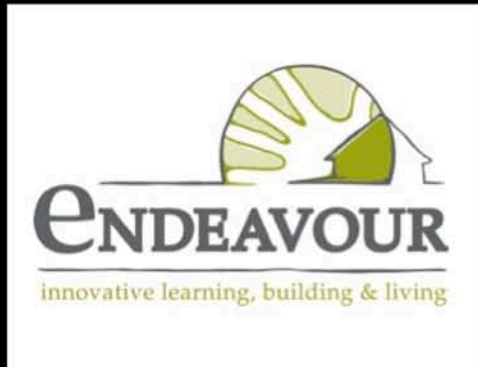




Canada's Greenest Home

An Endeavour Centre Project
www.endeavourcentre.org



About this book

In 2011, an opportunity to build an urban infill home in the city of Peterborough arose when local by-laws changed to allow for smaller lot sizes to encourage urban density.

The Endeavour Centre partnered with a brave and adventurous funder, Neeraj Jain, to undertake the building of what we hoped would be the “greenest” home in Canada.

We strived to combine the many facets of sustainable building, including high energy efficiency, low embodied energy, local materials, low waste, net zero energy and water use and high indoor air quality.

This book documents the remarkable adventure this project entailed...

Making Canada's Greenest Home

An Endeavour Centre Project, 2012
www.endeavourcentre.org

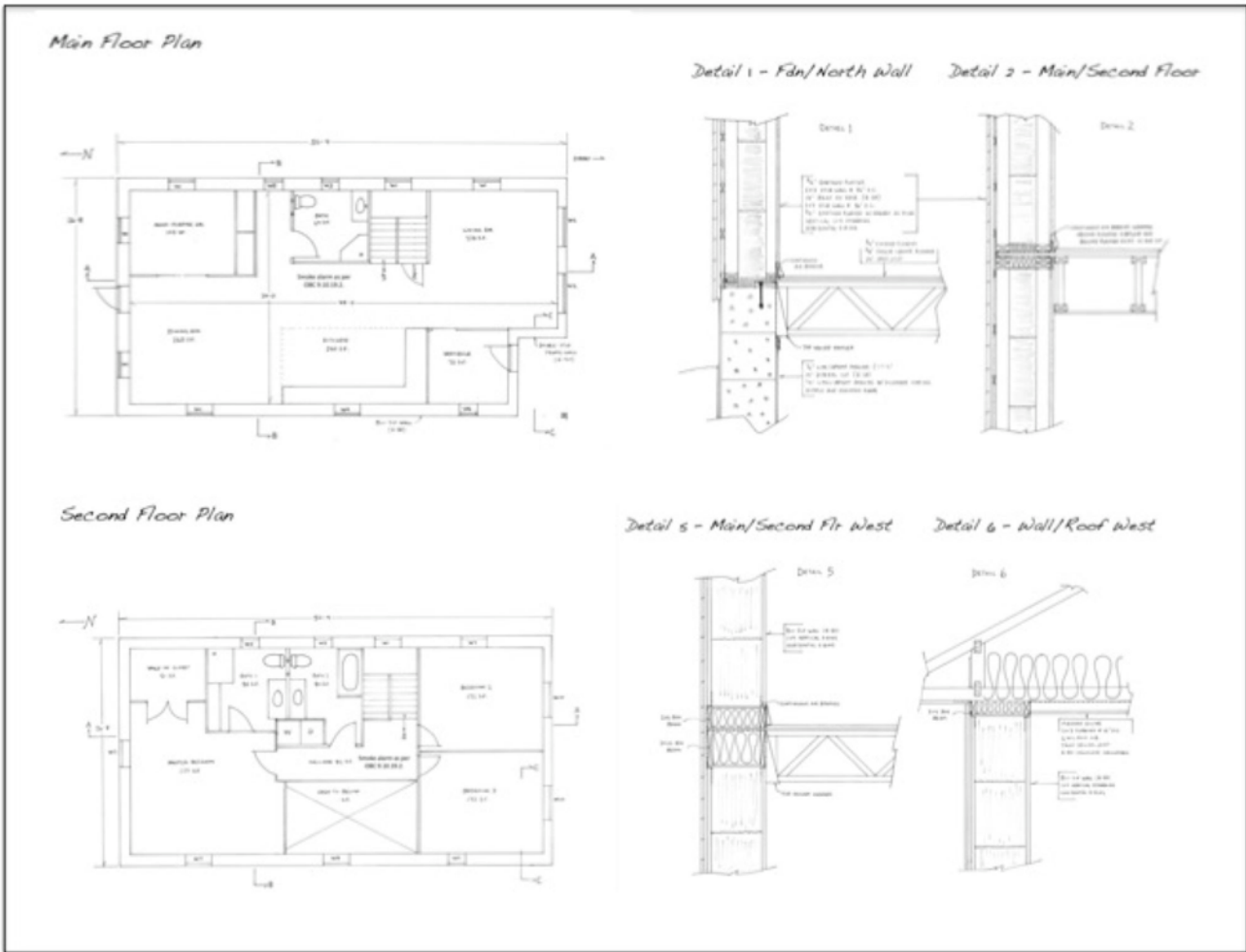
Education is key

The Endeavour Centre's projects are about learning and sharing

Endeavour's project to design and build Canada's Greenest Home is part of our ongoing efforts to train builders and designers in the art and science of sustainable building. This project was undertaken as part of our Sustainable New Construction program, a five-month certificate program in which our students take a leading role in building and managing a full-scale sustainable building project.

The class of 2012 faced a real challenge with this project, as it involved numerous innovative materials and systems combined with a high degree of fit and finish.

We want to thank the students for all of their efforts throughout the program.



