.

Each session was run by a practitioner and one or more of the SoA students who helped coordinate the various activities. The event ended with a 'big reveal' of the cabin design and discussion of how the design was developed to incorporate sustainable principles and input from the scouts. After the event, the Leadership Group was invited to tour a local architecture firm and have a discussion with senior and junior members of the office on what an architect does in practice.

2.7. September 2013 to May 2014, construction

Throughout the construction process, students and scouts were kept abreast of progress and invited to the site for tours at key points. This opportunity was highly valued especially by architecture students, as for most students it was their first exposure to seeing something they helped design under construction. Additionally, students from a variety of unrelated courses toured the site during construction and after completion in technology courses that used the cabins as case studies.

In all, the construction process was more complex for these simple cabins than it might have been for a more standard building, and the students were able to witness the process. They observed the challenges of the construction process with regard to code compliance: the jurisdiction changed fire marshals during construction, and the new marshal had a different interpretation of key aspects of the project. They were exposed to the process of utilizing a new material system (ICLT) in one of the first times in practice: the original intention for the piers was to minimally disturb the site, but due to the load of the solid wood panels and the structural engineer's caution in working with a new system, the oversized footings required significantly more excavation than originally intended. They were exposed to the process of public relations and fundraising: students observed the process of soliciting donations for materials and assemblies to help offset costs for the cabins. These and many other lessons were beneficial to students in their understanding of the day-to-day workings of construction administration.

2.8. July 30, 2014, Ribbon cutting

A ribbon cutting celebration took place on July 30, 2014 in which scouts, camp staff, GSU board members, parents, architecture students, contractors, vendors, and local politicians took part in celebrating the cabins' dedication. Speakers discussed the process of design and construction and scouts, students, and the authors led people on tours of the cabins, which had been in use since the beginning of the summer camp season. The celebration was also attended by several local and regional news outlets, which provided coverage of the cabins, featuring the scouts' involvement and the ICLT material utilization.

3.0 TRANSLATABLE FRAMEWORK

3.1. Strategic partnerships

The authors have found that one of the most difficult aspects to building strategic industry partners is the challenge of convincing these companies and organizations of the value of architects' ability to strategize, design, and research. It is important to be cautious of individuals and organizations seeking free design assistance under the guise of offering 'valuable experience' for students. Often times starting with a small research project to establish trust and demonstrate the benefit of student and/or faculty engagement or showing successful past projects is a strategic first step toward building a lasting collaborative relationship.

3.2. Student engagement

Student engagement is critical in creating rich collaborative partnerships such as Project: ARCHITECTURE. Not only do the students gain valuable experience in design and construction projects but they also get the opportunity to serve as teachers and mentors to younger children, reinforcing the value of their education and experience. Given this responsibility, students take ownership over the process and are advocates and assistants in realizing the best possible end result.

For this project, the authors chose not to conduct the design and research as part of a formal course for two reasons: the project was going to invariably last longer than one semester and continuity of the students across a two-year process wouldn't be feasible within the academic structure; and flexibility in structure let students phase in and out of the project based on needs and interest. Additionally, students were able to receive IDP credit for their time spent on the project.

In addition to the creative work and outreach components of the project, the authors have made every effort to leverage the partnership with the Girl Scouts for real-world design opportunities for architecture students. For example, faculty taught a graduate seminar in the spring of 2013 on digital fabrication where students designed and built tables that the scouts indicated were desirable for communal activities in the cabins. The GSU served as the 'client' for the tables, and students involved in the cabin project who were not part of the course participated in critiques.

3.3. Faculty research

Oftentimes faculty research is disconnected from service and teaching activities. By layering several components to the project and seeking out potential connections (the graduate seminar in digital fabrication using the tables as a project for example), the authors were able to devote the time needed to achieve this undertaking without sacrificing other work or creating an overload. Administrative support is critical to the success of such an undertaking as well as faculty buy in to the value of community-engaged practices as research. For example, the contract developed for the project was the first of its kind at the university and required extensive work from the college and university legal departments, and administrative assistance was needed in advocating for an exemption to the university policy of charging approximately 50% overhead on research money. By demonstrating the positive experience for students and benefit for the non-profit GSU, the funding was accepted as a grant but under a service designation with 0% overhead.

3.4. Education and outreach

Like many architecture programs, the authors' institution is constantly seeking ways to elevate the dialog about good design in the broader community, develop relationships with potential applicants, and create more meaningful connections with the practicing community. Through anecdotal accounts and more formal metrics, the project has been incredibly successful at achieving the immediate goals. Time will tell if engaging with the Leadership Group of middle- and high-school students will lead to an increase in applications from these scouts who self-identified as being interested in architecture. Additionally, the social and religious context of Utah has historically led to a far more male-dominated education and practicing community than the national averages. By focusing this project on outreach and education to women (though not excluding men), the project has the additional advantage of serving an underrepresented population of current and future architecture students.

3.5. Observations and next steps

Much was learned from the project on the logistics side. Future projects will be structured based on both custom contracts as well as standard AIA owner-architect and owner-contractor agreements. The methods of engagement with students and professionals were highly effective, but retention of Leadership Group scouts over the year-long sequence of events waned. Feedback and discussions with these girls has led to the idea of developing an "Architecture Badge" as a tangible goal that the scouts can work toward with a discrete number of activities to commit to in advance. Following up with the scouts is critical over the next several years, and the offer has been made to sponsor future capstone Gold projects (the equivalent to Boy Scouts' Eagle Scout distinction). Building off of the success of the cabin project, the authors are working with the GSU on a vision plan for the GSU's other Utah camp, which consists of 350 acres of pristine mountain landscape outside Park City, Utah, a best practices guide for the national organization on such partnerships, as well as a variety of other building and planning projects at multiple scales.

CONCLUSION

Beginning even before the completion of construction, the project received 5 important design, collaboration, and diversity achievement awards, and was extensively covered in the regional media. During a national convention for the Girl Scouts of America held in Salt Lake City, the authors toured property managers from all over the country around the cabins and discussed the collaborative process that led to their development. The authors are confident in stating that the project overall has been a tremendous success in its goal to serve as an outreach, teaching, and research initiative that links faculty and students in architecture, Girl Scouts of Utah, and female practitioners with industry to create learning opportunities about architecture through sustainable building design and construction projects.

The authors also believe that the project has had a significant impact on the community, which includes the general public in the form of GSU, parents, and troop leaders; the academic community of students and faculty who volunteered for the project; and the professional community who engaged in mentoring the GSU and architecture students by sharing their expertise. This impact includes both a sustainable focus as it relates to the ICLT material utilized for the cabin design as well as a social focus as it relates to current and future female architects.

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REFERENCES

- Greve, Nina. 2014. "Gut im Brett! Passivhäuser in Massivholzbauweise." *Passivhaus Kompendium 2015*: 83-85
- Smith, Ryan. 2010. *Prefab Architecture: a guide to modular design and construction*. 128-131. Hoboken: John Wiley and Sons, Inc.
- Smith, Ryan E. 2011. *Making the Most of the Beetles*. University of Utah Redthread (online): <http://redthread.utah.edu/making-the-most-of-the-beetles-%E2%80%93-an-alternative-use-of-standing-dead-forest-wood/6184>