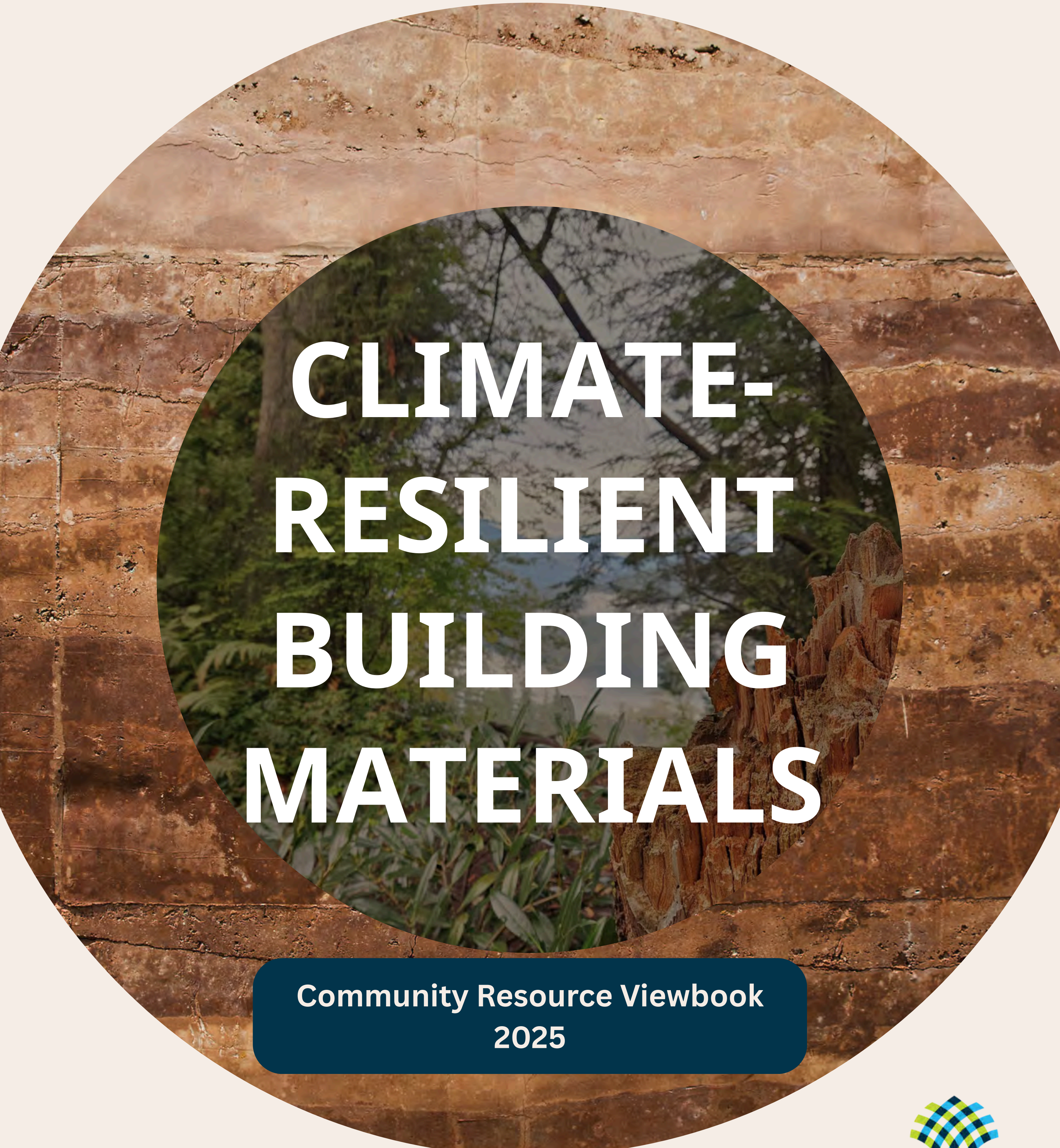
CLIMATE-RESILIENT BUILDING MATERIALS



Community Resource Viewbook
2025

PICS

About the Viewbook

The building materials branch of the Rural & Remote Community Resilience project focuses on the **potential of climate-resilient building designs and materials.** Through sharing key information and examples about building materials and techniques from regions climatically similar to BC's, we provide information to support building design and renovation decisions for communities facing climate-related hazards, including wildfires, heat domes, and extreme precipitation. This viewbook shares accessible information for a non-technical audience, particularly housing managers or planners in rural and remote communities, about climate-resilient building materials.

Acknowledgements

This viewbook is part of a PICS-funded project, Building Climate Resilience in Rural & Remote Communities. The project is centred around collaborations that bridge climate strategies and policies in British Columbia with Indigenous and community-driven expertise. It focuses on low-carbon resilience in housing, technical systems, and community planning.

The project team would like to thank the following people for their guidance and support in completing this project:

- The many people we have had informal discussions with that helped to guide our direction and offered feedback along the way.
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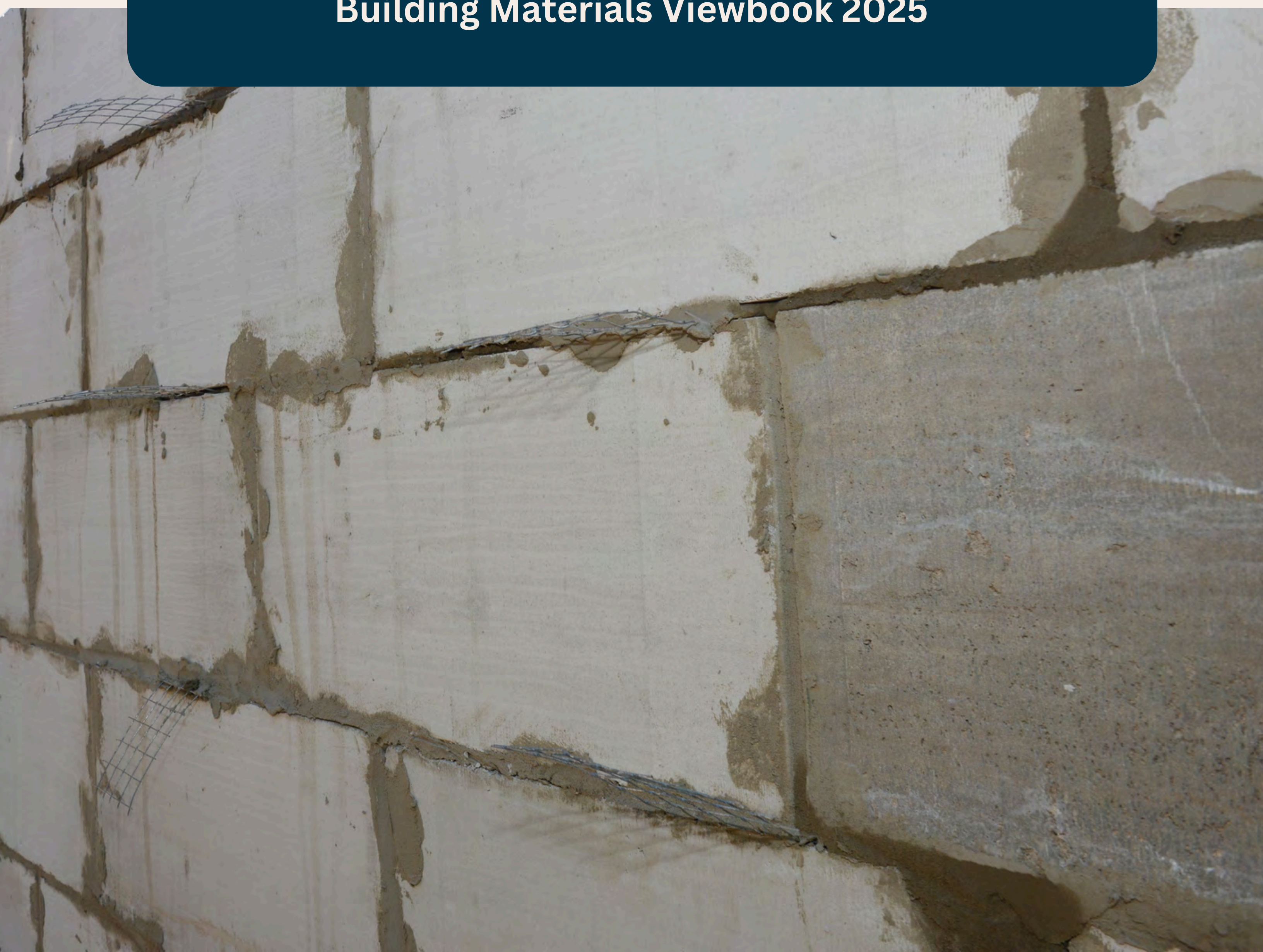
PART 1: SUMMARY TABLES