Floor plans and details

The floor plan shows 2300 square feet of living space over two floors. The details give high priority to insulation and air sealing for energy efficiency.



Changes to municipal by-laws made it possible to sever this lot

The dimensions of the new lot are 36 feet x 200 feet. This is large compared to some urban areas, but considered quite narrow in Peterborough.

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A sign signals our intentions to build Canada's greenest home.

From the outset, public education was a strong part of our building mandate. Online blog updates and on site tours were conducted throughout the process.

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Celebrating the completion of footings

The construction of the footings (using high slag content concrete) was the first building work undertaken by most of our students.

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Placing Durisol ICFs

Locally manufactured Durisol blocks, made from waste wood chips, cement and Roxul insulation, are mortared to the footing to create a level first course.

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Stacking Durisol blocks

Durisol is dry stacked course by course, with the Roxul insulation facing the exterior side of the building.

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Durisol corners

Special corner blocks from Durisol ensure a good fit and minimal bridging. These blocks achieve an R-28.

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Durisol close-up

Durisol blocks have the same R-value through the block as they do where insulated by Roxul. Horizontal and vertical rebar reinforces the concrete to be poured in the channels.

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Hempcrete joint filling

Our own modification of the Durisol process involved using site-mixed hempcrete to fill some of the inevitable gaps between the blocks.



Concrete pump truck arrives

The completed Durisol foundation walls are to be filled with a high-slag concrete, placed using a pumper truck.



Easy filling of ICFs

The pump truck makes it quite easy to direct concrete into each of the vertical channels in the Durisol.



Pour is complete

With the Durisol forms poured full of high-slag concrete, the mood is celebratory!

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Parging of Durisol

A lime/cement parging material is applied directly to the Durisol, which is a great substrate for plaster.



Waterproofing and drainage

A material called Liquid Rubber is the most environmentally friendly waterproofing we could find, with low-VOCs and water-based. Sloping drainage pipes duct water away from the base of the foundation.

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Dimple mat and caulking

A 100% recycled plastic dimple mat is the final layer of water protection for the foundation. Non-toxic, no-VOC caulking protects each screw hole.

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Washers for dimple mat

After applying caulking in the appropriate dimple hole, a plastic washer is used to attach the mat to the wall. Durisol takes a screw without needing to pre-drill.

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Final steps before backfilling

The top edge of the dimple mat is secured, and landscaping fabric covers the drainage pipe and gravel.

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Perlite insulation between sill plates

Perlite is a natural insulator, a type of “popcorn rock” harvested regionally. It insulates between the sill plates.



Perlite close-up

A lightweight mineral, perlite is a good choice for sill plate insulation as water can drain through it, but it does not degrade when wet.



Open web floor joists

Finger-jointed, open web floor joists are hung inside the foundation. These joists can be cut to length on site, and are the same cost as 2x10s while being lighter, stronger and truer.

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Finished floor system

Hung entirely inside the foundation, the floor joists do not cause any thermal bridging to the outside of the building.

Local pine floor decking

In the absence of plywood decking that is formaldehyde free, we elected to use locally-milled pine for the floor decking.

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Air sealing for the walls

An air barrier is laid under the floor decking and will attach to the walls, ensuring no leakage around the perimeter of the building.

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Starting the prefab bale walls

The class visits the Nature Built Walls facility to help with the construction of the Bio-SIPs. First step is to sort and size the straw bales.

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Preparing the forms

The Bio-SIPs are built horizontally inside forms. The base of the form is coated with used vegetable oil to prevent the plaster from sticking to the form.

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Plaster levelled in form

The lime/cement plaster is poured into the form and levelled to be 1 inch thick prior to the straw bales being placed in the form.

“Buttering” bales

The straw bales have a coat of plaster worked into their surface before being placed in the forms. This ensures a strong bond between bales and plaster.

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Bales placed in forms

The buttered bale is placed into the wet plaster in the form.

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Bales squeezed in

Each course of bales fits tightly into the forms, requiring them to be squeezed against each other.

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Beating bales

Each course of bales is beaten to drive it tightly against the preceding course. A tight fit all around ensures an even R-value for the finished wall.



Bale stomp!

The bales are forced down into the form to ensure good contact with the wet plaster below.



Plaster worked into top surface

The top side of the bales have the plaster worked vigorously into the surface.



Screeding top side

The final layer of plaster is screeded to be level with the form all around.



A finished panel

The class poses with their first finished panel. Building bale walls this way requires about 1/4 of the labour time of building the same walls on site.



NatureBuilt BioSIPs arrive

All the walls for the home fit on one delivery truck.

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Crane set up

A crane is hired to take the walls from the truck and place them on the foundation.

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Over the power lines.

The walls needed to clear the power lines at the road, necessitating a larger crane than would normally be required.

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Moving into position

Each wall section is numbered, and is moved into place before being secured to the foundation and temporarily braced.

Air tightness detailing

The air barrier from the foundation is overlapped with the barrier on the Bio-SIP and taped to ensure a tight seal at this critical junction.

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South wall framing

The narrow south wall of the house is double stud framed and will receive dense-packed cellulose insulation.

FSC confusion

Despite the bold FSC (Forest Stewardship Council) stamp, the above 2x4 does not meet FSC requirements for certification, while the lower one without the FSC stamp does.

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Air tightness detailing

Second floor joists hang inside the walls to prevent air and heat leakage. The air barrier between Bio-SIP panels are overlapped and taped.

Second floor decking

Locally milled pine is used to deck the second floor joists. While the wood was not FSC certified, we liked that the wood was harvested and milled locally.

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First Bio-SIP on second floor

The crane returns to install the second floor bale wall panels.

