

Home for the Homeless using Cross Laminated Timber (CLT) Waste Stream

Introduction

Homelessness has been a rapidly growing social crisis in our city. To address this in a humane manner, a local architect has started a program where a 125 sq. ft accessory dwelling unit (ADU) is built in the backyard of a willing homeowner; the surrounding community provides support to help the resident to get back on their feet. Since 2010 about 10 ADUs have been built using traditional light timber frame construction using volunteer labor. A student team, as part of its capstone project, improved the existing design with the use of waste stream from a Cross Laminated Timber (CLT) manufacturing process.

Current Light Frame ADUs



Project Scope

- Explore using waste material from Cross Laminated Timber (CLT) for ADU construction
- Develop design that is easy to assemble and disassemble by unskilled volunteer labor force
- Improve current design to incorporate sustainable features and Living Building Challenge

Health, Safety and Welfare Issues of Project

- **Homelessness is a social problem** involving public health, safety and welfare
- **Fire safety** of timber structures was addressed
- **Vibration** of timber floors for user comfort was studied

CLT Production and Construction

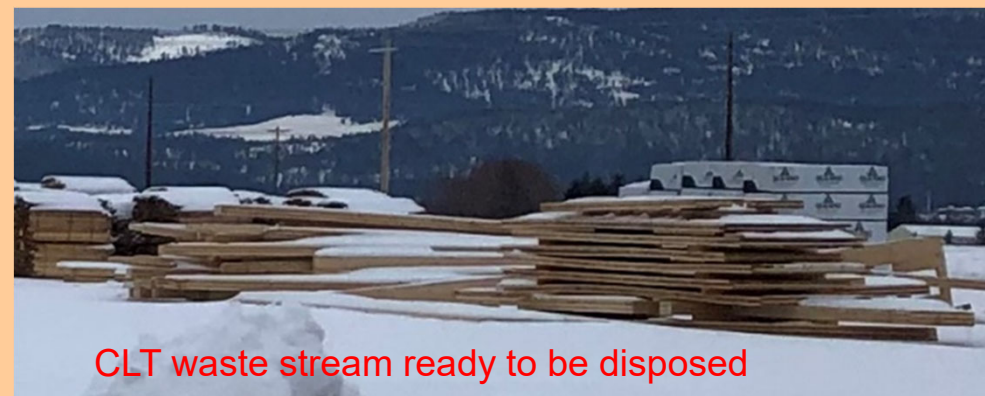
3, 5, 7 or 9 layers of lumber bonded together with adhesives to form 10ft x 40 ft panels



Building components (walls, roofs, beams and columns) pre-cut in factory using CNC machines and shipped to site for construction

