Rammed Earth

Creating a 500-Year House

A design-build team demonstrates the durability of an ancient material

BY KILEY JACQUES

The rammed-earth construction technique is several thousand years old and is thought to have originated independently in both China, where original rammed-earth sections of the Great Wall are still standing, and the Iberian Peninsula. Other examples include the Hakka Tulou—a series of five-story round apartment buildings in China—and the Alhambra palace in Spain.

The technique has a lot to recommend it. The green-building benefits include low embodied energy, recyclability, high thermal mass/low energy loads, and nontoxicity. For those reasons, Terrell Wong, principal of Stone's Throw Design in Ontario, Canada, is a fan of the material and the method. She also appreciates the durability and longevity of rammed-earth houses. When describing rammed earth to her clients, Wong says, "It is the structure, the insulation, the finish, and the thermal mass for a building. It will never need painting, and it will last 500 years, if not more."

SEDIMENTARY ROCK Materials for the rammed earth used on this project were sourced from a local quarry, which kept the embodied energy low. Typically, Stone's Throw Design specs 2-ft.-thick walls with a compressive strength between 1600 psi and 1800 psi.

Wong's rammed-earth walls are built in panels approximately 11½ ft. long, and the material is a mix of 20% to 30% clay, sand, and 5% to 10% cement. In cold, wet climates, a silicate-based waterproofing agent is often added. The walls are constructed in place in lifts, and 1 ft. of material is layered into formwork and compressed down to 6 in. with a pneumatic tamper. The forms are about 20 in. wide and 4 ft. tall, often built of HDO plywood and dimensional and engineered lumber. When a wall is more than one panel long, a recess is added to one end of the first panel, and the second panel is molded into that space, locking them together. Conduit for pipes and wires are added during the process, and it's important to know where conduit and windows are going because they can't be moved once the wall is up. Typically, walls are done and dry in 24 hours, with a load-bearing capacity on par with concrete.

For the past 10 years, Wong has designed three to four rammed-earth houses per

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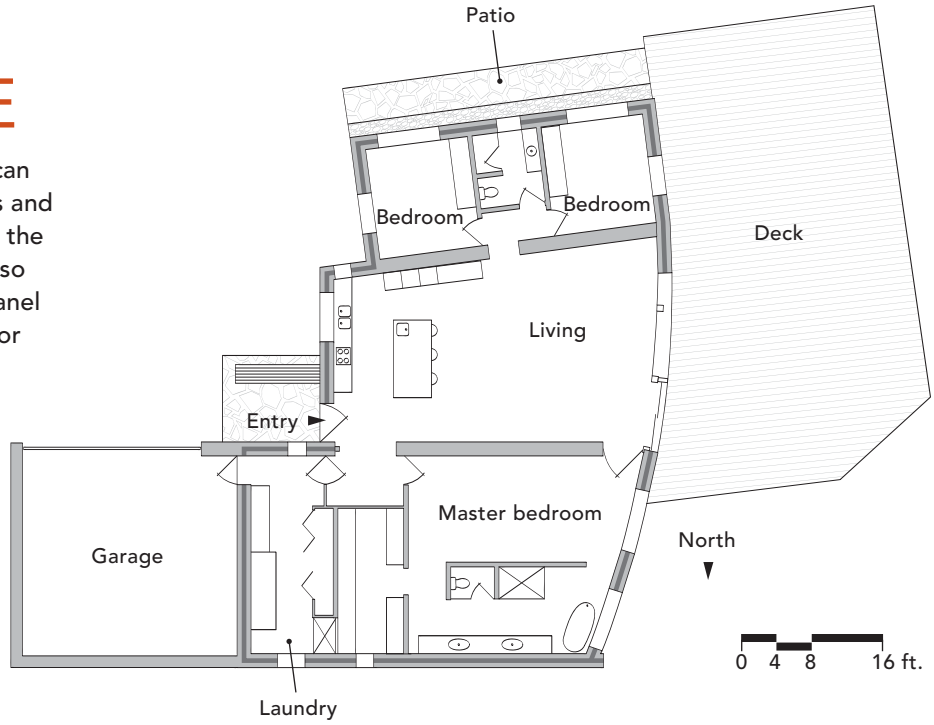
CASE STUDY

A HYBRID HOME

Many rammed-earth homes are hybrids. They can be a combination of stick or timber-frame walls and rammed earth, as seen here, where sections of the second floor are straw-bale construction. It's also possible to use CLT (cross-laminated timber) panel roofs. Wong regularly includes rammed earth for interior partition walls as well.