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Panels nearly completed

Each panel is guided into place and fastened to the second floor deck.

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Second floor panels completed

With all the panels installed, the house is ready for the frame wall sections to be built.



Gypsum board sheathing

A gypsum board sheathing called DensGlass is used on all the frame wall sections. This sheathing maintains the high degree of vapour permeability of the bale walls.

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Roof trusses are delivered

The boom arm of the truss delivery truck raises the truss bundles onto the building.

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Light through the trusses



Roof framing is complete

The main roof and the shade roof over the first floor windows are completely framed and awaiting strapping and roofing steel.



North wall framing complete

The double stud framing on the north is on 36 inch centres to allow for a straw bale in each stud cavity.

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Framing and air sealing

The second floor interior walls are framed, and careful air sealing is done between the ceiling and the exterior walls.

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Poraver basement insulation

Poraver, an expanded glass bead made from recycled glass, is used to make an innovative insulation under the basement slab floor.

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Testing Poraver mix

Poraver is mixed with metakaolin (a fired kaolin clay, byproduct of making Poraver beads) and hydrated lime to make a cement-free, mineral insulation.

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Basement floor prepared for insulation

A heavy 10-mil poly barrier is laid over the gravel base and taped and caulked to the basement walls in advance of pouring the Poraver insulation.

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Mixing Poraver

The dry Poraver ingredients are mixed with water to make "slurry balls" which are delivered to the basement.

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Pouring Poraver

An 8-inch layer of Poraver mix is laid on the basement floor. This will give us approximately R-16.

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The Poraver insulation is complete

The roughly troweled finish is ready to receive the concrete basement floor. The Poraver insulation is solid enough to walk on in 24 hours.

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PV installed on roof

5 kilowatts of photovoltaic panels are mounted on the roof. This should be sufficient for the home to operate at net zero energy usage.

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Inverter for PV

The inverter for the photovoltaic system converts the DC power generated by the panels to AC power to sell to the utility company.

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Keeping track of waste

Throughout the project, we tracked our “waste” carefully, sorting and weighing everything that left the job site.

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A fraction of the waste

Our final tally was 3,537 pounds of recycling and 852 pounds of landfill. That's about 10% of the average 8,000 pounds of landfill per residential build in Ontario!

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Straw bales installed

The north wall of the house was baled on site to give students some hands-on experience in this form of construction.

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Bales straightened and air sealed

To match the straightness of the prefab bale walls, we carefully pounded the bales to make a flat substrate for the plaster. Air sealing around the windows was carefully detailed.

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North wall fully baled

Both stories of the north wall are fully baled. The wooden blocks on the studs are for horizontal strapping to support the eventual wood siding finish. Before siding, the walls were fully plastered.

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Mixing clay plaster

Our clay plaster was a mix of bagged kaolin clay, sand and chopped straw, combined with water in a mortar mixer.

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Careful mix ratios

The clay plaster was mixed with 1 part clay, 1.5 parts sand and 3 parts finely chopped straw, all measured by volume.

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Excellent mix!

The clay plaster is a stiff mixture that is very high in chopped straw. This allows the entire desired thickness to be installed in one coat, while building up to a very straight and smooth finish.

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Plaster begins

Loving described as mounds of elephant dung, enough plaster for the whole wall can be mixed at once, and then used over the course of a couple of days to complete the wall.

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Wall nearly plastered

Despite having no previous plastering experience, the class creates a very smooth wall. Note the 2x4 leaning on the left, which was used to check for straightness. The clay mix is very forgiving, with long working times.

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Dense packed cellulose insulation

The frame wall sections of the building were insulated with dense-packed cellulose, blown into place with a high pressure blower.

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No longer loose insulation

Installed to a density of 4 pounds per cubic foot, the cellulose insulation no longer settles or moves. When touched, it feels more like a typical batt insulation.

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Air barrier for cellulose walls

The frame walls are not being plastered, and so need an air barrier to maintain air tightness.

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MemBrain allows vapour diffusion

Unlike typical plastic vapour barriers, MemBrain allows for drying through diffusion under humid conditions. This can help the walls to stay dry when vapour drive is inwards, especially during hot periods in the summer.

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Fully air barred

Each frame wall section receives a permeable air barrier membrane, and these are carefully tied into the bale wall sections and the window and door openings.

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Air sealed interior

The different wall types and the window sections are all carefully detailed to keep the home as air tight as possible.

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Triple pane fiberglass windows

Triple pane windows from Inline Fiberglass are given different coating treatments depending on their exposure. This south facing window has a high solar heat gain coefficient (SHGC).

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Qualified for area indicated.
Admissible pour les régions indiquées.

Canada  ENERGY STAR 1 800 367-2000 energystar.mrcan- mcan.gc.ca	ER/RE=48  = Zones A B C D	
 National Fenestration Rating Council CERTIFIED	Inline Fiberglass Ltd. 325 Series CPD # IFL-A-4-00071-00001 Fiberglass Frame Triple Glazing - Argon Fill - Low E High Fixed	
ENERGY PERFORMANCE RATINGS		
U-Factor 0.17 (U.S./I-P)	0.97 (Metric/SI)	Solar Heat Gain Coefficient 0.50
ADDITIONAL PERFORMANCE RATINGS		
Visible Transmittance 0.52	—————	
<small>Manufacturer warrants that these ratings conform to applicable NFRC procedures for determining window product performance. NFRC ratings are determined for a fixed size of window unit, regardless of the specific product size. NFRC does not warrant any product and does not warrant the suitability of any product for any specific use. Contact manufacturer's literature for other product performance information. www.nfrc.org</small>		
46217- / 0002		

Fiberglass windows

The installation of the triple pane windows gives us the first sign of a final finish, and is an exciting landmark.