Building Materials Viewbook 2025



Building Materials at a Glance

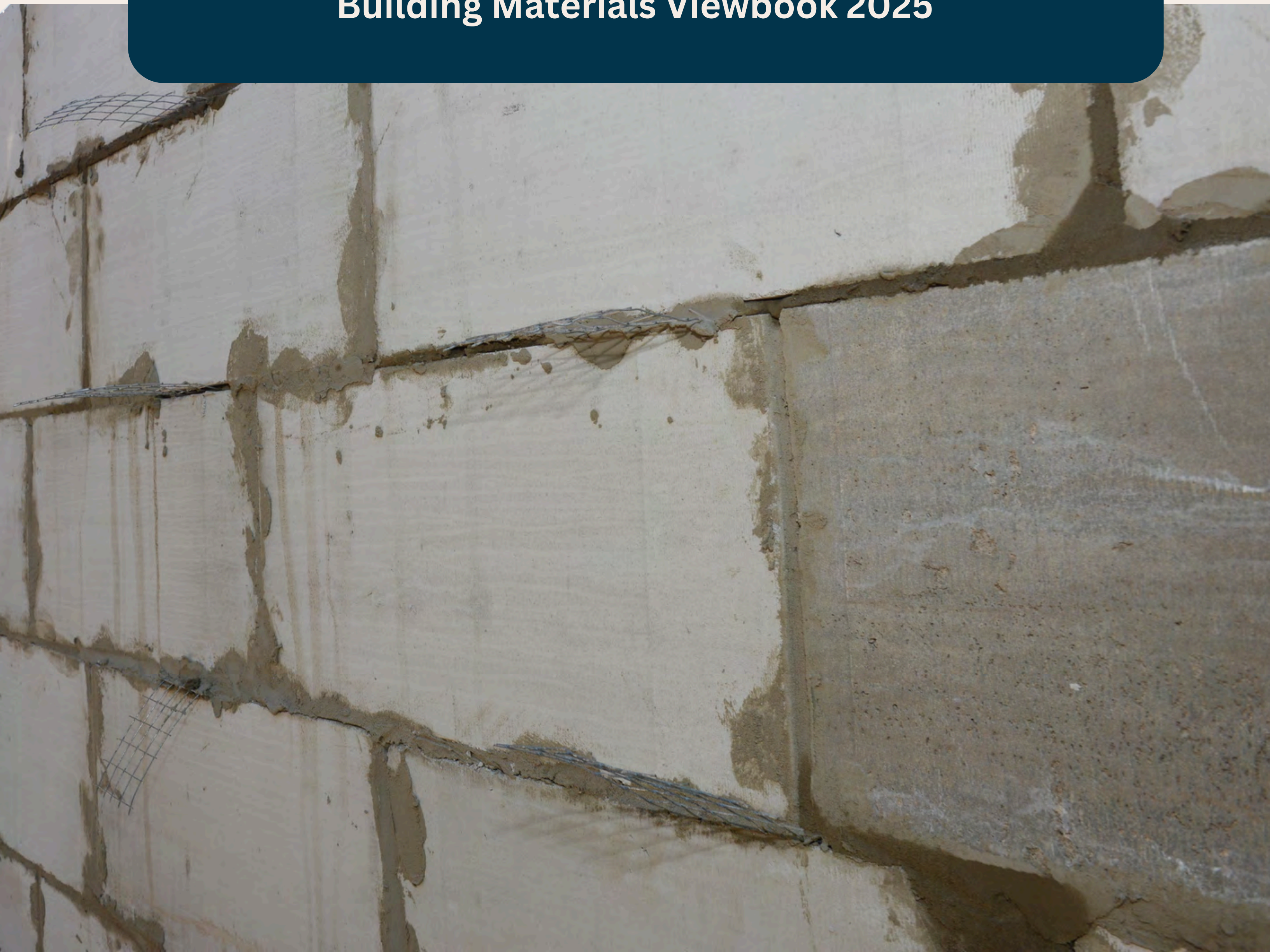
Material	Fire Resistance	Rain and Floods	Extreme Temperatures	Wind	Seismic Resilience
Rammed Earth	✅ Naturally fire-resistant.	⚠️Rammed earth is vulnerable to flood/moisture damage, including mold.	✅ Temperature regulation: Good thermal mass aids in maintaining comfortable temperatures. ⚠️ Poor insulation.	⚠️Roof is vulnerable to damage in windy conditions.	⚠️Reinforcements are needed to improve seismic resilience, such as bracing or panels.
Straw Bale	✅ Fire-resistant, with a 2-hour fire rating. Plaster further strengthens fire resilience.	❗ Risk of moisture retention and mold, especially if exposed to rain or water during construction	⚠️ Temperature regulation: low density means low thermal mass. ✅Insulation: Straw bale has higher insulation value than standard walls.	✅Can withstand substantial dynamic force (i.e., wind) with minimal movement	✅Straw bale absorbs energy well and straw bale walls have wide footprints.
Cob	✅ Fire-resistant, with a 2-4 hour fire rating.	❗ Vulnerable to flood damage	✅Temperature regulation: good due to high thermal mass. ⚠️ Insulation: low	❓Little information available about wind resistance	⚠️Reinforcements are needed to improve seismic resilience
Hempcrete	✅ Fire-resistant, with a 1-4 hour fire rating.	✅ Hempcrete is naturally vapour-permeable and the presence of lime makes the material more resilient to moisture and mould.	✅Temperature regulation: good due to high thermal mass. ⚠️ Insulation: moderate.	Typically used as infill, so has less influence on wind resilience	✅ Hempcrete is flexible, elastic, and lightweight. This makes it more seismically resilient.
Autoclaved Aerated Concrete (AAC)	✅ High hourly fire rating, which means AAC can withstand fire for a long period before damage.	✅Moisture does not pull deeply into AAC and it is inorganic, so it will not decay when exposed to moisture	⚠️ Temperature regulation: Lower due to low/moderate thermal mass. ✅ Excellent insulation.	⚠️Needs reinforcements for wind resistance	✅High compressive strength contributes to seismic resilience.
Mass Timber	✅ Fire rating of 3+ hours; surface char forms a protective layer.	⚠️Risk of swelling/decay without protective detailing.	✅Temperature regulation: good due to high thermal mass. ⚠️ Insulation: moderate.	✅ Strong wind resistance due to engineered connections that provide stability.	✅Flexibility and engineered joints help withstand earthquakes

Building Techniques at a Glance

Technique	Fire Resistance	Rain and Floods	Extreme Temperatures	Wind	Seismic Resilience
Pit Houses	✅Naturally fire-resistant. Can be further fire-proofed with steel roofing.	⚠️Needs to be well ventilated to reduce buildup of moisture. Stagnant air can lead to mold growth. Flood risk due to low structure (exact location matters)	✅Great natural insultation and less heat loss from wind due to low structure. For low to medium cost, roof overhangs or insulation (reflective roofing) can be added.	✅Natural protection due to being underground, and less impact due to low structure.	⚠️Reinforcements needed through bracing or panels, such as wood or metal frames or tyre foundations (earth-filled tires) below the walls.
Modular Construction	✅ / ⚠️ Short construction time can make it easier to avoid wildfires. Buildings can be made with fire-resilient materials.	⚠️Depending on materials used, buildings can be made to be more moisture resilient. Needs to be well ventilated to reduce buildup of moisture. Stagnant air can lead to mold growth. ✅ Raising the foundation and waterproofing can improve flood resilience. Some modular buildings can float or be moved out of flood zones, such as Rotterdam's Floating Pavilion.	❗ Many modular homes reported overheating. Following energy modeling guidelines can mitigate this risk.	⚠️Wind resilience requires composite panels and robust connections. Debris-impact and connection fatigue may be issues.	⚠️Seismic performance dependent on design, particularly the strength of connections.