For the project featured here, Wong was charged with designing a single-family home in a small rural subdivision surrounded by woodlands. Using Passive House strategies, she worked with Aerecura Rammed Earth Builders to reduce energy use by maximizing the thermal mass potential of rammed earth, to harvest southern light and cross breezes (the rammed earth walls enhance the passive ventilation), and to locate windows and overhangs where appropriate. The result is a home whose natural cooling capacity omits the need for mechanical equipment. For heat, the house uses roughly 20kw annually.

The exterior walls comprise 530 tons of material in the form of two 6-in. wythes of rammed earth around 6 in. of insulation. Because 90% of the unprocessed material came from a nearby gravel pit, the embodied energy of this house is exceptionally low. Recycling efforts included repurposing some of the wooden formwork used in the construction on the interior.



INTERIOR ENVIRONMENT Because rammed-earth walls are thicker than conventional walls, they have some soundproofing qualities, and mold won't grow on them because the material is devoid of organic matter, making for good indoor-air quality.

THERMAL MASS Rammed earth's ability to absorb and store solar radiation—which is re-radiated at night—makes it an energy-efficient building material. It maintains consistent indoor conditions by preventing temperature and humidity spikes.

Floor-plan drawing: Patrick Welsh

TRANSITION POINTS
Exposed timber framing is attached to a ledger with epoxied anchor bolts. Windows and doors are formed using volume displacement boxes, which hold the units' places while walls are being erected.

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year. She says it's still something of a fringe method in Canada, and notes that there are just a few builders doing rammed-earth construction in all of Ontario. One of them is Sylvia Cook, principal of Aerecura Rammed Earth Builders. Though rammed earth is often said to work best in arid climates, Cook makes this point: "The thermal-mass effect works equally well for hot climates, where heat gain is delayed, and for cold climates, where heat loss gets shifted from the middle of the night to the middle of the day, when the sun makes up the difference. This keeps the temperature consistent year-round. Our belief is that it remains a 'fringe method' due to lack of knowledge of the system."

Rammed-earth walls are also notable for their earth-toned striations. To get that look, pigment is added to the cement, which the ramming process moves to the edges of the board form so the colors are visible on the wall's outermost layer. "You get this natural umbrage of color," says Wong, adding that those waves can be exaggerated by varying the amount of material in each layer.