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The students say goodbye

The eight intrepid students of the class of 2012 take their leave at the end of the summer. Their efforts were an integral part of the eventual success of the home.

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Mitsubishi Zuba air source heat pump

The outdoor portion of the air source heat pump (ASHP) extracts heat from the outside air and converts it to usable heat using the refrigerant cycle. It functions to temperatures as low as -30 C.

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Mitsubishi Zuba indoor portion

The air handling end of the ASHP is in the basement. A radiator transfers heat from the refrigerant to the air handling unit, where it is distributed throughout the house through ductwork.

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Energy Recovery Ventilator
vanEE Gold Series
Model: 1000
Capacity: 1000 CFM
Efficiency: 85%
Voltage: 240V
Wattage: 1500W
Weight: 45 lbs
Dimensions: 24" x 24" x 12"

vanEE
Gold Series

INSTALLATION INSTRUCTIONS
1. Read the entire manual before installation.
2. The unit must be installed in a well-ventilated area.
3. The unit must be installed in a dry location.
4. The unit must be installed in a location where it will not be exposed to moisture.
5. The unit must be installed in a location where it will not be exposed to dust or debris.
6. The unit must be installed in a location where it will not be exposed to oil or grease.
7. The unit must be installed in a location where it will not be exposed to corrosive vapors.
8. The unit must be installed in a location where it will not be exposed to high temperatures.
9. The unit must be installed in a location where it will not be exposed to high humidity.
10. The unit must be installed in a location where it will not be exposed to high air velocity.
11. The unit must be installed in a location where it will not be exposed to high air pressure.
12. The unit must be installed in a location where it will not be exposed to high air pollution.
13. The unit must be installed in a location where it will not be exposed to high air noise.
14. The unit must be installed in a location where it will not be exposed to high air vibration.
15. The unit must be installed in a location where it will not be exposed to high air humidity.
16. The unit must be installed in a location where it will not be exposed to high air temperature.
17. The unit must be installed in a location where it will not be exposed to high air pressure.
18. The unit must be installed in a location where it will not be exposed to high air pollution.
19. The unit must be installed in a location where it will not be exposed to high air noise.
20. The unit must be installed in a location where it will not be exposed to high air vibration.

Energy Recovery Ventilator

The ERV is a requirement for an air-tight home. It draws fresh air from outside and transfers both heat and humidity to the incoming air from the outgoing air. It keeps the air fresh and balanced in the home.

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Discovering Siga Tapes

The discovery of Siga Tapes from Switzerland allow us to step our air sealing efforts up a notch. These flexible, durable and incredibly sticky tapes give an exceptional seal around windows and where different materials meet.

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First blower door test

An initial blower door test is performed once we have the exterior fully sheathed and sealed. This allows us to find leaks and problems while we can still address them.

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Barriers breached!

After getting a good air tightness score of just over 1 air change per hour at 50 pascals depressurization (1.0 ach/50), the drywall crew slices the barriers in numerous places. Luckily we spotted the problems in time to fix them.

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Solar hot water system installed

Two solar hot water collectors will provide the majority of domestic hot water for the building. The exterior of the building is also fully strapped ahead of the siding being installed.

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Finishes begin

A homemade limewash for the wooden ceiling on the first floor is the first of the natural finishes used throughout the building. It is made from 1 part casein powder, 12 parts water and 16 parts hydrated lime.

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Ceiling whitewashed

The local pine ceiling is whitewashed in two coats. This brightens up the wood while still allowing it to absorb and release moisture. All our finishes were chosen for their healthy ingredients and permeability.

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Lifetime treatment for cedar shingles

Locally milled white cedar shingles were used as siding on the upper portion of the building. They are dipped in Lifetime, a non-toxic, mineral based wood treatment.

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Lifetime protection

The Lifetime product gives the shingles a nice coloration and protects them from water and UV. It also prevents the rough appearance of untreated shingles as they fade in the sun.

