Cottonwood Cabins: An Investigating into Screw Laminated Mass Timber Construction

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It has been argued that the most significant, yet troubling, legacy of modernism has been the specialization of the various elements of building once directed and harmonized by the master builder.[1] Relegating buildings to an individual specialist has inevitably created more complicated building assemblies requiring each material to handle only a particular function. If we are to overcome this oversight, a more complex building methodology should replace these complicated building systems dominating building construction today.[2]

Recent advances in construction technology and an interest in sustainable building techniques have led to a resurgence in wood building. Touted as a renewable resource that sequesters carbon Mass Timber, and more specifically, Cross Laminated Timber (CLT), is gaining in popularity. Often used as both structure and interior finish, CLT panels have a place in more complex building assemblies by eliminating the need for multiple single functioning materials.

While CLT satisfies a more complex and monolithic construction technique, it should still be scrutinized with the same skepticism as its more complicated predecessors. In 2019, ColoradoBuildingWorkshop, the design-build program at the University of Colorado Denver tasked students to reimage log construction for a series of cabins in Thoreau, New Mexico. (figures 1,2,3) The challenge was to engage mass timber construction without dismissing the deep architectural history of the camp. The earliest set of six log cabins was designed by Kurt Vonnegut Sr, the renowned writer's architect-father. (figure 4)

As students in the course began to analyze various forms of mass timber construction, they quickly realized that CLT was

Figure 1. Exterior image of one of the six Cottonwood Gulch Cabins designed and built by ColoradoBuildingWorkshop. Image credit Jesse Kuroiwa.

Figure 2. Exterior entry of one of the six Cottonwood Cabins. Image credit Jesse Kuroiwa.

Figure 3. Interior of the Cottonwood Cabins. The SLT is visible in the wall, floor, ceiling, doors, and bunk beds of the cabin. Image credit Jesse Kuroiwa.

deficient in resisting the elements. The nature of the layered construction and glues used to hold these layers together are a liability when exposed to moisture. This inevitably relegates CLT's expression to the interior surfaces leaving the building clad in some other material. During the material research portion of the studio, alternative mass timber techniques were also considered. The students studied Nail Laminated Timber (NLT), but it lacks a weather-tight seal due to the wood shrinkage and nail retraction. They also dismissed the most traditional technique, log construction, because of the chinking between the wall timbers demanding constant maintenance in drier climates.

In search of a low maintenance option, the students collaborated with a local timber consultant, Rocky Mountain Joinery, and Structuralist Engineers to speculate on a modified version of NTL. Screw Laminated Timber (SLT) replaces the 2x lumber with three by six-inch tongue and groove timbers while swapping the nails for engineered screws. (figure 5) The assembly eliminates glue to achieve solid floors, walls, and ceilings allowing exposure to the exterior elements. Its' tongue and groove timbers allow the wood to retract without creating air gaps, and the screws keep the assembly tighter than nails.

Structurally the SLT is also leveraged within each cabin to act monolithically as a single diaphragm, achieving greater spans and cantilevers than individual lumber pieces could alone. (figure 6) As the ends of the cabins cantilever past the support piers, the timbers are connected with threaded rods allowing the structure to act as a portal frame. Unlike CLT, the assembly method for NLT allows for walls to be assembled on-site. This eliminates the need for cranes, which were unusable given the density of the forest and inaccessibility of the area.

Outside, the cabins are elevated above the landscape on minimal foundation points (figure 7) to help separate the fauna of desert New Mexico, some of which carry Hantavirus, from the campers inhabiting the cabins. On the interior, the bunks float above the floor, hung from the ceiling by steel rods. This removes all interior vertical surfaces and provides clear sightlines into corners, leaving no spaces for mice to hide or nest. The monolithic nature of the SLT also eliminates the typical cavity construction found in most summer cabins.

