Five high-performance walls that work in Alaska

Aaron Cooke, Architect
Cold Climate Housing Research Center
aaron@cchrc.org

Introduction

Resiliency and durability in built construction in Alaska and the circumpolar north is dependent on an understanding of and respect for both the region's uniquely antagonistic physical environment and the logistical complexities in distributing power and heat. Resilient buildings in Alaska must focus on two basic premises in regards to heat and power: intelligent supply and reduced demand. Strategies for providing and retaining heat that are imported from other more benign and infrastructure-rich climates — even those with cold winters — often fail upon first being introduced to the circumpolar region. These imported best practices must then be modified, adapted, or discarded. This process of failure, adaptation or abandonment of temperate-zone construction techniques uses up scarce financial resources and leaves in its wake many buildings with short lifespans or, just as commonly, inefficient buildings that are financial liabilities and health detriments to their occupants.

The Cold Climate Housing Research Center (CCHRC) is an industry-based, nonprofit corporation created to facilitate the development, use, and testing of energy-efficient, durable, healthy, and cost-effective building technologies for people living in circumpolar regions around the globe. CCHRC has extensively researched strategies for intelligent supply of heat and power as well as construction techniques that reduce demand for heat in buildings. One area of research emphasized by CCHRC is the design and construction of high-performance wall envelopes. Increasing insulation values and air tightness on walls in the thermal envelope of a building is a field of study that can lead to great reductions in heating demand.

However, wall design in the Alaskan and circumpolar context is not as simple as adding insulation value alone. Adding insulation and air tightness without a northern-specific understanding of vapor drive, dew point, detailing complexity around penetrations, and shipping logistics often leads to wall failure, mold, health problems for occupants, unforeseen expense, and lawsuits. CCHRC has tested numerous wall assemblies in its Mobile Test Lab (MTL) to see how both conventional and prototype walls react to increased vapor drive, extreme outdoor cold, and increased indoor humidity typical in the circumpolar environment. From these controlled experiments CCHRC has created full-scale prototype homes to test real-world living conditions of occupied buildings with super-insulated envelopes. CCHRC disseminates the results of this body of work to architects, contractors, planners, and the public at large for use in design and construction. What follows is a primer on five high-performance wall types that have experienced success in greatly reducing heating demand while understanding the complexities of the region's unique physical, logistical, and economic environment.

The REMOTE Wall System

Description

CCHRC developed the REMOTE Wall System (Residential Exterior Membrane Outside insulation TEchnique) to address the problem of mold and extreme vapor drive through penetrations in the vapor barrier of conventionally framed stud walls. A common problem associated with poorly sealed vapor barriers in Alaska is the condensation of water vapor on the sheathing plane within a wall, which commonly leads to mold and rot. Adapted from the PERSIST wall technique used in northern Canada[1] , the REMOTE wall moves the majority of the insulation to the outside of the wall in order to keep the sheathing warm and dry. The wall type uses sufficient rigid foam so that two-thirds of the total wall R-value is located on the outside of the vapor barrier. This keeps the dew point outside the warm-side wall cavities and sheathing, ensuring the framing members stay warm and, thus, dry.

Assembly

In the REMOTE Wall, a 2x4 wall is framed with the vapor barrier applied outside of the exterior sheathing, rather than inside. The 2x4 stud cavity is filled with fiberglass insulation. Since the vapor barrier is outside the wall cavity, penetrations for plumbing and electric runs become much easier and less expensive to install. Rigid foam board is attached on the exterior vapor barrier using roofing screws with plastic washers. The building designer will calculate the amount of rigid foam insulation necessary for the climate. For instance, in Fairbanks and Interior Alaska, 2/3 of the overall insulation value must be on the outside of the sheathing to keep the wall safe from condensation issues. Variations on this design have utilized 6-mil poly sheeting or peel-and-stick self-adhering membrane as the exterior vapor barrier. Vapor-permeable air barriers with drainage capability such as Tyvek® DrainWrap™ are also commonly used in place of a vapor barrier, as the lapped joints of rigid insulation, plywood sheeting, and air barrier have a combined permeability rating sufficient to keep condensation of water vapor out of the wall. In contemporary REMOTE walls, vapor-permeable air barriers are more commonly used than vapor barriers.