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Historic shingle patterns

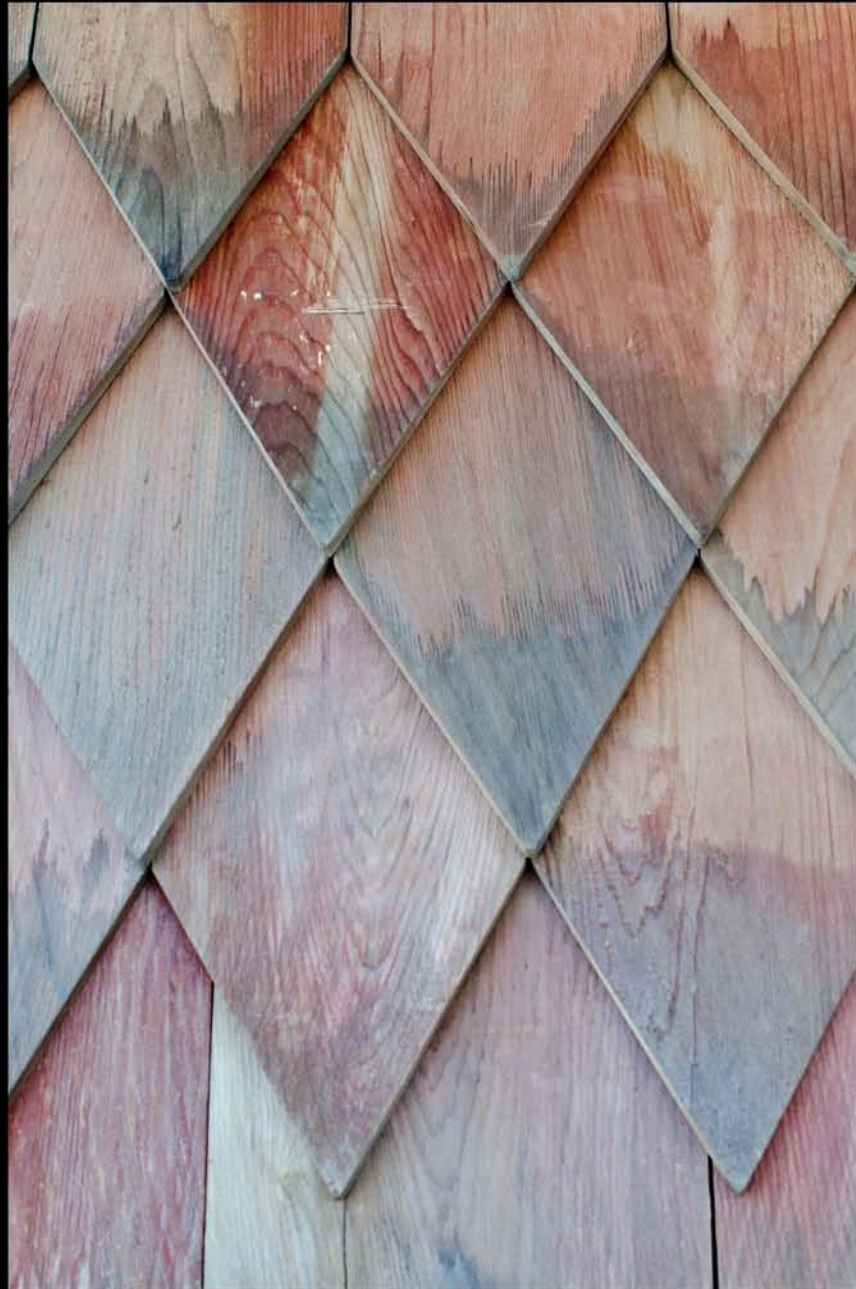
We chose cedar shingles for their beauty, durability, low environmental impact, and because there is a long history of shingled gables in Peterborough. We studied and matched historic patterns for the gable.

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Cedar shingle close-up

Lifetime stain brings out red, green and grey tones in the cedar shingles. This diamond pattern is around the front door, and it also a historical pattern.

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Pure Pine siding

Pure Pine siding is regionally harvested FSC certified and uses Sansin EcoStain as the finish. It is applied as a vented rain screen, meaning that there is space for air to move behind the siding to ensure the walls can dry.

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Blending sidings

The cedar shingles and the pine siding blend well together around the front door.

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Exterior nearing completion

The exterior of the house is almost complete. A proper front deck made from local white cedar is all that remains to be completed in this photo.



The "heart" of the solar hot water system

This orange box is the control centre and heat exchanger for the Thermo Dynamics solar hot water system.

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On demand water heater

The EcoSmart electric on-demand water heater is a modulating unit, meaning it only adds the amount of heat required to reach the desired temperature. It marries well with the solar hot water.

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Hot water centre

The combination of solar hot water with the on-demand heater ensures minimal energy bills for hot water. The waste heat recovery unit on the right preheats incoming water during showering.

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Rainwater treatment

The rain water collection system is capable of supplying potable water to the house, or can supply water to a selection of fixtures in the home.

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Electrical centre

The PV inverter and the main electrical panel are placed together. A full power monitoring system will be installed at this location.

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Clivus Multrum composting toilet

Though offering a viable composting toilet option, we ended up removing the Clivus Multrum before it was commissioned, feeling it was too cumbersome for the future homeowner.

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Envirolet SmartFlush composting toilet

This vacuum flush composting toilet replaced the Clivus Multrum. Smaller, simpler and easier to maintain, it is the best option we've seen for home scale composting with minimal adaptation required for owners.

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SmartFlush vacuum flush toilet

This vacuum flush toilet is the only composting toilet arrangement that does not involve an open pipe connecting to the composting chamber. This makes it cleaner, neater and more energy efficient. It only uses 0.2 liters per flush!

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Lots of natural finishes

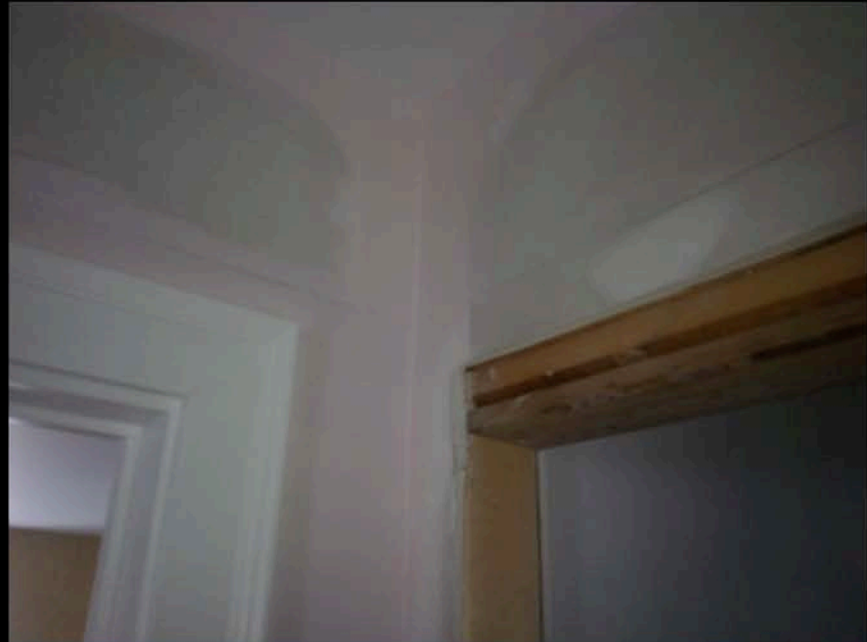
In order to have all natural finishes in the building and no toxic chemicals at all, we used a range of different natural paints and surface treatments, including lime, clay and milk paints as well as natural oil paints.