PART 2: SINGLE-PAGE FACTSHEETS

Building Materials Viewbook 2025



Rammed Earth

Building with rammed earth involves compressing earth - a mix of sand, gravel, and clay, often with stabilisers such as lime or cement - into vertical *formworks* layer by layer. This approach produces strong, compact walls.

Formworks are temporary wooden or plywood frames used to shape the wall.

Hazard Resilience

Wildfire

Fire-resistant (4-hour fire rating)

Rain and Floods

Risk of damage from floods (can be mitigated with structural changes)

Windy

Roof is vulnerable to damage

Extreme temperatures

Good temperature regulation but poor insulation

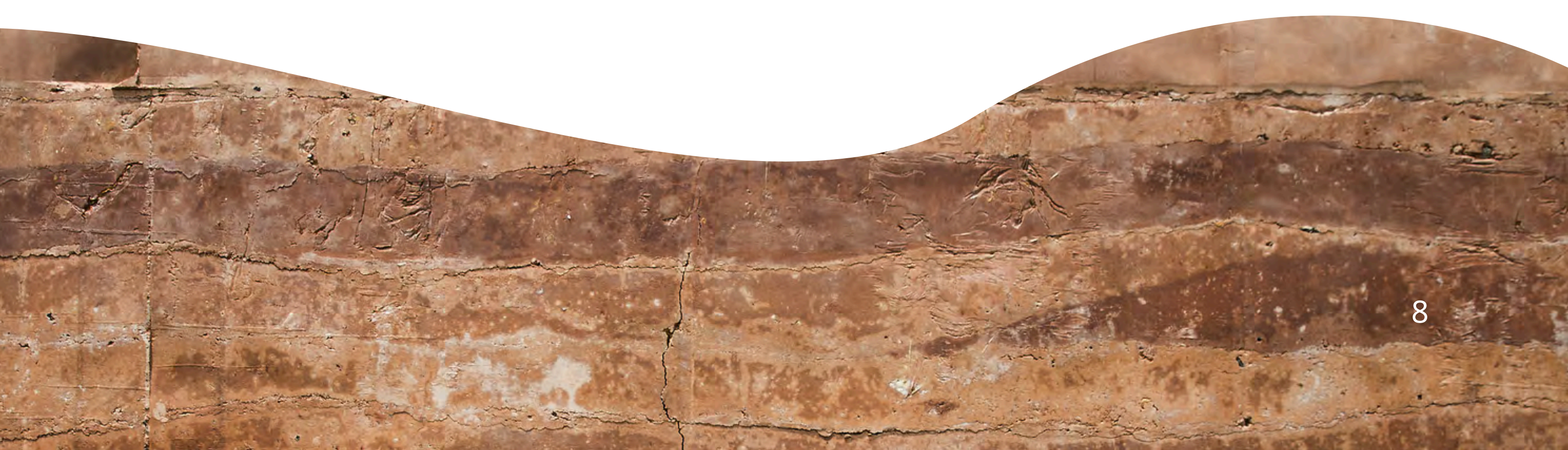
Seismic

Needs reinforcements for seismic resilience

Cost Analysis

Cost estimates for rammed earth vary depending on many factors, including site, soil type, and labour/transportation costs. innovative earth, a company based in Alberta, Canada, estimates rammed earth construction costs $250-350 per square foot (estimate accessed in 2025).

Generally, costs for rammed earth are likely to be higher upfront compared to conventional materials, with a long-term return because of its sustainability.



Straw Bale

Straw is a grain stalk (such as wheat, rice, rye, or oats) without the head. Straw-bale can be used as infill for post and beam/timber framing walls. Straw can also be compressed into agriboard or blocks.

Hazard Resilience

Wildfire

Fire-resistant when paired with plaster (2 hour fire rating).

Rain and Floods

Risk of moisture retention & mold, especially if exposed to water during construction

Windy

Panels filled with straw bale, if constructed well, are resilient against wind

Extreme temperatures

Low thermal mass but a great insulator

Seismic

Seismic-resilient due to energy absorption and wide footprint

Costs

For a straw bale wall, costs are estimated at $180-208 per square foot (number based on an American website accessed in 2025). This does not include components other than the straw bale, such as the foundation, roof, doors, windows, and plumbing.

Straw bale is generally more affordable and easier to work with compared to other materials. However, as with all other building projects, actual costs will vary based on many regional and site-specific factors.

Cob

Cob consists of clay, straw, sand, lime and water, which is mixed and becomes stiff when cured. The final product resembles a form of concrete. While the material can be load bearing for single story/low-rise structures, it is typically used as infill for timber post and beam walls.

Hazard Resilience

Wildfire

Fire-resistant (2-4 hours of exposure)

Rain and Floods

Vulnerable to flood damage

Windy

Little information available about wind resistance

Extreme temperatures

Excellent thermal mass supports temperature regulation. Little insulation.

Seismic

Needs reinforcements for seismic resilience

Cob is a natural, sustainable building material.

- It can be constructed using locally available materials.
- It is relatively beginner-friendly and cost-effective.

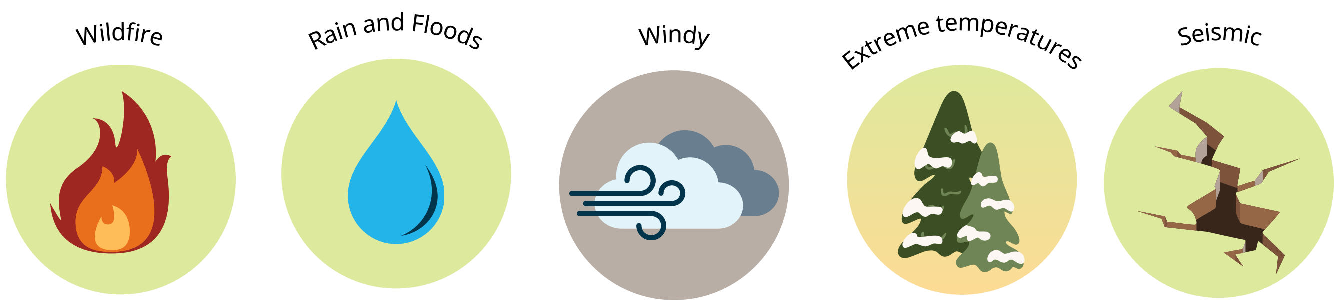
However, cob is absent in the Building Codes and Regulations, which can make its use more complicated.

As of 2025, recent and credible public estimates of costs were not available. Estimates may be available through local suppliers. Generally, cob is made with relatively low-cost materials but is labour-intensive to work with.

Hempcrete

Hempcrete is composed of the dried woody cores of hemp fibers, lime, and water. While some innovative load-bearing applications are being explored, the material is best suited as insulation or infill for walls.

Hazard Resilience



Wildfire	Rain and Floods	Windy	Extreme temperatures	Seismic
Fire-resistant (1+ hours of exposure)	Breathable and resilient to mould	Typically used as infill, so has less influence on wind resilience	High thermal efficiency and moderate insulation	Flexible and lightweight, leading to seismic resilience

Unlike wood, hempcrete is pest-resistant. Hempcrete also has the unique ability to sequester carbon, meaning that it can be net-negative in embodied carbon emissions. The productivity of hemp crops, as well as their abundance in BC, further highlight the materials potential as a sustainable and climate resilient option. However, due to its low compressive strength, the material remains feasibly limited in its application to insulation or infill. Some builders also mention hemcprete has a social stigma associated with it. Finally, its absence in the Building Codes and Regulations further complicates its use.

As of 2025, recent and credible public estimates of costs were not available. Estimates may be available through local suppliers. Hempcrete may be more expensive than standard infill options.

Autoclaved Aerated Concrete (AAC)

Autoclaved aerated concrete (AAC) is a mineral-based building material made from sand, water, limestone, cement, and aluminum powder. The mixture is then hardened in an autoclave (pressurized steam chamber). It is a lightweight form of concrete best used as cladding to provide a protective exterior for new and existing buildings. AAC can also be used for low to mid-rise load-bearing walls.

Although AAC has many benefits as a climate-resilient, pest-resistant material, limited supply options and specialised training requirements have constrained its use in British Columbia.

Hazard Resilience

Wildfire

Fire-resistant, with a high hourly fire rating (> 4 hours)

Rain and Floods

Breathability of the material prevents mould.