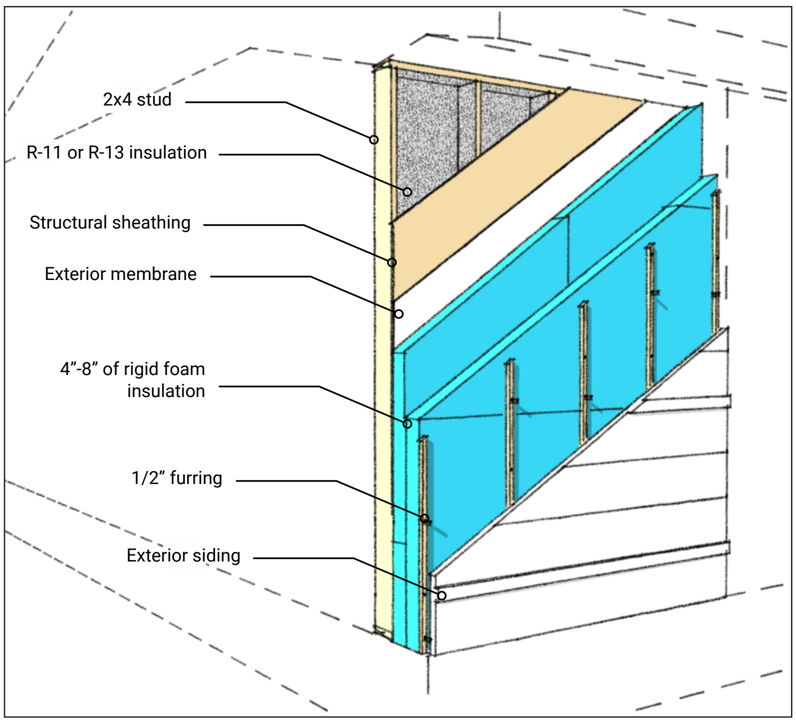

Figure 1: The REMOTE wall assembly arranges materials with the intent of keeping the dew point of water vapor on the outside of the vapor barrier, while creating a cavity on the warm side of the vapor barrier for utlity runs. The amount of exterior insulation necessary to keep moisture out of the stud cavity varies by region, and should be calculated by the designer.

Figure 2: Rigid foam insulation is applied to the exterior of the stud wall in a REMOTE wall assembly. The insulation is applied in two layers and the joints are lapped and sealed to further inhibit the infiltration of cold air in the winter.

Applications

REMOTE wall construction has become one of the most common assemblies in high-performance residential buildings in the state, and has also been adopted by commercial construction in the last decade. Additionally, REMOTE wall retrofits have increased in frequency for existing structures that need to increase their energy performance to remain resilient. CCHRC has created a construction guide for both new construction and energy retrofit construction for the public, as well as a calculator for determining how much rigid insulation is necessary to keep the dew point out of the wall.[2] This calculation is extremely important in retrofits of existing buildings, as placing too little exterior insulation to an older building can cause condensation issues that could damage the wall and lead to rot and mold instead of improving it.

The Arctic Wall System

Description:

The Arctic Wall system is a contemporary variation of a traditional double wall. It is different than a traditional double wall in three key ways: 1) It uses gusset plates to tie studs in line as opposed to staggering them, which creates more regular and efficient framing; 2) it generally uses dense-pack cellulose insulation instead of fiberglass; and 3) it has the option of eliminating the traditional vapor barrier in certain climate zones of Alaska in order to create a diffuse-open wall assembly.

Assembly:

The Arctic Wall system is comprised of a 2x6 interior structural wall filled with blown-in dense-pack cellulose. Gypsum drywall is fastened directly to interior side of the structural wall. Half-inch grade "C-D" exterior grade plywood sheathing board (CDX plywood) that has been taped and sealed is fastened to the exterior side of the structural wall. The tape used on the sheathing is an airtight, vapor-permeable material. A layer of Tyvek® HomeWrap®, a vapor-permeable air barrier, is secured to the exterior side of the taped sheathing. The combined taped sheathing and vapor-permeable air barrier makes up the air barrier system. An exterior balloon-framed 2x4 wall (either dimensional lumber or steel c-channel) wrapped with a vapor-permeable membrane (Tyvek® HomeWrap®) contains 12 inches of blown dense-pack cellulose against the air barrier system. A 1x4 furring strip sandwiches the outer membrane to the outer framing; the exterior siding is attached to the furring strips, providing a ¾-inch air gap. The air gap created by the furring strips provides ventilation behind the siding and a drainage plane along the outer membrane.

