Building Better in the Kootenays

A Natural Building Case Study

BUILDING TYPE
Single detached dwelling
Double stud framing

LOCATION
Krestova, BC
(Climate Zone 5)

ORIENTATION
South East Facing

SIZE, FLOORS
1,534.9 ft^2/ 142.6 m^2
1 floor

ROOMS
2 Bed / 1 Bath + Den

YEAR BUILT
2022

ESTIMATED COSTS

- Actual cost without labour: **$230,000** (~$150/ft^2)
- Total build cost including an estimated cost for labour: **$322,000** (~$250/ft^2)

Highlights

This local builder-owner endeavored to build a highly energy efficient, low carbon, and healthy home. The wall system in their build uses a technique called light clay straw to create a highly insulated and airtight building. The materials used for the walls have fewer embodied carbon emissions than many other conventionally used construction materials. **This home is an exciting example of how to balance affordability with energy efficiency, embodied carbon, healthy indoor environments, and community building.**

This document offers a brief overview of its energy and embodied carbon performance, dives into the specifics of the low embodied carbon wall assembly, and discusses the homeowners experience constructing this home.

Energy Efficiency measures seek to reduce operational emissions (i.e., the greenhouse gas emissions emitted through building energy use such as through heating, cooling, and lighting) via reduced energy consumption.

This high performance home is built to BC's highest efficiency standards. Energy efficient features in this home include an air source heat pump for heating and cooling, triple glazed windows, high R-value ceiling, walls and foundation, passive solar design, and an extremely airtight envelope. Natural building techniques were used to create well insulated and airtight walls.

Step Code Level	5
Air Changes per Hour	0.86 ACH
Annual Energy Consumption	19 GJ/yr

Embodied Carbon refers to the emissions produced through the extraction, manufacturing, transportation, installation, maintenance, and disposal of building materials. Please note that this study looked only at the upfront embodied carbon emissions associated the building materials (i.e., emissions associated with the extraction and manufacturing).

This project had fewer embodied carbon emissions than the average new home in Nelson & Castlegar, with its total emissions per square metre coming in 20% under the local average. The straw used in the walls is considered to be carbon sequestering and is the main contributor to this better embodied carbon performance. The rest of the build used more conventional construction materials.

Material Carbon Intensity (MCI)	122 kg CO_2e / m^2
Average MCI in Nelson & Castlegar	150 kg CO_2e / m^2

City of NELSON · BUILD ENVIRONMENTAL · Harmony Engineering · FORTIS BC Energy at work

Low Carbon Wall Assembly

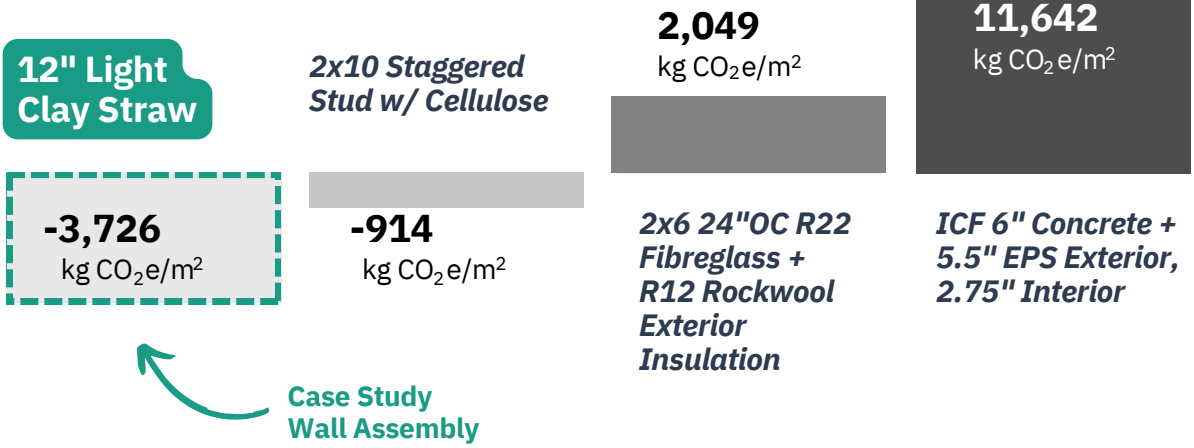
This section of the case study will dive into one component of this build that performed very well in terms of its embodied carbon. It highlights a low-carbon natural building technique and shows comparisons between the light clay straw construction method and other wall systems. This section will be followed by some reflections from the homeowner.