Windy

Wind resistant with reinforcements

Extreme temperatures

Low/moderate temperature regulation but an excellent insulator.

Seismic

Relatively high compressive strength and light weight contributes to seismic resilience.

As of 2025, recent and credible public estimates of costs were not available. Estimates may be available through local suppliers. The upfront cost of AAC may be higher than conventional concrete but its lightweight nature makes it more affordable to construct with.

Mass Timber

Mass timber construction uses engineered wood products, such as cross-laminated timber (CLT), glulam, and nail-laminated timber (NLT), which are formed by bonding layers of wood with adhesives or fasteners. Panels and beams are manufactured off-site for strength and speed, then assembled on location for tall buildings and other structures. This method offers significant environmental benefits, strong structural performance, and efficient construction. However, like other lumber products, mass timber is vulnerable to moisture damage and pest infestation.

Hazard Resilience

Wildfire

Fire resistant, as surface char forms a protective layer. Fire rating of 3+ hours.

Rain and Floods

Moisture management is needed. Risk of swelling or decay without protective detailing.

Windy

Strong wind resistance as engineered connections provide stability.

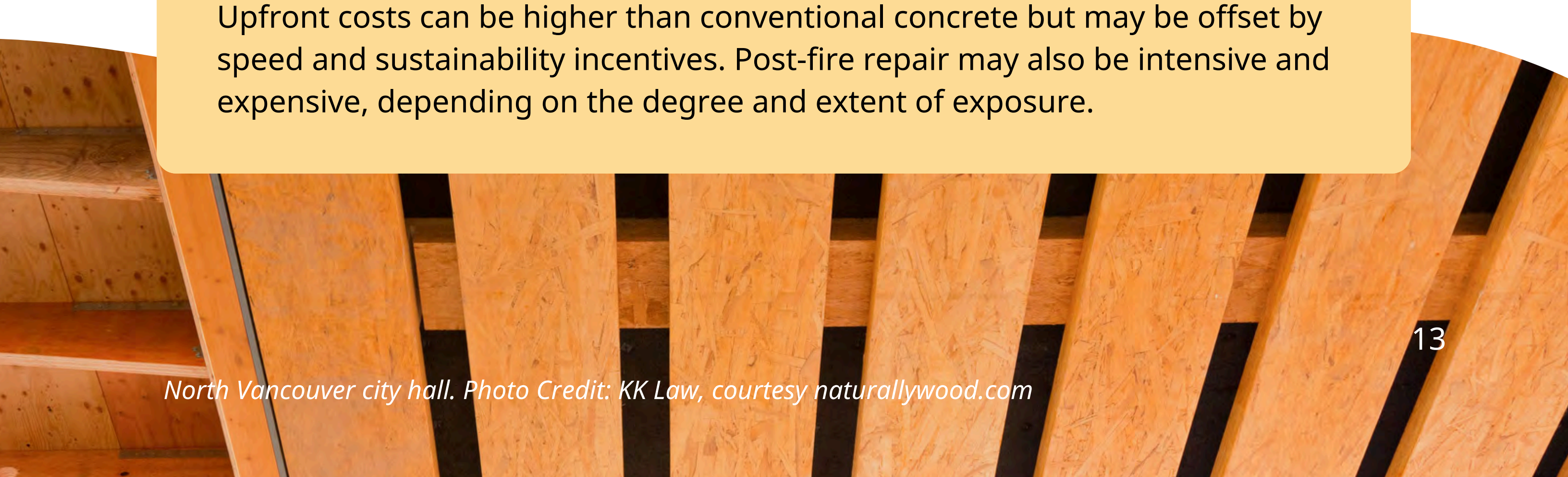
Extreme temperatures

High thermal efficiency and moderate insulation.

Seismic

Flexibility and engineered joints help withstand earthquakes.

Cost estimates for mass timber construction can vary by region, design, and supply factors. In British Columbia, current quoted costs for mass timber systems are in the range of $400–$450 per square foot, influenced by demand, manufacturing capacity, and regulatory support. Prefabrication reduces construction time and labor, while local sourcing supports regional economies. Upfront costs can be higher than conventional concrete but may be offset by speed and sustainability incentives. Post-fire repair may also be intensive and expensive, depending on the degree and extent of exposure.



North Vancouver city hall. Photo Credit: KK Law, courtesy naturallywood.com

How do these materials compare to conventional concrete?

Conventional concrete combines cement, aggregate, water, and supplementary cementitious materials such as fly ash, slag, or recycled aggregate. It remains the dominant material for foundations, floors, and walls in BC due to its structural strength, versatility, and local availability. Recent innovations include low-carbon cements and advanced admixtures that enhance resilience and reduce emissions. Concrete may be site-poured or precast to lower waste and speed assembly.

Hazard Resilience

Wildfire

Fire-resistant, with 2-4 hour fire ratings.

Rain and Floods

Water and mold-resistant. Needs protective coatings and sealing to prevent damage.

Windy

Strong wind-resistance, esp. if steel-reinforced.

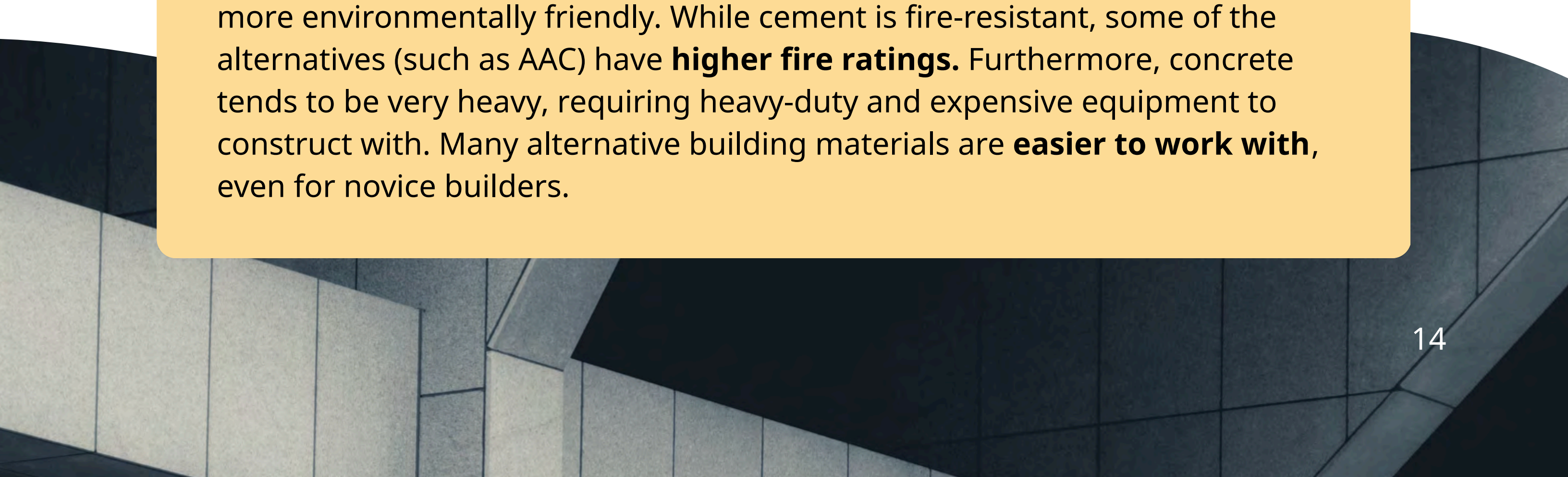
Extreme temperatures

High thermal mass but additional insulation needed.

Seismic

Resistant if reinforced with steel.

Why consider alternatives?
While cement is widely available, strong, and generally reliable, cement production is **emissions-intensive** and globally accounts for about 7% of greenhouse gas emissions. Although lower-emissions processes are being developed, many other building materials, like straw bale and cob, are much more environmentally friendly. While cement is fire-resistant, some of the alternatives (such as AAC) have **higher fire ratings.** Furthermore, concrete tends to be very heavy, requiring heavy-duty and expensive equipment to construct with. Many alternative building materials are **easier to work with**, even for novice builders.



Pit Houses

Pit houses are partially built into the ground. They historically provided warmth and shelter during the winter season for various Indigenous peoples in the Plateau region. While they are no longer common dwellings, they remain culturally important.

Advantages of pit house construction:

- Fire-resistant
- Excellent thermal insulation.