Figure 3: The Arctic Wall assembly consists of a thick cavity of up to 24" filled with cellulose insulation applied at a specific moisture content and density

Figure 4: Some iterations of the Arctic wall will utilize a balloon-framed outer stud layout of light-gauge steel channel studs. These studs are uniformly straight and do not conduct thermally due to the break in the wall.

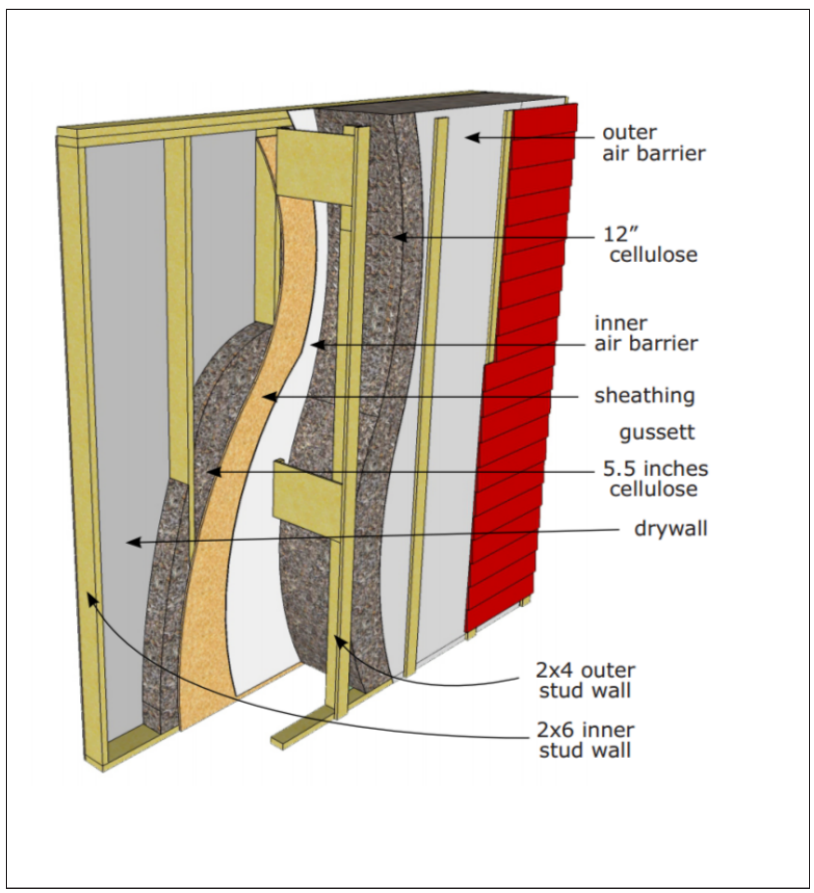

Figure 5: The Arctic Wall as developed by Reina Properties, a builder in the Fairbanks area.

Applications:
The Arctic Wall is a high-performance wall type that is gaining popularity among builders and residents aiming for increased air-tightness and near-“Passive House” standards for energy demand. The diffuse-open version of this wall has been built in many high-performance residences in the Alaskan Interior, where dry conditions and extremely cold winters make it a resilient and extremely high-performing envelope in construction. For applications on the coastal humid regions of the state, a vapor barrier would be encouraged.

The Quinhagak Wall System

Description:
The Quinhagak (KWIN-a-hawk) wall system is designed to address the advanced insulation requirements and also the logistical costs of remote construction in communities without road access or large-scale infrastructure. Named after the village of Quinhagak, Alaska, where it was first developed, it uses spray-applied polyurethane insulation to create both a thermal envelope and a vapor barrier in a single monolithic envelope. Spray-applied polyurethane insulation has a perm rating that allows it to function as a vapor barrier while greatly reducing thermal bridging in the envelope. It comes in 55-gallon barrels and expands in the gun nozzle of the applicator mechanism on site. This means that it is easily transportable. In remote Alaska, logistics comprise an average of 40% of the total cost of any construction activity. While spray-applied polyurethane does not compete economically with other types of insulation on the road system, it transports compactly, which makes it an economically competitive material for remote construction sites.