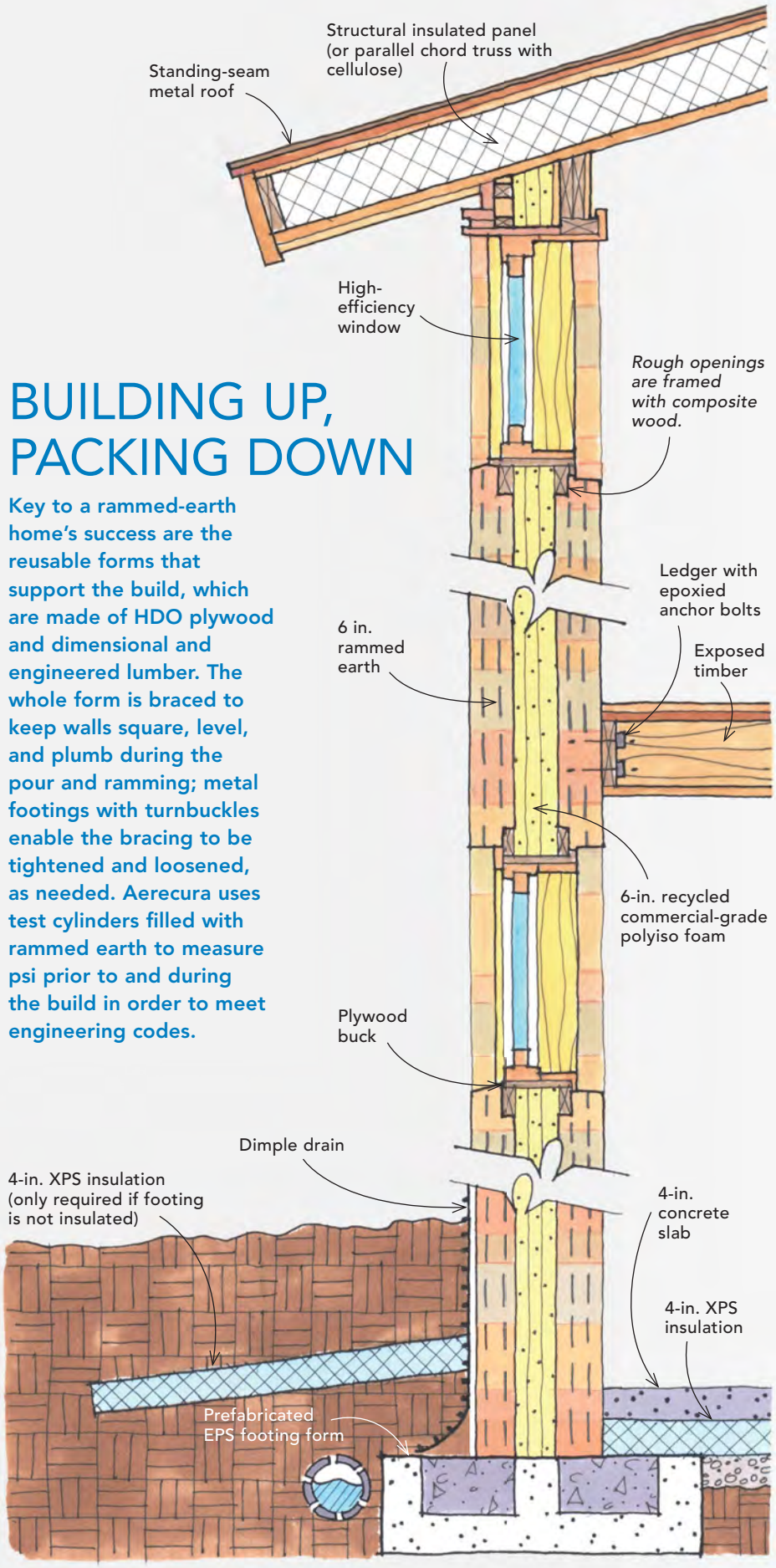
Though rammed-earth construction has been modernized, North America has not adopted building codes for it. "In Canada, we use a solution that demonstrates rammed earth meets code requirements because it is much like concrete or concrete block," Wong explains, adding that in colder, wetter climates rebar is needed to reinforce structures. She also integrates recycled polyiso insulation into the middle of rammed-earth walls to minimize thermal bridging. In Australia and New Zealand, where rammed-earth houses are more common, codes have been formalized. In fact, research conducted in earthquake-prone New Zealand suggests that monolithic earth walls withstand earthquake conditions better than brick or block walls.

Predictably, the complexity of a project influences cost—curved or angled walls are going to be more expensive than their conventional counterparts because the rammed-earth method is labor-intensive. But by keeping the design and formwork simple, Wong was able to use the method for an affordable housing project. □

Kiley Jacques is design editor. Photos by Riley Snelling, courtesy of Stone's Throw Design, except where noted.

BUILDING UP, PACKING DOWN

Key to a rammed-earth home's success are the reusable forms that support the build, which are made of HDO plywood and dimensional and engineered lumber. The whole form is braced to keep walls square, level, and plumb during the pour and ramming; metal footings with turnbuckles enable the bracing to be tightened and loosened, as needed. Aerecura uses test cylinders filled with rammed earth to measure psi prior to and during the build in order to meet engineering codes.



Photos facing page: courtesy of Aerecura Rammed Earth Builders. Drawing: Martha Garstang Hill.

MOVING MATERIAL A skid-steer loader with a 1-yd. bucket is used to lift the soil close to the formwork.

LOADING THE FORM In order to avoid the patterning that can result from machine-dumped soil, it is hand-shoveled into the formwork. Elevation marks on the inside of the form boards indicate the fill line. Rebar adds structural support.

PACKING IT IN The soil mixture is compacted and stabilized with a pneumatic tamper; Portland cement acts as the binder. The team starts with roughly a foot of material and tamps it down to 6 in.