Potential drawbacks:

- Risk of overheating, mold, and poor air quality due to poor ventilation.

Wildfire

Fire-resistant

Rain and Floods

Poor drainage can lead to flooding and rot. Mitigation measures are required.

Windy

Wind-resilient, but roof needs anchors.

Extreme temperatures

Good thermal insulation aids in heat retention.

Seismic

Reinforcements needed through bracing or panels.

Recent information about the cost of construction pit houses in similar climates as BC's is unavailable. Estimates may be available through local suppliers.

Dodeca-Home under construction. Photo credit: Skeetchestn Dodeca-Homes

Modular Building

BC faces a growing housing supply and affordability gap. Communities are searching for solutions to accelerate the construction of new housing. Modular housing is a construction method that uses building modules that are built in-factory, then combined on-site. This method requires less on-site construction labour, which can speed up the construction process. The adoption of modular buildings is still relatively new in BC, and research on whether modular buildings are resilient to the effects of climate change is needed. However, the advantage of quick on-site construction provides several benefits for communities that experience short construction seasons and need quick and effective solutions to rebuild after extreme climate hazard events.

Modular homes are **flexible** options that can be built with **moisture** and **fire-resilient** materials.

However, **overheating** is a common concern, and building quality is highly **variable** based on the materials and design used.

Wildfire

Can be built with fire-resistant materials.

Rain and Floods

Can be built with moisture-resilient materials and/or constructed on a high foundation.

Windy

Performance depends on strength of connections.

Extreme temperatures

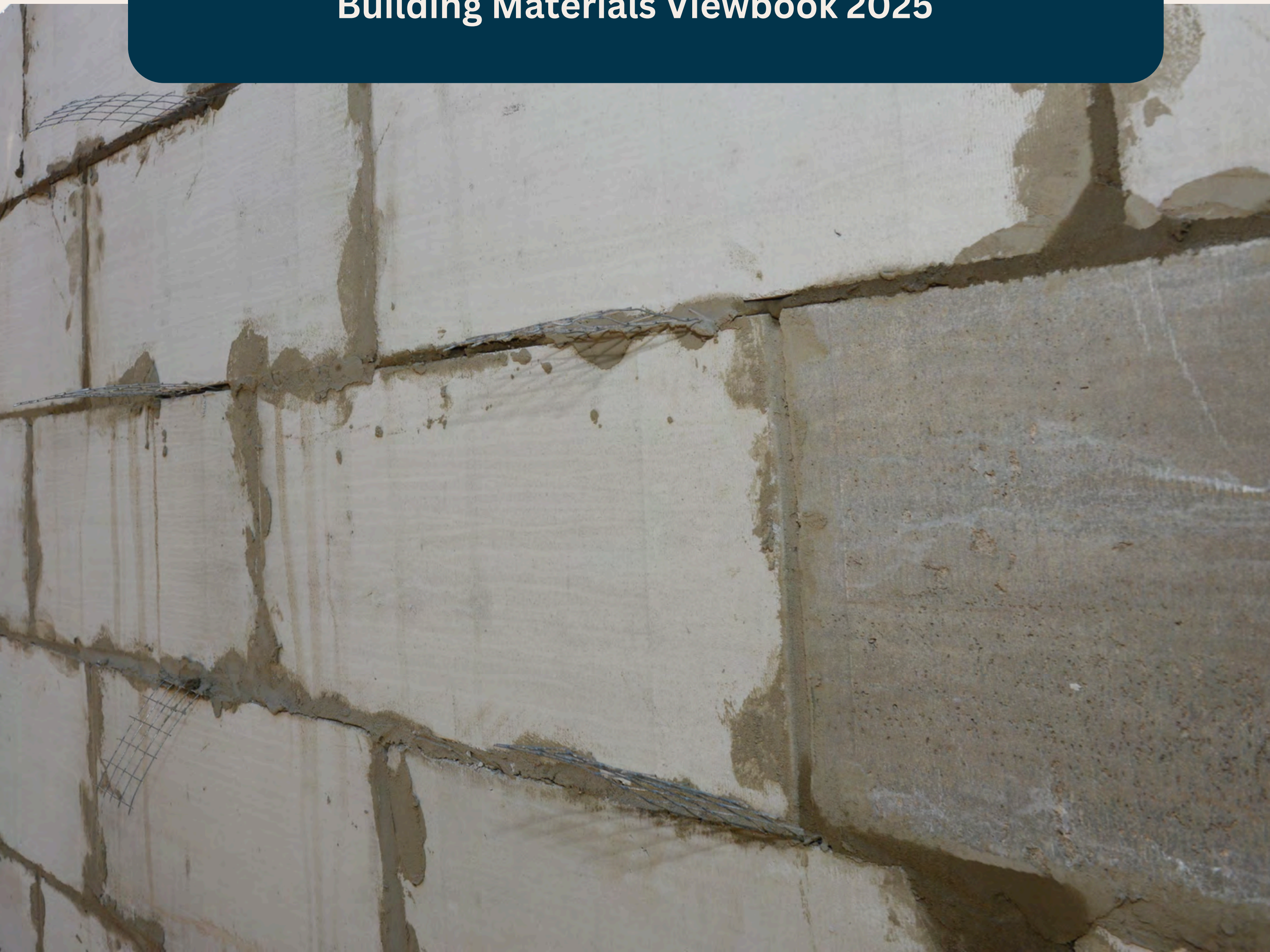
Heat loss and overheating depend on exterior insulation.

Seismic

Mixed seismic performance depending on design

PART 3: EXTENDED FACTSHEETS

Building Materials Viewbook 2025

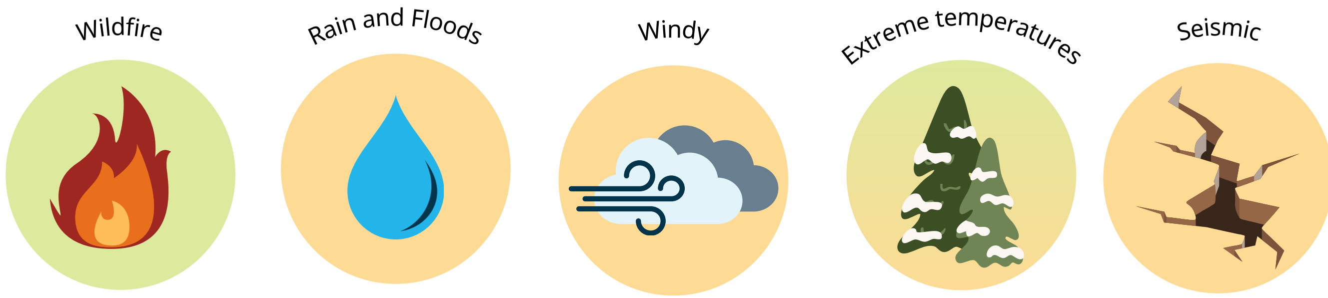


Rammed Earth

Building with rammed earth involves compressing earth - a mix of sand, gravel, and clay, often with stabilisers such as lime or cement - into vertical *formworks* layer by layer. This approach produces strong, compact walls.

Formworks are temporary wooden or plywood frames used to shape the wall.