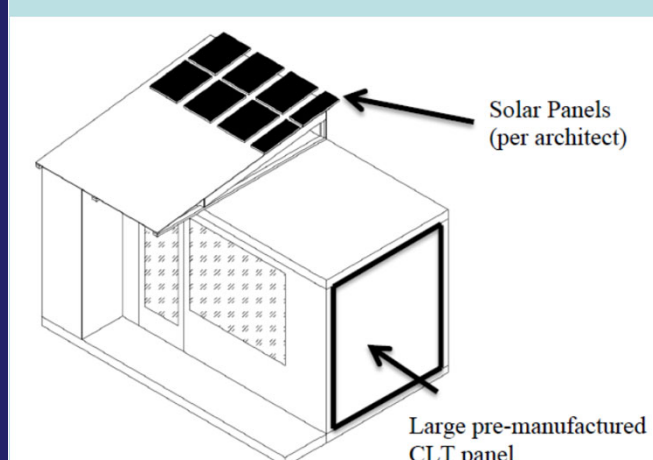


Cut outs and waste CLT discarded



CLT ADU Options Considered

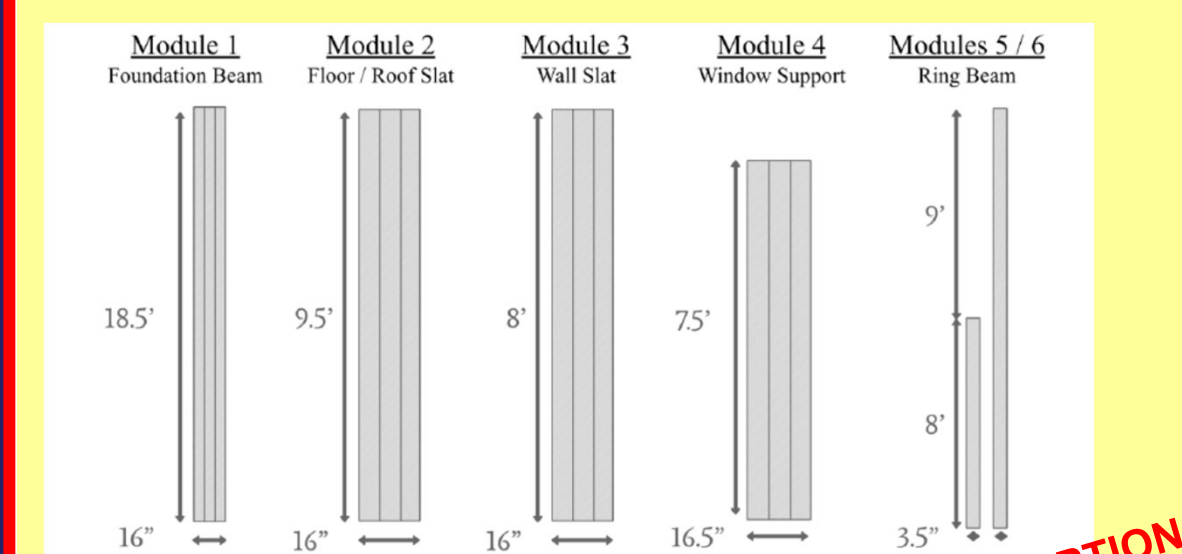
Option 1: Using pre-manufactured CLT panels
Pre-manufactured CLT panels purchased to build ADU



- Least cost effective
- Does not meet goal of using CLT waste stream
- Panels too heavy for volunteers to carry

Option : Modular CLT slats

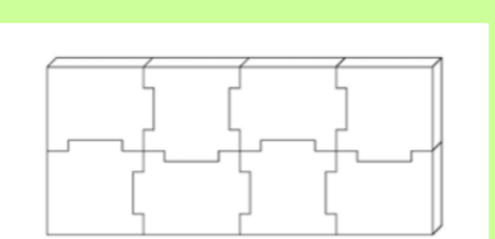
Five different sized panels cut from CLT waste stream and used to assemble ADU



- Cost Effective
- Easy to maneuver in restricted spaces
- Interchangeable pieces make it easy to assemble/disassemble ADU by volunteers

CHOSEN OPTION

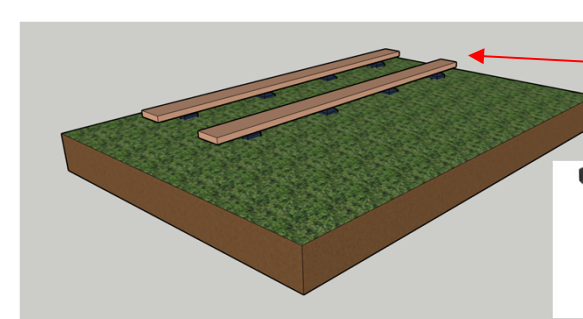
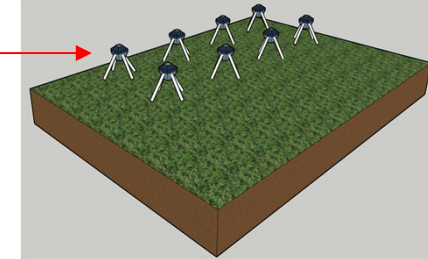
Option 3: Use small building block CLT pieces
30" x 30" pieces of CLT waste products shipped to construction site; pieces assembled on site like Lego® to build ADU.