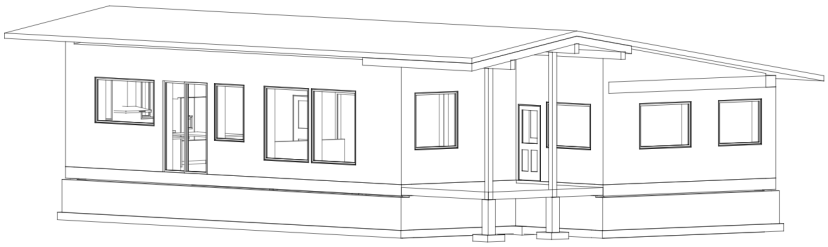
Some natural materials are considered to be carbon sequestering, or carbon-negative, when used in construction. In this context, it means that these materials physically contain more carbon than was emitted in the extraction and manufacturing processes that created them. This leads to a negative embodied carbon number, as seen below. Examples of other carbon sequestering materials include cellulose, cork, bamboo, straw, and hemp.

As new energy efficiency codes are introduced that require more insulation, choosing carbon storing materials will be critical to ensure that we are limiting the overall emissions associated with new construction.

The graphic below compares the embodied carbon emissions from the light clay straw walls used in this project against other commonly used assemblies of the same R-value. The infill for the walls in this home is 12" of clay slip mixed with straw, which is an excellent carbon storing material.

Of note:
In BEAM and many other tools that calculate the embodied carbon of buildings, wood is not considered carbon sequestering because of the implications of forestry practices on emissions. This field is evolving rapidly and it is expected that accounting methods will change in the coming years.

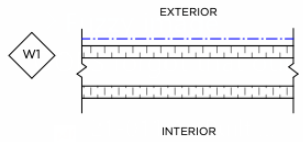




The below graphics provide more detail about the different wall assemblies and materials used in this build. Although this case study aims to highlight the light straw clay wall system, other assemblies used include an ICF crawlspace, insulated slab, and truss roof with blown cellulose insulation.

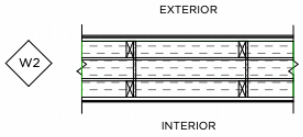
VERTICAL ASSEMBLIES

EXTERIOR WALLS



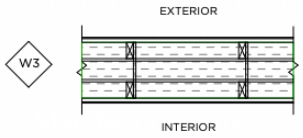
FOUNDATION WALL - ICF

DAMP-PROOFING
2 5/8" RIGID INSULATION
CAST-IN-PLACE
REINFORCED CONCRETE
2 5/8" RIGID INSULATION



EXTERIOR WALL - LIGHT CLAY W/ BOARD AND BATTEN

1 1/2" BOARD AND BATTEN
1/2" PT STRAPPING
3/4" CLAY PLASTER
3 1/2" WOOD STUD LAYER @ 16" O.C.
CONNECTED WITH GUSSETS
3 1/2" WOOD STUD LAYER @ 16" O.C.
W/ 14" STRAW LIGHT CLAY
STABILIZED W/ HORIZONTAL
BAMBOO RODS @ 24" O.C.
3/4" CLAY PLASTER VAPOUR
BARRIER
1/4" FINISH CLAY PLASTER



EXTERIOR WALL - LIGHT CLAY W/ CLAY PLASTER

1/4" FINISH CLAY PLASTER
3/4" CLAY PLASTER
3 1/2" WOOD STUD LAYER @ 16" O.C.
CONNECTED WITH GUSSETS
3 1/2" WOOD STUD LAYER @ 16" O.C.
W/ 14" STRAW LIGHT CLAY
STABILIZED W/ HORIZONTAL
BAMBOO RODS @ 24" O.C.
3/4" CLAY PLASTER VAPOUR BARRIER
1/4" FINISH CLAY PLASTER