Hazard Resilience



Fire-resistant (4-hour fire rating)

Risk of damage from floods (can be mitigated with structural changes)

Roof is vulnerable to damage

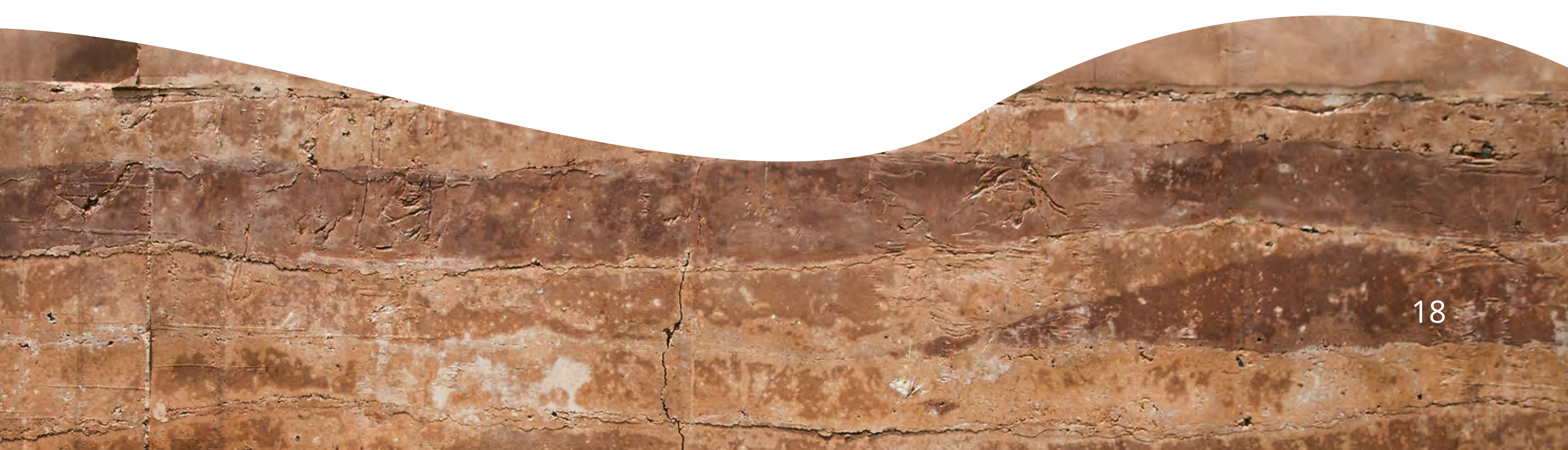
Good temperature regulation but poor insulation

Needs reinforcements for seismic resilience

Cost Analysis

Cost estimates for rammed earth vary depending on many factors, including site, soil type, and labour/transportation costs. innovative earth, a company based in Alberta, Canada, estimates rammed earth construction costs $250-350 per square foot (estimate accessed in 2025).

Generally, costs for rammed earth are likely to be higher upfront compared to conventional materials, with a long-term return because of its sustainability.



Hazard Resilience of Rammed Earth

Hazard	Level of Resilience
Wildfire	✅ Naturally fire-resistant, with a fire rating of up to four hours (meaning it can withstand fire for up to four hours).
Floods and rain	⚠️Rammed earth is vulnerable to flood/moisture damage. Sealing and drainage systems are needed. If seals are inadequate, a raised design can reduce vulnerability to floods. However, rammed earth buildings are generally best for dry or temperate climates.
Extreme Temperatures	✅ Good thermal mass aids in natural temperature regulation. ⚠️ Need reinforcements for insulation.
Wind	⚠️Roof is vulnerable to damage.
Earthquakes	⚠️Reinforcements are needed to improve seismic resilience, such as bracing or panels: • Wood or metal frames (medium cost) • Cross-bracing (medium cost) • Tyre Foundations (earth-filled tires) below the walls (low cost)

Cost-effective reinforcements to address moisture challenges

Gravel drainage surrounding the foundation, which prevents capillary rise and directs water away.

Low-medium cost

French Drain: a pipe with gravel foundation to direct water away. They are implemented through exterior walls.

Low-medium cost

Water or moisture barrier, such as lime plaster or clay (*low cost)* or EPDM liners (rubber membranes) underneath floors (*medium cost*).

A mix of **clay, lime, and cement** can reduce the risk of erosion and provide moisture control.

Low cost

Benefits & Risks

Aspect	Benefit of Rammed Earth	Risk of Rammed Earth
Environmental	Low carbon emissions, local materials can be used, little to no waste produced.	Soil sourcing can be unsustainable if done poorly, which could affect ecological landscapes.
Durability	50-100 year lifespan, fire-resistant.	Erosion and moisture damage can occur if no reinforcements are implemented.
Energy Efficiency	Good thermal mass improves temperature regulation. Passive solar design can also lower energy usage.	Lacks insulation. Reinforcements for extra layers in cold climates can address this drawback.
Economic	Little to no long-term maintenance and costs.	Higher initial costs for labour.
Social	Opportunities for capacity-building through labour, knowledge, and skill development, although this can also be a challenge if capacity does not currently exist.	
Regulation & Codes		There are currently many gaps in codes and approvals.

Technical Feasibility & Construction

Materials:
Typical material requirements include soil (sand, silt, and/or clay), and water. Lime or cement may be added to address the risk of erosion and moisture damage.

Lifespan: Estimated lifespan of 50-100 years. External walls rarely need resealing and no painting is required.

Construction
Building with rammed earth requires knowledge of soil composition, compaction techniques, formwork, and frameworks. Indigenous Knowledges may also be relevant, as earthen structures were key components of the social, cultural, and economic practices of many civilizations. Construction is estimated to take 2-4 months for a single-family home.

Typical equipment requirements include pneumatic tampers, mixing equipment, shovels, and concrete mixers.

Specific expertise is needed for soil mixing, high-pressure pneumatic tamping tools, and overall labour. Construction time can be lengthened by the time needed to cure walls. Walls are susceptible to flooding if they are not sealed properly.

Improper construction can lead to:
- Weak walls prone to shrinkage, cracking, and swelling if constructed with the wrong soil mix.
- Weak structure/erosion and poor load bearing if soil is insufficiently compact.
- Mold, erosion, or structural failure if waterproofing and drainage is poor.
- Collapse if seismic reinforcement is insufficient.

Barrier: Building Codes
There are various code barriers to rammed earth construction:
- There are few accepted and clear universal standards for seismic protection, insulation, and load-bearing.
- It is unclear how soil composition and compaction affect building code standards.
- There is a lack of data to show that seismic requirements are met, and strategies for reinforcing rammed earth are not standardised.
- Additional layers may be necessary to meet thermal insulation requirements.
- Moisture resistance is not included in codes.
- Codes lack variability for geography and climate.

Maintenance & Retrofits

Addressing cracks and peels in the wall: cracks and peels can be repaired through earth mortars or mixes compatible with the house

Priority: Moisture Reinforcement
The general goal of reinforcements is to prevent moisture from moving into the building.

- Capillary breaks can stop water from moving into the building.
- Breathable lime plasters can also provide moisture protection.
- Avoid cement renders, which can trap moisture, unless it's part of a stabilizing mix.

Priority: Seismic Reinforcement
The general goal of reinforcements is to strengthen the material and structure.

- Confining bands and steel plates can help reduce the risk of collapse and promote strength.
- Steel anchors can support the foundation.
- The soil mix plays a significant role in the material's strength.

Rammed earth wall

Cost Estimates

Keep in mind that many factors can affect end costs. For rammed earth, soil type will affect foundation costs. Sloping land may require retaining walls, adding expense. Design choices (including the number of windows and doors, fixtures, fittings, home size, and wall height) will also influence construction costs.

Cost estimates for rammed earth vary depending on many factors, including site, soil type, and labour/transportation costs. innovative earth, a company based in Alberta, Canada, estimates rammed earth construction costs $250-350 per square foot (estimate accessed in 2025).

Geographic variance:
Costs may vary due to higher transportation costs in remote and special access areas. In Coastal BC communities with more moisture, the need for increased moisture barriers would increase costs. Northern BC villages would require extra insulation to address extreme cold temperatures, which would increase costs as well.

Example: Nk'Mip – Desert Cultural Centre (Osoyoos, BC)

Constructed in 2006, this semi-underground structure is made from rammed earth walls. As the center's website explains, "each layer is made of concrete mixed with local soil and mineral pigment, is poured and tamped down separately. The thick walls have a layer of insulation and steel reinforcement, greatly increasing energy efficiency and earthquake resistance." The building also has many other ecologically sustainable design features, including a 'green roof' with desert vegetation, a radiant heating and cooling system that eliminates the need for air conditioning, and the use of pine-beetle damaged wood for the decorative accents.

Learn more about the Centre.

Photo credit: Nk'Mip Desert Cultural Centre

Example: Terra Firma Builders Ltd.

Terra Firma Builders is based on Salt Spring Island in British Columbia and specialises in SIREWALL (Structural Insulated Rammed Earth wall) construction, a proprietary form of modern rammed earth. The company both builds with rammed earth, including the Nk'Mip Desert Cultural Centre, amongst many other projects, and provides courses on working with the material.

Learn more about Terra Firma Builders.

Note Space: *Community & Personal Knowledge*

Straw Bale

Straw is a grain stalk (such as wheat, rice, rye, or oats) without the head. Straw-bale can be used as infill for post and beam/timber framing walls. Straw can also be compressed into agriboard or blocks.