- Discarded portion of waste stream easy to obtain
- Least expensive option
- Complex to assemble
- Requires several pieces of hardware to assemble

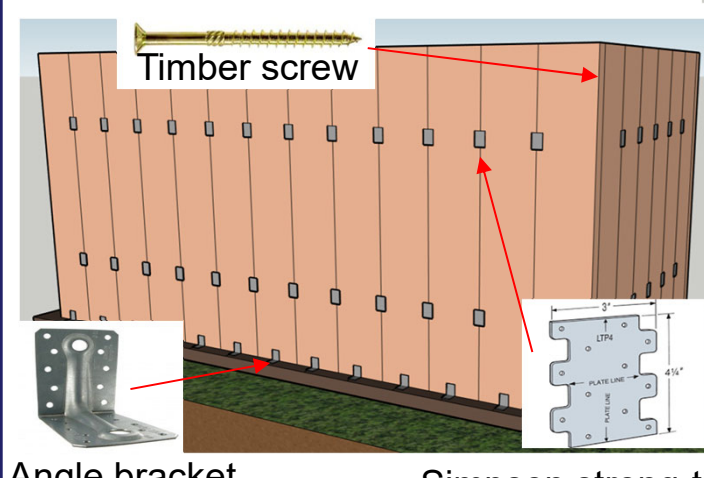
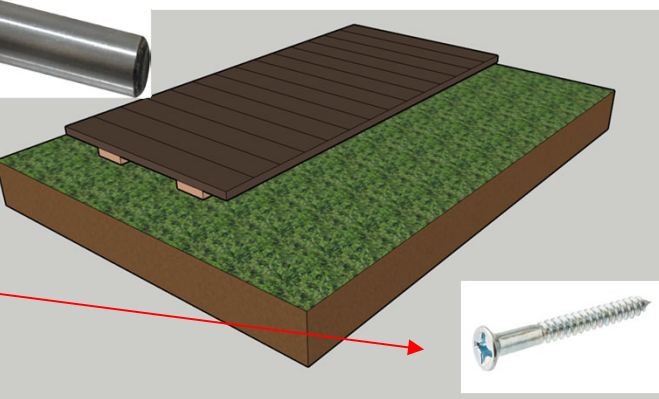
Modular CLT Slat - Construction Sequence

- two rows of four **Diamond Pier foundations** are installed



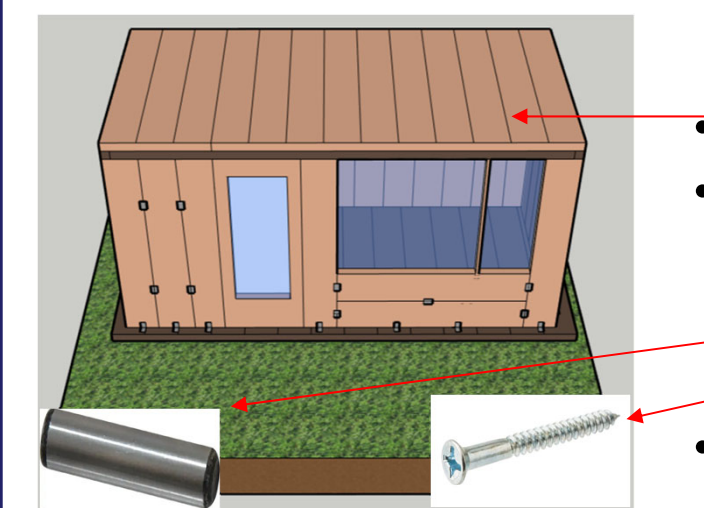
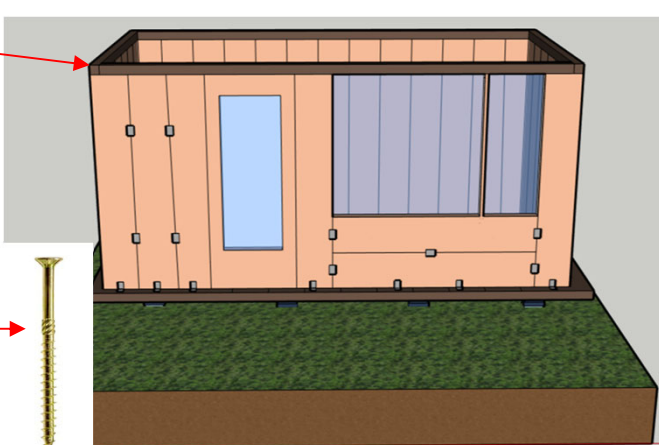
- two **foundation beams** placed on top
- beam connected to foundations with **5/8" x 5 1/2" ASTM A325 structural bolts**