Assembly:
The Quinhagak wall is comprised of 4” metal studs on the inside with AC-grade plywood functioning as both the interior sheathing and finish. A thermal break plastic gusset spans the desired thickness to light-gauge angle-iron that holds the exterior cladding out from the inside of the stud. The gusset prevents heat from conducting through the studs, and can be cut to any thickness depending on the desired overall R-value of the assembly. For instance, a 3.5” gusset would create a wall with an overall thickness of 7.5” for an R-value of R40. Higher R-values can be achieved by increasing the size of the gusset without changing any of the other materials in the assembly. Spray foam is applied continuously to the foundation, walls, and roof, creating a monolithic envelope with no gaps or thermal bridging. The spray foam is applied from the inside of the structure outward in 2” lifts to the inside face of the exterior metal panel cladding, allowing the application to occur out of adverse weather conditions. This wall assembly is simple and super-insulated without the added material of traditional double-wall construction. The entire assembly is constructed on an elevated production jig with windows and cladding installed before the insulation is applied.

Figures 6 and 7: The Quinhagak wall emphasizes materials that are easy to ship and can be assembled without heavy equipment. It can be framed on a jig and then lifted into place in sections by hand.

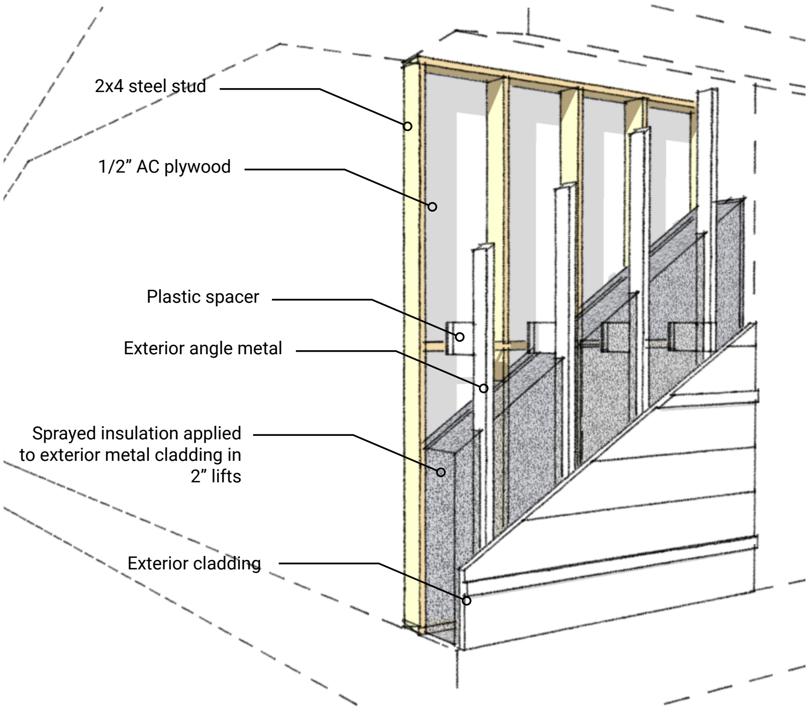

Figure 8: The Quinhagak wall takes advantage of a complete thermal break within the cavity of the wall, allowing for the use of light-guage steel channel on the inside and simple angle metal on the outside, for a lightweight, easily shippable assembly.

Figure 9: The Quinhagak wall utilizes the low permability and affordable transportability of spray-applied polyurethane foam insulation to create a monolithic thermal envelope that also functions as a vapor barrier.

Applications:

The Quinhagak wall is designed for remote locations, with material selection addressing the unique economic challenges of transporting materials to site. Spray foam insulation transports more economically than bulky rigid foam or cellulose. Steel studs are selected for their ease of shipping (two nested c-channels take up the same amount of space on a barge/plane as one 2x4 wood stud). Although steel studs would be inappropriate in a conventionally framed wall due to thermal conduction properties, the plastic gusset creates a thermal break that allows for this logistically-superior product. The interior sheathing material in the Quinhagak wall is ½" AC grade plywood, which transports by barge better than Gypsum, is more mold-resistant, and can double as the shear resistance strategy of the wall, reducing materials. The wall is light enough that four carpenters can carry it to the floor platform and install it, an important consideration in remote sites where heavy equipment is often not available.