Each cabin's bunk beds are designed to offer campers agency on how they occupy the space. (figure 8) The traditional single mattress bunk beds found in most summer camps are replaced with floating post-tensioned SLT platforms. Each platform is extended along the wall's length, providing more space than

Figure 4. One of the original six cabins designed by architect Kurt Vonegot Sr. Image credit Rick Sommerfeld

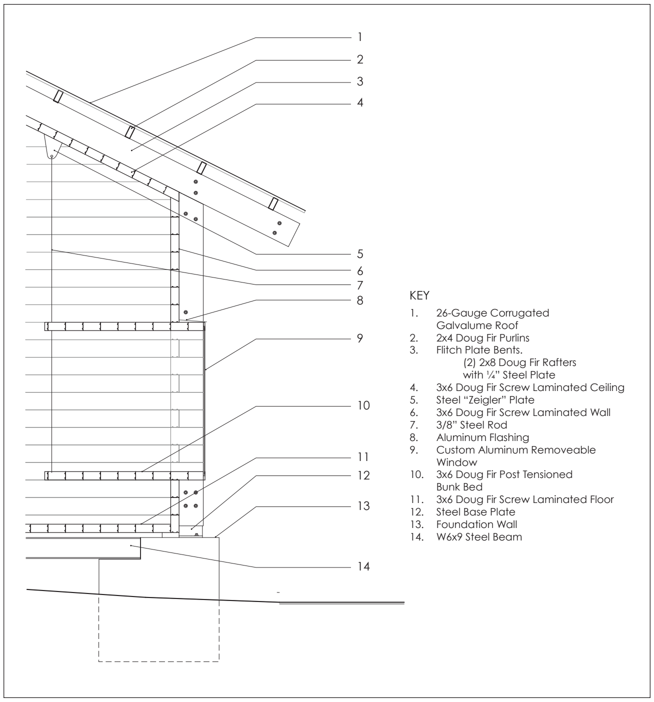

Figure 5. Screw Laminated Timber (SLT) wall section and hanging bunk bed detail . Image credit CU Denver.

Figure 6. Detail of the cantilevered SLT floor and wall assembly during construction. Image credit CU Denver

Figure 7. The foundation points and beams required to support two of the cabins. Image credit Rick Sommerfeld

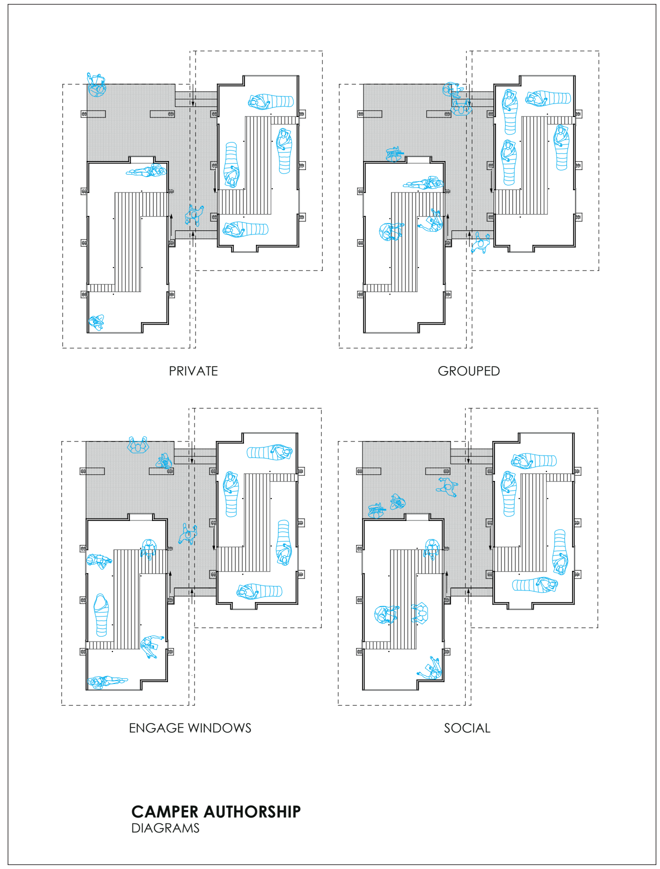

Figure 8. Camper agency diagrams. Image credit CU Denver.

is required for a single mattress. This gives each camper the ability to choose whether they engage a window, sleep close to a friend, utilize negative space for benches, or find their own creative way to make the cabin their own. (figure 9)

The fabrication of these beds provided the most considerable on-site challenges. The beds were designed as a post-tensioned monolithic assembly. While they were mocked up at full scale as part of the studio's proof of concept phase, we failed to consider the movement of the wood when not pinned to a bent frame at longer lengths. Something the full-scale mock-up did not incorporate. (figure 10) While the beds maintained their shape at the wall, the floating edge in roughly 15% of the bunks twisted or cupped enough that it was noticeable. To solve this issue, students swapped warped timbers out of the laminated assembly for straighter boards. However, in severe cases, compression members had to be added to the tension rods to better align the assembly.