- Floor slats connected with **3/8" x 2" dowels**
- floor connected to foundation beam with **5/8" x 6" flat head screws**

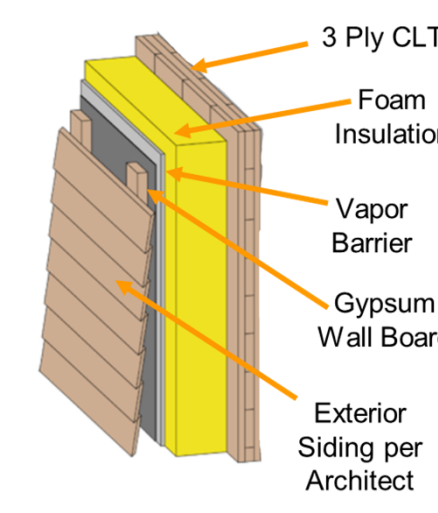


- Wall slats assembled and connected...
 - to each other with **LTP4 Simpson Strong-Ties**
 - to floor with **ABR 9020 Simpson Strong-Tie angle brackets**
 - at corners with **1 1/4 inch SDWS Timber screw**

- **Ring beams** placed on top of wall slats
- Ring beams connected to wall and at corners with **Simpson Strong-Tie SDWS Timber screws**



- Roof slats placed
- Roof slat construction similar to floor with **3/8" x 2" dowels and 5/8" x 6" flat head screws**
- **External Insulation** placed



Engineering Analyses of Modular CLT ADU

Team performed the following analyses (details provided in Project Description)

- **Gravity Analysis**
 - Ability to carry self weight, live load and snow load
- **Wind Analysis**
 - stability against overturning at 110 mph wind events
- **Seismic Analysis**
 - performance in a Type II (most buildings of ordinary occupancy) seismic event
- **Vibration of Floor**
 - Performance of floor to verify no discomfort to user.
- **Fire Safety**
 - Performance after a 1-hr fire event

Comparison of Cost Current Light Frame vs CLT Waste Stream ADU

Home Element	Cost (\$)	
	Light Frame	CLT Waste Stream
Structural Lumber	2,390	760
Structural Hardware	760	1,130
Finished Carpentry ¹	5960	1,660
Coatings	840	400
Envelope ²	3530	4,160
Transportation	-	1,350
Common Materials ³	30,700	
Total Cost	44,200	40,600

¹trimming around openings, cabinetry inside ADU

²architectural finishes and materials for a weather tight enclosure (sealant, insulation, rainscreen)

³foundation, metal roof and siding, doors, windows, interior work, plumbing, HVAC, electrical soloar, landscaping, utilities and permits

Professional Engineers and Allied Professional Participation

- A faculty member (**SE**) advised the team
- A faculty member (**PE**) taught the capstone course
- An **Architect** served as the project sponsor and owner representative
- A **professional engineer** from industry mentored the team on current ADU building practices.
- **CLT factory personnel** met with team to explain the manufacturing process and waste stream generation
- **Diamond pier (foundation) manufacturer** met with team to explain product and construction practices
- Team worked with **unskilled volunteers** to understand the challenges to be aware of in the design process

Knowledge and Skills Gained

Engineering & Technical Skills

- Working knowledge of **various design codes**
- **AutoCAD** for drafting and **Sketchup 3D modeling software** for presentation
- Exposure to **sustainable design features, hardware and connection design, concept of Living Building Challenge** and **cost estimation**

Professional Skills

- Ability to interact with **engineers, allied professionals and volunteers**
- **Communicate effectively orally and through writing**
- **Project management and leadership skills:** running meetings with an agenda and following up action items, managing schedules and budgets; working as a team
- Ability to **work in virtual environment**
- Awareness of **ethical and social responsibility** of engineers