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AFM Safecoat Naturals paint

The natural oil paints from AFM Safecoat are remarkably similar to conventional paints in cost, appearance and ease of use, and yet are completely biodegradable and healthy.

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Cabinetry from Tall Tree Woodworks

The kitchen cabinetry is made from FSC certified and zero-emissions materials by a local wood worker.

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Entry vestibule

The entry vestibule gives lots of room for boots, coats and outdoor gear. Natural lime (white) and clay (orange) paints finish the walls, with a durable tile floor.

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Finishes continue

An FSC certified maple floor from Nadurra has a no-VOC finish. Home made clay plaster (red) blends with Auro lme paint (white) on the walls.

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Home made clay finish plaster

A thin skim coat of clay plaster is applied over the thick clay base coat on the north wall. We use 10 parts clay, 4 parts sand, 1 part calcium carbonate, 1 part flour paste and ~3.5 parts water, plus natural pigment from Kama Pigments.

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Kreidezeit clay paint

Kreidezeit clay paints come pre-tinted and are the easiest and most reliable clay paint we've used. The finish is durable and has a great texture.

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Kreidezeit casein paint

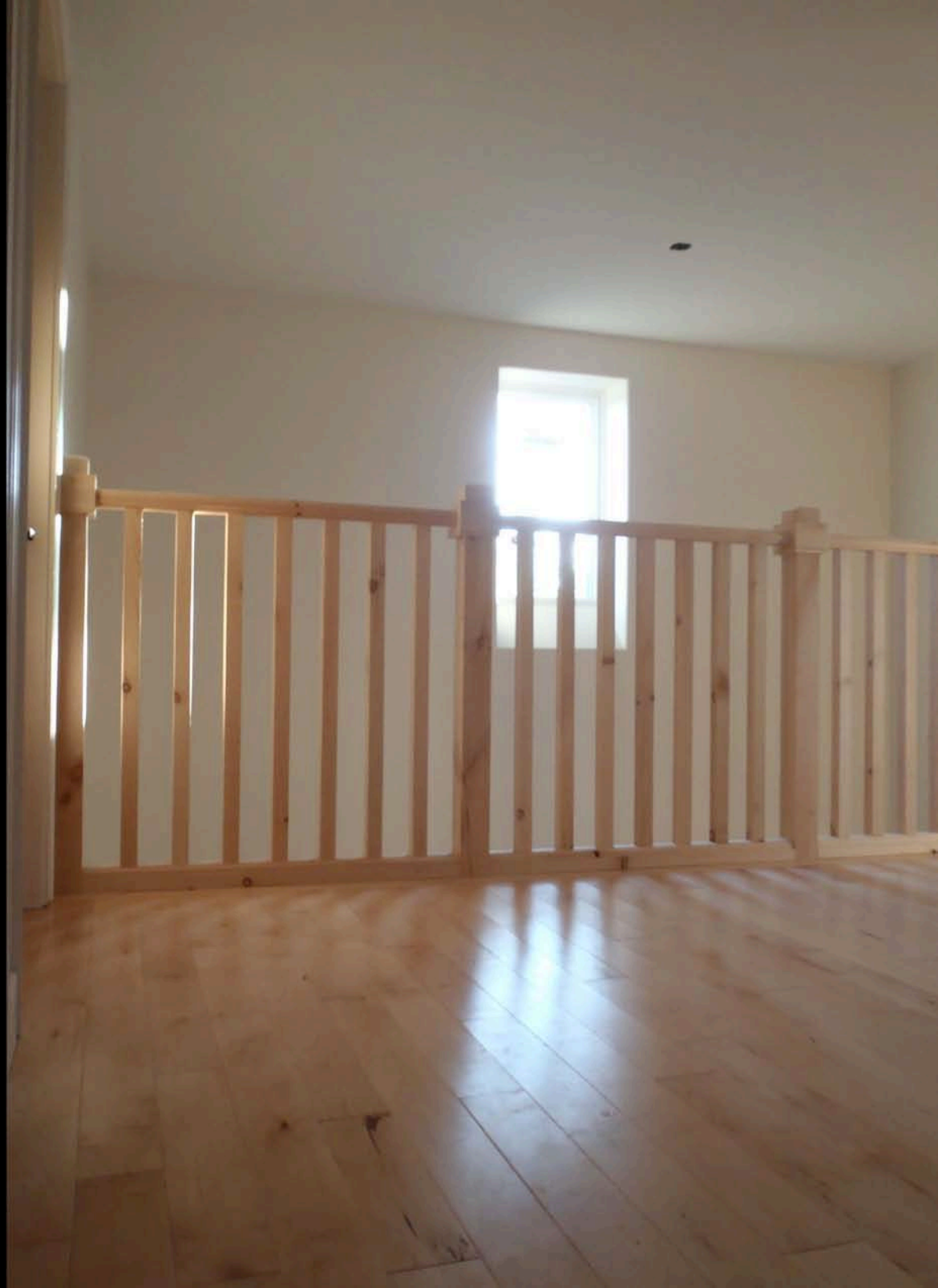
The casein paint from Kreidezeit uses vegetable casein, rather than milk protein. We added tint to the white base paint, and the results were excellent.

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Lots of natural light

A crucial part of the design included ensuring light from more than one direction in every space and room in the home. This gives plenty of natural light without large window sizes.