Hazard Resilience

Wildfire

Fire-resistant when paired with plaster (2 hour fire rating).

Rain and Floods

Risk of moisture retention & mold, especially if exposed to water during construction

Windy

Panels filled with straw bale, if constructed well, are resilient against wind

Extreme temperatures

Low thermal mass but a great insulator

Seismic

Seismic-resilient due to energy absorption and wide footprint

Costs
For a straw bale wall, costs are estimated at $180-208 per square foot (number based on an American website accessed in 2025). This does not include components other than the straw bale, such as the foundation, roof, doors, windows, and plumbing.

Straw bale is generally more affordable and easier to work with compared to other materials. However, as with all other building projects, actual costs will vary based on many regional and site-specific factors.

Climate Resilience

Component	Straw Bale
Fire	✅ Although straw is combustible, if combined with plaster, straw bale has a 2-hour fire rating, which means it can withstand fire for about two hours before it is destroyed. This is twice as fire resilient compare to frame walls. The compression of straw into blocks minimises oxygen, limiting combustion potential.
Floods	❗ Straw bale is vulnerable to flooding. High moisture or lack of ventilation can lead to mold. Straw bale should be kept 2-3 feet above the ground to prevent moisture from seeping upwards.
Moisture	❗ Straw bales must be waterproof and breathable. Moisture levels should be below 15% (ideally 10%), and levels about 20% can lead to rot. Load capacity is also reduced under high moisture. Straw bale must be 2-3 feet above the ground to prevent moisture from seeping upwards. Plaster can also protect the bales from moisture.
Extreme Temperatures	⚠️ Low density means they do not store much heat and have low thermal mass (low temperature regulation abilities). ✅ Long thermal lag, which means straw bale can delay temperature changes. Straw bale also has higher insulation values than standard walls filled with fiberglass, cellulose, or rock wool.
Wind	✅ Straw bale walls can withstand substantial dynamic force with minimal movement (see the BaleHaus@Bath case study for more detail)
Seismic	✅Straw bale absorbs energy well and straw bale walls have wide footprints. Both these attributes make straw bale seismic-resilient - a study from the University of Nevada showed straw bale was able to withstand 200% greater shakes than a simulated 6.7 magnitude earthquake.

Benefits & Risks

Aspect	Benefit of Straw Bale	Risk of Straw Bale
Environmental	Straw bales are locally available in most parts of BC.	The plasters used with straw bale often have embodied greenhouse gas emissions, meaning their production emits CO_2 or its equivalents.
Durability	The long-term durability of straw bale is dependent on preventing moisture build-up. If built correctly to minimise moisture exposure, then straw bale walls will last.	Insect infestation and mold are both potential issues. Adequate sealing and resealing can protect bales from both risks. Straw bale can rot if moisture levels are above 20%.
Energy Efficiency	Very energy efficient, with higher insulation value than standard walls filled with fiberglass, cellulose, or rock wool.	
Economic	Relatively affordable material	Construction is labour intensive, which can increase prices.
Regulation & Codes		Straw bale buildings fall under non-conventional building methods in the BC Building Code, which means they need approval from a structural engineer before a building permit is issued. However, recent increases in cob and straw bale construction has led to more testing being completed.

Technical Feasibility

Materials:
Compressed straw is the primary material used in straw bale. Plaster may be added to protect the straw from moisture and improve fire resilience. A pure lime or earth-lime hybrid is best for breathability (although cement-lime plaster mixes resist erosion, they trap moisture and worsen decay).

Straw bales will typically make up 14-20% of a building. Other materials are necessary.

Maintenance and Lifespan:
Straw bale homes can be durable if they are built correctly. Generally, the long-term durability of straw bale relies on preventing moisture build-up. If straw bale walls are constructed correctly in ways that minimise moisture exposure and if a breathable plaster and/or rainscreens are used, then straw bale can last for decades.

Any cracks in plaster must be filled promptly.

Barrier: Building Codes
Straw bale buildings are classified as a ‘non-conventional’ building method in the BC Building Code, which can make it more difficult to obtain a building permit. Approval from a structural engineer is required. However, the recent increase in cob and straw bale construction is leading to more testing being completed.

Construction Methods

Construction Methods:
Straw bales can be used for:

Load bearing: straw bales are used to support vertical loads, which are important for structural stability.	**Frame infill:** straw bales fill a structural frame.	**Prefabricated panel systems:** straw bales are used in pre-made wall units.

Compared to other building materials, straw bale is a 'beginner-friendly' material and accessible to newer builders with relatively little training. That said, there are still precise steps and guidelines, particularly strict storage standards to minimise moisture exposure, proper compaction to promote fire resilience, and the use of plaster to support resilience and structural longevity.

Construction can take 9-12 months or more because working with straw bale is labour intensive. The cost of straw bale is estimated at $180-208/square foot. Costs may be cheaper close to the time of harvest.

Minimise moisture!
It is important to design straw bale homes to minimise moisture exposure. This can be done through:

- Using **moisture sensors** to detect potential issues early.
- **Overhangs** that prevent moisture from entering from wall cracks.
- **Avoiding exposed sites.**
- **Flashing**: thin strips of impervious material that will prevent water infiltration at joints and seams.
- Vapour-permeable construction through lime or earth-based **plasters** that prevent trapped moisture. Repair and replace any failed renders.
- A **mechanical ventilation system** to extract moisture and warm incoming fresh air.
- Proper air **sealing** is essential to prevent internal condensation.

Example: BaleHaus@Bath

BaleHaus @ Bath is a two-storey project made from straw and hemp cladding panels that were locally manufactured in a factory and then delivered to the site. The University of Bath's BRE Centre for Innovative Construction Materials monitored the house for two years and found it maintained heat through frigid winters, stayed dry, and had good sound insulation.

More information about BaleHaus can be found on the ModCell website and the University of Bath's feature of the building.

Note Space: *Community & Personal Knowledge*

Photo credit: Agile Property and Homes Ltd and ModCell.

Cob

Cob consists of clay, straw, sand, lime and water, which is mixed and becomes stiff when cured. The final product resembles a form of concrete. While the material can be load bearing for single story/low-rise structures, it is typically used as infill for timber post and beam walls.

Hazard Resilience

Wildfire	Rain and Floods	Windy	Extreme temperatures	Seismic

Wildfire	Rain and Floods	Windy	Extreme temperatures	Seismic
Fire-resistant (2-4 hours of exposure)	Vulnerable to flood damage	Little information available about wind resistance	Excellent thermal mass supports temperature regulation. Little insulation.	Needs reinforcements for seismic resilience

Cob is a natural, sustainable building material.

- It can be constructed using locally available materials.
- It is relatively beginner-friendly and cost-effective.

However, cob is absent in the Building Codes and Regulations, which can make its use more complicated.

As of 2025, recent and credible public estimates of costs were not available. Estimates may be available through local suppliers. Generally, cob is made with relatively low-cost materials but is labour-intensive to work with.

Climate Resilience

Component	Straw Bale
Fire	✅ Good fire resistance. Cob's clay, sand, and straw composition makes it naturally fire-resistant, especially with thick walls and earth or lime plasters. Straw within the cob acts as fiber reinforcement and is not present in high enough quantities to sustain combustion.
Floods	⚠️ Low flood resilience. Well-compacted, straw-reinforced cob walls resist initial short-term immersion but overall are vulnerable to long-term flooding, which leads to deterioration, erosion, and potential failure if saturation persists; proper foundations and moisture detailing (sealing gaps) can help.
Moisture	⚠️ Moisture-sensitive. Cob's high clay and straw content allow for some moisture vapor diffusion, but the wall will degrade if subjected to persistent wetting or poor drying. Breathable, thick plasters and good site drainage are essential for longevity.
Extreme Temperatures	✅ Excellent thermal mass. Cob walls absorb and slowly release heat, stabilizing interior temperatures. ⚠️ However, cob's insulation value is low, so thick walls are needed in cold climates for comfort. With the right mix (added lime, appropriate wall thickness), cob is resilient to freeze–thaw conditions.
Wind	⚠️ Excellent against wind-driven surface erosion. There is less evidence for high wind load (hurricane) resistance. Thick, well-plastered cob walls do not erode significantly, but their lateral strength under extreme wind loads is undocumented; structural reinforcements may improve this.
Seismic	⚠️ Low inherent seismic resilience but can be improved. Unreinforced cob is brittle under earthquakes, but affordable, natural reinforcements (bamboo, wire mesh, wooden grids) can substantially increase resilience, making cob viable in some seismic regions with appropriate design.