A post-occupancy analysis was done by the 2020 design-build class nine months after the 2019 project was completed. Their analysis revealed that the project had performed as expected over the camp's summer season, but noted additional warping in the beds and warping at the bottom of two of the sliding doors. As part of their coursework, they were asked to consider new solutions to reduce the wood movement and, over the three-day field trip, implement these modifications.

The six cabins represent an investigation into alternate assembly methods of mass timber. By having students analyze the deficiencies of one assembly method, in this case, CLT, they could construct a more appropriate solution. The polyvalent design leverages the material's attributes to benefit the structure system, building program, monolithic wall assembly, and nearly inaccessible site.

ENDNOTES

1. Stephen Kieran and James Timberlake. Refabricating architecture: How manufacturing methologies are poised to transform building construction. New York: McGraw-Hill. 2004.

2. Kiel Moe. Convergence: an architectural agenda for energy. London: Routledge. 2013.

Figure 9. Hanging bunk beds provide camper's agency over their space while elevating them above the floor. This allows clear lines of sight and discourages animals from nesting in the cabins . Image credit Jesse Kuroiwa

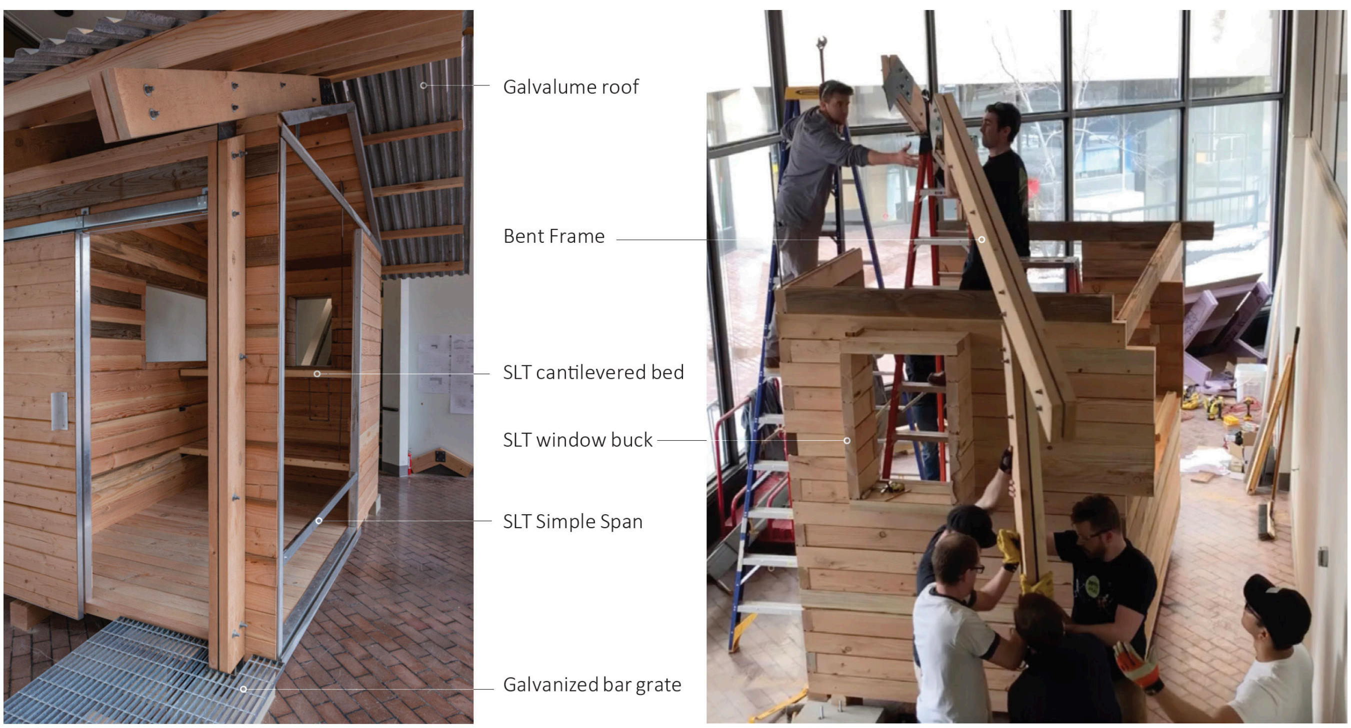

Figure 10. Two views of the 1:1 proof of concept mock-up built prior to the start of the cabin construction. The students used the design exercise to gather critical information about tolerance, materials, detailing, and construction sequencing. Image credit Rick Sommerfeld