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Kitchen nearly completed

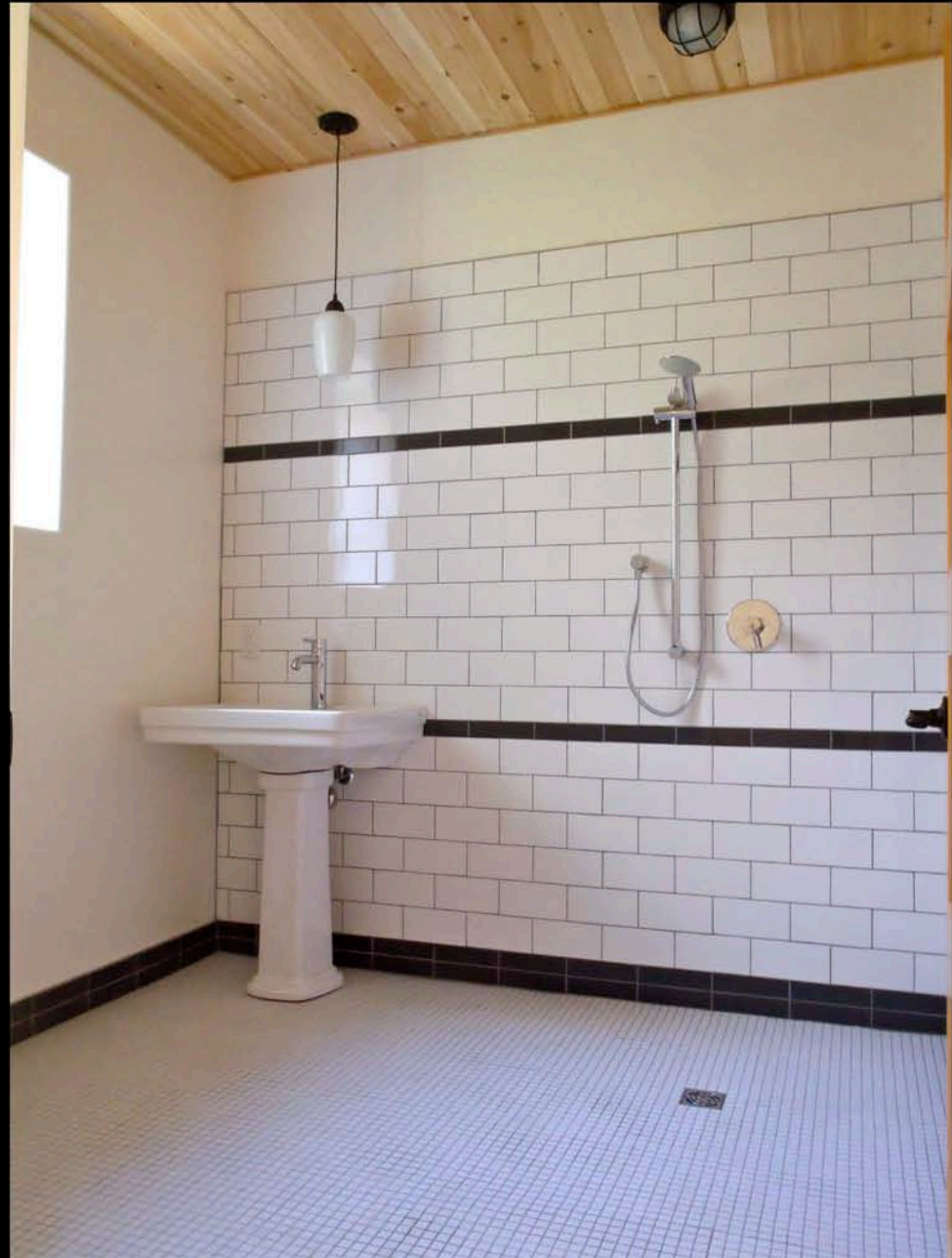
Paperstone countertops (black) give a durable, no-VOC finish. The maple and walnut countertop on the island is treated with AFM Safecoat oil-wax.

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Fully accessible bathroom

The main floor of the home is fully accessible, including a wheel-in shower in the accessible bathroom. Cedar ceilings in all the bathrooms provide a moisture sink.

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Natural materials, natural light

Natural materials and finishes combine perfectly with lots of natural light to create a warm and inviting space.

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Cedar ceilings in shower rooms

While the home includes an air exchanger to help deal with excess humidity, the cedar ceilings in the shower rooms result in very little excess humidity in the first place.