PARTITION WALLS

W4 - INTERIOR PARTITION - 2X4

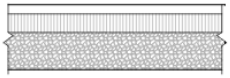
3/4" CLAY PLASTER
2x4 WOOD STUDS @ 24" O.C
3/4" CLAY PLASTER

W5 - INTERIOR PARTITION - ACOUSTIC PLUMBING WALL

3/4" CLAY PLASTER
2X6 STUD FRAMING @ 24" O.C.
5 1/2" LIGHT CLAY INSULATION
3/4" CLAY PLASTER

HORIZONTAL ASSEMBLIES

FLOORS



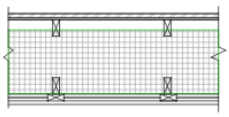
F1 - SLAB ON GRADE - CRAWL SPACE

2" CONCRETE
VAPOUR BARRIER
4" RIGID INSULATION
CRUSHED ROCK W/ RADON
MITIGATION PIPING

F2 - JOIST FLOOR

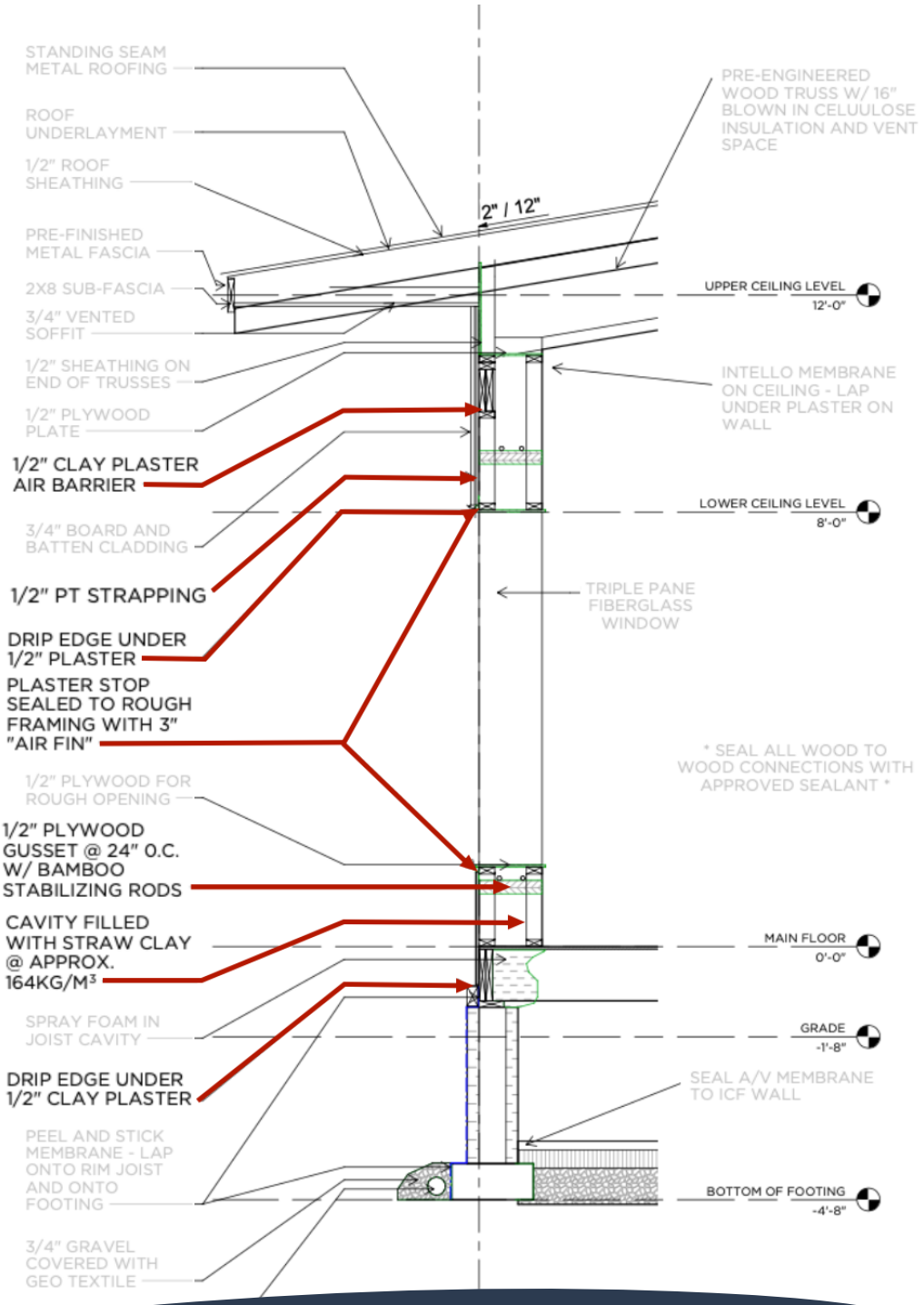
FLOOR FINISH (SEE FINISHES PLAN
AND SCHEDULE)
3/4" PLYWOOD SUBFLOOR
2 X 12" FLOOR JOISTS @ 24" O.C.

ROOFS



R1 - TRUSS ROOF

STANDING SEAM METAL ROOFING
UNDERLAYMENT
1/2" PLYWOOD SHEATHING
TRUSSES @ 24" O.C. W/ 16" BLOWN IN
CELLULOSE INSULATION W/VENT SPACE
INTELLO A/V MEMBRANE
1 1/2" STRAPPING
3/4" WOOD CEILING IFNISH



This sectional view highlights the materials and practices used for this home's wall system. **With careful planning, these alternative materials can be used to create well insulated and highly airtight homes**. The insulating technique used for the walls is called light clay straw (also known as straw clay or slipstraw). It involves mixing a clay slip with loose straw, which is then put into formwork and built up in the exterior walls. In this project, horizontal bamboo stabilizing bars were added every two feet. Once the formwork has been removed and the mix has dried, the walls can be plastered. This project used earthen plaster which was mixed on site using clay, sand, cellulose and wheat paste.