The Integrated Truss Wall System

Description:

The integrated truss is a single structural framing unit that combines the exterior walls, floor joists, and roof into one structural assembly. The assembly is tipped up either by hand or with the aid of a boom, greatly accelerating the speed of construction. The integrated truss system allows homes to be framed in a single day, an important consideration in the short construction season in Alaska. The truss design lends itself to a super-insulated envelope, as the depth of the walls, roof, and floors are scaled to accommodate the desired amount of insulation. The structural requirements of the trusses make them deep enough to fit a very high R-value of insulation and still provide a warm space to run wiring and mechanical systems. As each piece of the truss is comprised of an inner and outer chord with webbing in between, conductive heat loss is greatly reduced.

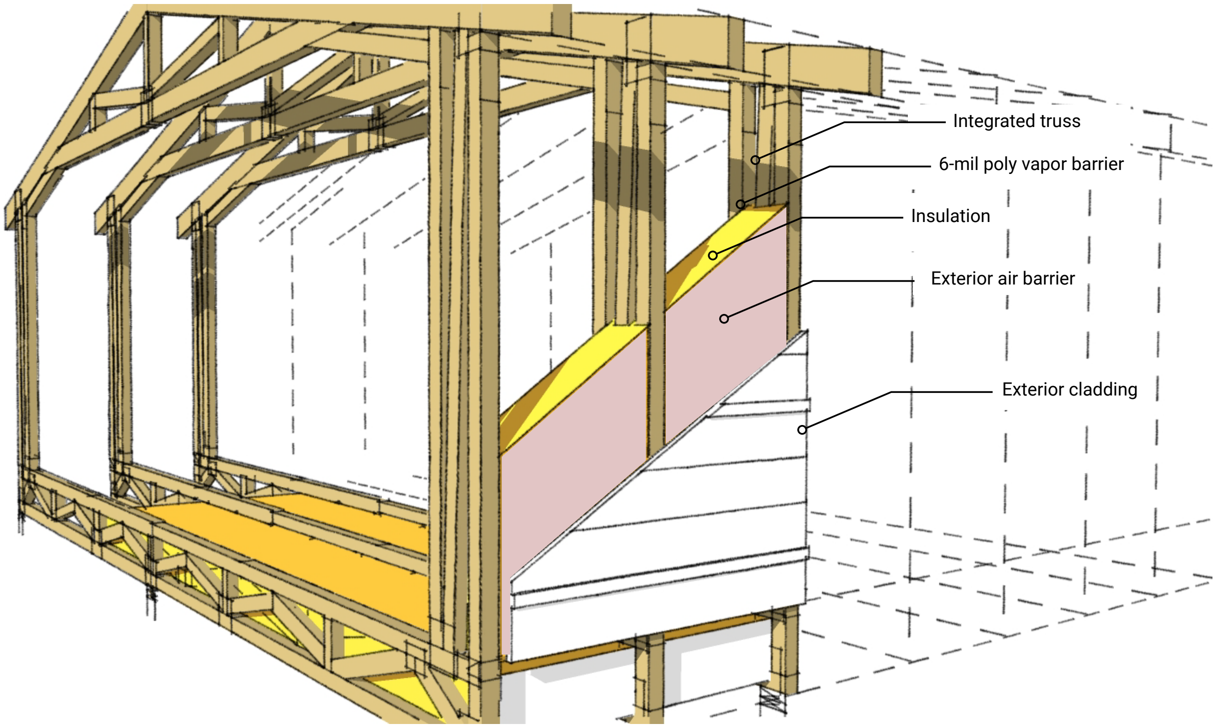

Figure 10: The integrated truss wall assembly incorporates roof, wall, and floor components into a single building component. The wall truss geometry calls for a thickness that can easily accommodate high-performance levels of insulation

Figure 11: The Integrated Truss wall system was developed with rapid deployment as a chief concern, so that a home could be framed in a single day. This addresses the north's short construction season and need get be out of the weather quickly.