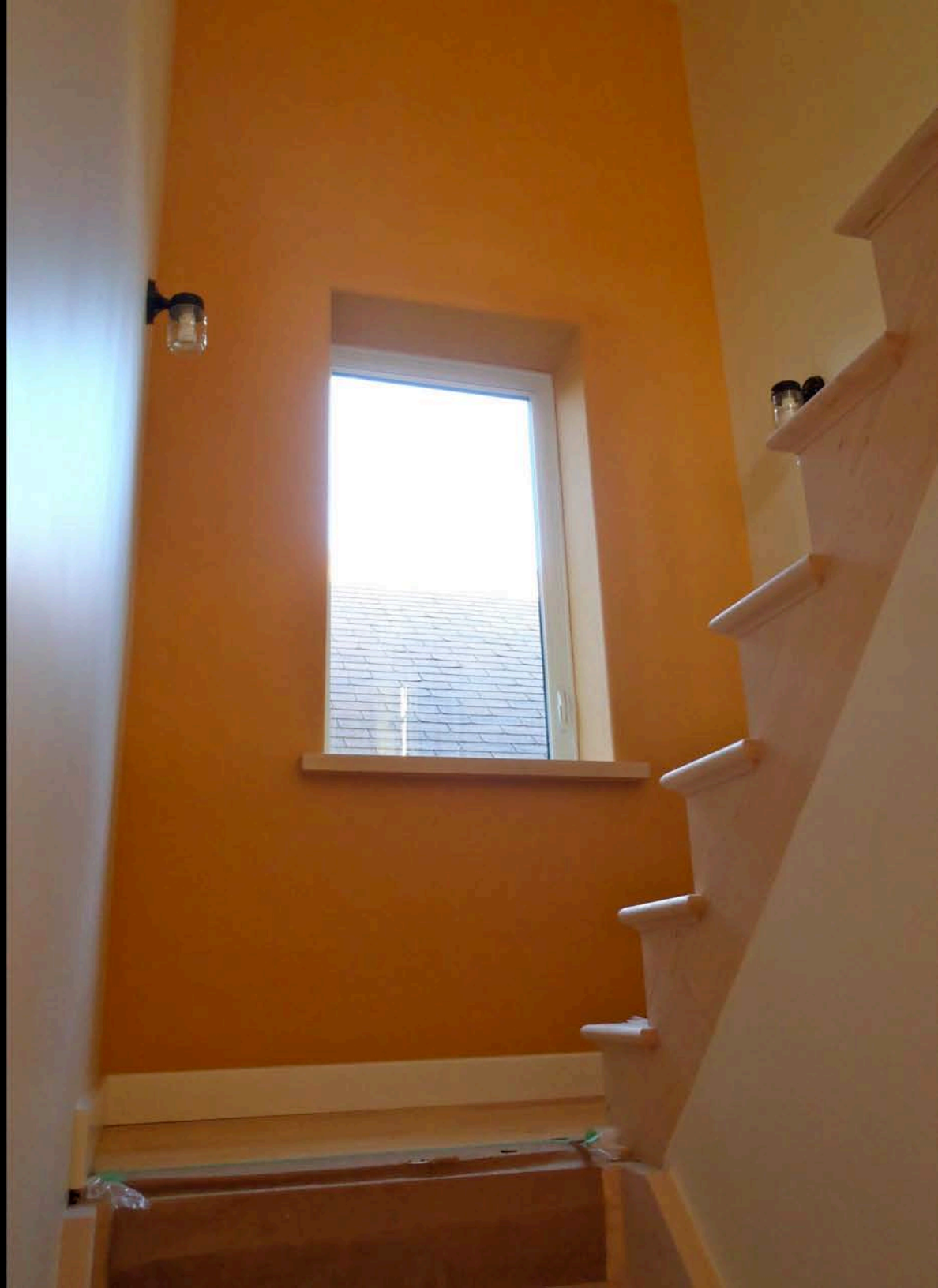
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Clay paint

Natural clay paint from Kreidezeit can give any type of wall a beautiful natural finish. These paints can be used over existing paints, making natural finishes possible anywhere.

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Induction cooktop

The inclusion of an induction cooktop and convection oven result in half the energy use of conventional electric cooking devices.

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LED light bulbs throughout

We experimented with a wide variety of new-generation LED lightbulbs to find the models that work best in each space in the home. These bulbs give warm, comfortable light, and most work with dimmers.

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Adding occupants

All the natural finishes and healthy materials are given life when the home is occupied.

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Comfortable spaces

There are comfortable spaces and corners throughout the home. Follow our blog about a year of living in Canada's Greenest Home at www.endeavourcentre.org



Is it Canada's Greenest Home?

We think so!

We set out to build a home that represented the best possible environmental practices in an urban setting.

We succeeded in making a home that is extremely energy efficient (rated to be 77% better than code requirements), with anticipated heating bills under \$350 per year. It is very air tight (0.63 ach/50), and a real-time monitoring system allows occupants to see their ongoing energy use. Net zero energy use is predicted. The combination of PV and a Bullfrog Power contract means that no fossil fuels are used in the operation of the home.

Indoor air quality is high, thanks to the air exchange system and the complete lack of toxins in all materials and finishes.

We sourced the vast majority of the materials for the home locally, from low-embodied energy sources, while generating a fraction of the waste.

The home outputs no human waste, and is capable of net zero water use.

We achieved all of this in an attractive package that is in line with conventional costs for custom home construction.

If you'd like to read more about our "self assessment report card" go to <http://endeavourcentre.org/2013/05/did-we-build-canadas-greenest-home/>

Suppliers and trades

Thanks to the following suppliers and trades:

NatureBuilt Walls (prefab bale walls), Flanagan and Sun (PV and solar hot water), Generation Solar (electrical), Living Rooms (AFM Safecoat products and natural finishes), The Healthiest Home (paints), Envirolet (composting toilets), Nedco Energy Services (electrical monitoring equipment), MitsAir (air source heat pump), PurePine (exterior siding), Millette Doors, Inline Fiberglass Windows, Eco-Building Resource (healthy caulking, glues and products), Nadurra Wood Corp. (FSC flooring), Poraver, Healthy Homestead (local lumber), Herrman's Timber Frames (SIGA tapes), Murphy Lumber (local lumber and shingles), HomeSol Building Solutions (energy analysts, LEED provider), Building Alternatives (structural engineering), Vallhalla Wood Preservatives (Lifetime finish), Tockay Natural Paints (Auro and Kreidezeit natural paints), Chisholm's Lumber (local lumber), Lute's Cedar (local lumber)



Keep following the project

The Endeavour Centre will continue to document this project with a blog devoted to “A Year of Living in Canada’s Greenest Home.”

Follow our reflections on commissioning and occupying the home, monitoring its performance and considering changes and improvements that could be made next time. Check www.endeavourcentre.org to subscribe to the blog.



Building Canada's Greenest Home

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