Homeowner Experience

This section summarizes the experience of the builder-owner: Alexis St Jean Duncan.

How **affordable** was this project?

This project prioritized cost-effectiveness by pursuing a simple, energy efficient design, doing the labour themselves, and being financially prudent with building material purchases.

"The cost of natural materials is dramatically cheaper than industrialized materials. This is usually offset by more labour costs, but becuase we did it ourselves this reduced the overall cost of the project dramatically. We were fairly thrifty with our conventional material purchases which certainly reduced the cost as well. I expect the annual energy bills to be about half of what I would pay for a "conventional" house, though I don't yet have enough data to confirm this. Our build cost was about $150/ft^2 which is less than half what a conventional build would have cost us."

What have you noticed most about the home since moving in?

"I have noticed that it's a very comfortable space to live in. Our passive solar design is working very well. On a day that was -3°C, with sun, our house was 23°C with no heat on. On another note, our main room has tall ceilings with lots of wood finishes so the space is quite loud. We are going down the road right now of sound mitigation for that room."

Describe the **labour and skillset** required to build straw-clay walls.

Though some natural building practices can be more time and labor intensive, they are quite accessible for anyone to learn, expanding the opportunity to have friends and community members participate in the building process.

"The skills required to frame these walls are the same as those needed for conventional framing. Doing the wall infill is very easy and quick to learn, as it is just coating straw with clay and putting the mix into forms. Anyone can learn this in about 10 minutes of instruction. One experienced person can keep 5-7 inexperienced people working. The plastering of the walls is the most technical part of the process but can still be done by just about anyone. It does take a lot of time and patience to get the plaster flat and an overall good result. This may be the most challenging part of a project like this, but there are many local people who are excellent plasterers who can be hired on or can provide mentorship"

Describe the **air barrier system** used and any notable details.

"I spent a lot of time planning my air barrier to reach Step 5 of the BC Energy Step Code. The foundation/crawl space is typical with some ICF and poly vapor barrier. For the walls, I used clay plaster with "air fins" where the plaster meets any wood (windows, doors, walls). An air fin is simply some sort of air impermeable material (1/8" plywood as an example) that is adhered to the window box (or door or wall) that extends 3-5 inches onto the wall and into the plaster. The plaster can lap over this "air fin" and provide continuity of the air barrier. For the ceiling, we used an intello membrane as it seems well suited for an attic space. We did install a 3.5" drop ceiling below my ceiling membrane so all electrical/services could be inside my air barrier and not penetrate it. I was also very diligent with sealing all framing componenets - plates to sub floor, window boxes etc."

"Our passive solar design is working very well. On a day that was -3°C, with sun, our house was 23°C with no heat on."

ALEXIS ST JEAN DUNCAN
HOMEOWNER & BUILDER

Why is natural building **important** to you?

- *"The use of **local and natural materials** can lead to fewer transportation and fabrication/manufacturing emissions.*
- *Building with natural materials has a lower barrier to entry so it becomes easier to hire local people or unskilled people to help with the build. Friends and family can more easily help due to the **low skill requirements**. The construction site is quieter when building this way so its easier to have meaningful conversations when working together as a team.*
- *It is much **healthier** to build with these materials as we are not exposed to as many chemicals etc. These materials have an ability to moderate temperature, humidity, and sound, as well as filter the air, resulting in a healthy home to live in.*
- *The materials are much **cheaper** than conventional materials.*
- *The **aesthetic** of plaster walls is very pleasing to me.*
- *The long-term **durability** over conventional construction and ease of repair work is appealing."*

"Incorporating natural building practices and materials has the ability to create healthy indoor environments, reduce costs, and involve community - all while sequestering carbon in the structure of our homes".

MICHELE DELUCA
ENERGY ADVISOR & CASE STUDY CO-AUTHOR

This project shows us that building energy efficient, low-carbon and healthy homes is already within reach for new homes in the Kootenays. The use of natural building techniques provides an opportunity to take advantage of carbon storing materials. With a little research, these practices can be learnt by not just experienced builders, but friends, family, and community members alike.

The project team recognizes that natural forms of building like light clay straw can be time intensive and many in the building community may not prioritize some of the features of natural building that Alexis values highly. Perhaps this just means however that it's time to innovate in the realm of natural building. How can we scale up certain elements of natural building practices to capitalize on its health and carbon benefits? **Utilizing carbon storing materials will become an increasingly important feature of our building emission reduction strategy moving forward and projects like this help us think through what is needed to further advance natural building in a way that aligns with our climate, health, and affordability concerns.**

Low Carbon Homes Pilot Project Team

This project was funded by a FortisBC grant.

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