Assembly:

The integrated truss wall comes in many variations but at its most basic has interior sheathing, an interior 6-mil poly vapor barrier, insulation, an exterior air barrier, and exterior cladding. Insulation thickness is dependent on the depth of the truss geometry. Common depths are 24", 18", and 12", depending on the desired insulation value. Most integrated truss assemblies incorporate a ventilated rain screen on the exterior of the wall in wet humid regions of Alaska. Many integrated truss assemblies also incorporate interior furring between the inside edge of the truss and the sheathing to create a space for electrical and plumbing runs that will keep penetrations in the vapor barrier to a minimum. Since the truss cavity is structural in nature and its geometry is based on that structure, it can be filled with numerous types of insulation. In general, it has utilized blown-in cellulose in the drier interior region of Alaska, blown-in fiberglass in the coastal regions, and has utilized spray-foam insulation in extremely remote regions.

Figure 12: In recent years, Integrated Truss home construction has typically incorporated a ventilated rain screen on the outside of the building, especially in coastal areas.

Applications:
The versatility of the integrated truss assembly has led to its growing popularity in the rural regions of the state. The factory-controlled conditions of the truss fabricator allow for greatly accelerated construction timelines during the short season.
The integrated truss is designed with four primary design criteria in mind:
1. To carry all of the structural loads of the roof, walls, and floor in one prefabricated assembly
2. To create a thick cavity that allows ample space for high R-value insulation in cold climate homes
3. To provide a protected chase for mechanical equipment as needed
4. To speed the process of framing construction in remote northern villages with extremely short building seasons

For this reason, it has experienced success in a variety of applications in Alaskan communities.

The Insulated Concrete Form Wall System
Description:
Insulated Concrete Forms (ICF) is a system of concrete formwork consisting of interlocking rigid insulation blocks. Unlike traditional concrete formwork that is removed after the concrete cures, ICF blocks are designed to stay in place and form the thermal insulation strategy of the concrete wall. Basic ICF walls are rated R-20 to R-24. ICF construction has become common for concrete construction in low-rise commercial and residential applications in areas where thermal insulation is one of the primary design constraints. They are compatible with frost-protected shallow foundations as well as with conventional concrete footing systems.

Assembly:
The ICFs are built to the desired height with spacers for the desired thickness of the concrete. Steel reinforcing bar design in ICF construction is similar to conventional methods. The ICFs themselves come in various thicknesses to address the desired insulation value and the amount of concrete desired in the overall wall assembly. Once the concrete has been poured, the interior of the ICF wall can be finished with gypsum wall board. Additional rigid foam can be added to the outside of these walls, and should be added in colder zones of the state to reach an R-40 assembly. The exterior of the assembly is furred ½" out for a ventilated rain screen, with exterior cladding attached to the furring.

Applications:
ICF construction is commonly used in foundation design of residential buildings or as the entire construction assembly for garages, storage buildings, and low-rise commercial construction. It takes advantages of the durability and longevity properties of concrete while mitigating concrete's poor insulation performance in cold climates. The stay-in-place method of constructing ICF walls eliminates the costs and logistics associated with conventional concrete formwork methods.

Conclusion
Designers aiming at improving resiliency and durability in built construction in Alaska and the circumpolar north should take into account best practices and research precedents that focus on northern-specific approaches to high-performance building design. A number of high-performance building envelope designs are available to the northern designer, architect, engineer, retrofit specialist, and building maintanence/building suprivisor staff through CCHRC and other innovative organizations. Through reduced energy demand and intelligent supply of heat and power, great gains can be made in operating costs, durability and longevity of northern buildings.

Endnotes

1 Makepeace, Chris B, and Barrie T Dennis. "PERSIST-Pressure Equalized Rain Screen Insulated Structure Technique-Design Approach ." Government of Alberta, 1998, https://web.ornl.gov/sci/buildings/conf-archive/1998 B7 papers/074_Makepeace.pdf.

2 "REMOTE Construction Manual." *REMOTE a Manual,* CCHRC, June 2009, http://cchrc.org/media/REMOTE_Manual.pdf