Benefits & Risks

Aspect	Benefit of Cob	Risk of Cob
Environmental	Made from natural, locally available soil, sand, clay, straw. Low carbon footprint, especially with site-sourced/repurposed materials. Non-toxic, recyclable, renewable, and compatible with circular economic approaches.	Impacts depend on site sourcing and soil transport. Vulnerable to local soil depletion if over-harvested. Without proper design, walls may require periodic repair or rebuilding.
Durability	Durable for centuries when built and detailed properly, especially with thick walls, overhangs, and regular maintenance. Resistant to surface erosion, pests, and fire.	Prone to degradation from flooding, persistent moisture, or poor foundations. Regular maintenance needed, including plaster repair and moisture management.
Energy Efficiency	High thermal mass moderates temperature swings. Provides a cool building in heat and warmth retention in winter with thick walls. Locally sourced materials reduce embodied energy	Requires thick walls for adequate insulation in cold climates. R-value is lower than most modern insulations; meaning perhaps it is not ideal for cold climates.
Economic	Low-cost where soil and sand can be harvested onsite. Simple construction methods reduce reliance on specialized labor and consequently reduce costs.	Labor-intensive, with long building and drying times. Local soil and sand quality may require supplementation. Permitting and approval can be a challenge.
Regulation & Codes	Interest and use is high among alternative building communities. Long historical use and growing body of contemporary research and BC-based consultants is making cob construction more accessible.	Not formally recognized in BC Building Code, making it an ‘alternative solution’ which requires an engineer to sign off on construction of cob structures.

Technical Feasibility

Materials:
Cob is made by mixing clay, subsoil, sand, straw, and water in specific ratios (typically 15–25% clay, 2% straw by mass, with sand/gravel as the bulk). Sometimes lime is added (especially for increased water resistance). Cob can be mixed by hand or mechanically, using local soil, with straw as reinforcement.

Lifespan:
Cob houses are durable when designed with adequate site drainage, proper overhangs, and maintained plasters. The flexible, vapor-permeable nature of cob supports healthy indoor air quality. Key risks include long-term water exposure/flooding and improper plaster maintenance.

Materials:
- Mixed in batches.
- Walls are hand-shaped or packed, allowing for sculpted or curved forms.
- Requires thick walls (often 12–24 inches) for structural strength and comfort.
- Buildings can be constructed entirely with cob or as hybrid designs (with post-and-beam frames).
- Exterior plaster (lime or earth) applied for weather protection.
- Construction timeline depends on wall thickness, drying conditions, and size; walls must dry thoroughly between courses for best structural properties

Barrier: Building Codes
Cob is considered an 'alternative solution' under the BC Building Code, necessitating performance testing and approvals from engineers. However, there are several BC-based consultants who are experienced with cob construction, as well as many beginner-friendly guides online, which make cob construction quite accessible to inexperienced builders, so long as they are aware of the regulatory hurdles.

Construction Methods

Cob may be:

Hand-formed into a **unreinforced, thick, sculpted wall**. This approach is best suited to dry climates or mild seismic zones.	**Layered "in formwork"**, meaning cob is poured or packed into forms, layer by layer. This approach allows for more conventional wall shapes.	Used in a **hybrid post-and-beam** with cob infill. The structural frame supports roof and loads, while the cob provides insulation, mass, and finish.

Structural Limitations & Flood Risk
Cob lacks the compressive and tensile strength of reinforced concrete or masonry; load-bearing capacity depends on wall thickness, soil quality, and (when used) reinforcement. Flood and persistent wet climates can cause long-term damage, which makes site and moisture detailing critical.

Reinforcement Options

Priority: Moisture Reinforcement
The general goal of moisture retrofits is to prevent moisture from moving into the building.

- Raising the foundation can prevent flood damage.
- Capillary breaks can stop water from moving into the building.
- Breathable lime or clay plasters, as shown in the photo below, can also provide moisture protection.

Priority: Seismic Reinforcement
The general goal of reinforcements is to strengthen the material and structure. Confining bands and wire mesh can help reduce the risk of collapse and promote strength because they connect roofs and foundational structures into the walls.


Exterior cob covered with lime plaster.
Photo credit: Valentijn Helmus

Example: Cob House, Stanley Park (Vancouver, BC)

The Cob House was constructed in 2004 at the miniature train yard in Stanley Park. It was designed by a team from UBC Civil Engineering and the BCIT Green Roof research facility. The structured won an Innovation Award from the Vancouver Regional Construction Association. It continues to be used now for Stanley Park Ecology's popcorn stand.

More information about the house and its construction be found on the Stanley Park Ecology's website.

Note Space: *Community & Personal Knowledge*

Photo credit: Stanley Park Ecology and Patricia Thompson

Hempcrete

Hempcrete is composed of the dried woody cores of hemp fibers, lime, and water. While some innovative load-bearing applications are being explored, the material is best suited as insulation or infill for walls.

Hazard Resilience

Wildfire

Fire-resistant (1+ hours of exposure)

Rain and Floods

Breathable and resilient to mould

Windy

Typically used as infill, so has less influence on wind resilience

Extreme temperatures

High thermal efficiency and moderate insulation

Seismic

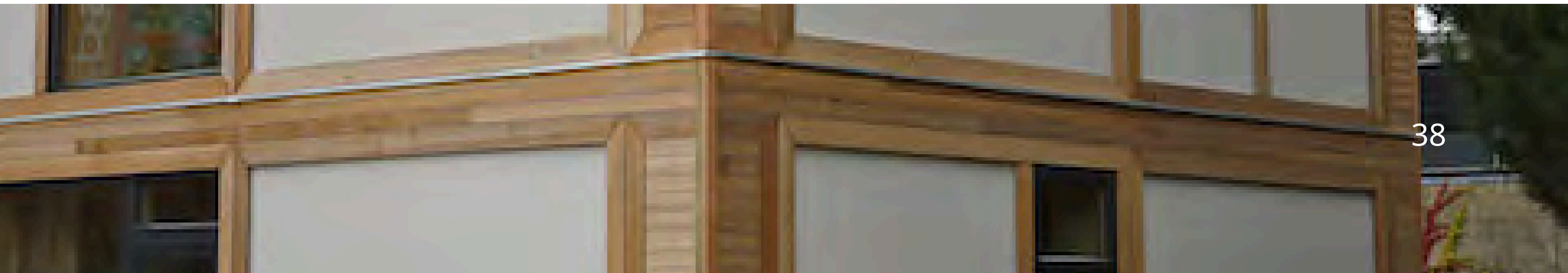
Flexible and lightweight, leading to seismic resilience

Unlike wood, hempcrete is pest-resistant. Hempcrete also has the unique ability to sequester carbon, meaning that it can be net-negative in embodied carbon emissions. The productivity of hemp crops, as well as their abundance in BC, further highlight the materials potential as a sustainable and climate resilient option. However, due to its low compressive strength, the material remains feasibly limited in its application to insulation or infill. Some builders also mention hemcprete has a social stigma associated with it. Finally, its absence in the Building Codes and Regulations further complicates its use.

As of 2025, recent and credible public estimates of costs were not available. Estimates may be available through local suppliers. Hempcrete may be more expensive than standard infill options.

Climate Resilience

Component	Straw Bale
Fire	✅ High fire resistance. Hempcrete achieves a ~1-hour fire rating per 4 inches of thickness when exposed to temperatures around 1700 °F (927 °C). Its lime binder and low organic volatility prevent combustion, and it does not release toxic fumes.
Floods	✅ Moderate flood resilience. Hempcrete can absorb and retain water when submerged, but it generally dries out without structural damage if allowed adequate ventilation. Its high-pH lime binder resists microbial growth and decay. For flood-prone areas, breathable exterior finishes and raised foundations are recommended.
Moisture	✅ Highly vapor-permeable and mold-resistant. Prolonged direct contact with water should still be avoided, and breathable protective coatings are recommended in damp climates.
Extreme Temperatures	✅ Excellent thermal performance. Hempcrete has significant thermal mass, allowing it to moderate indoor temperature swings. Good freeze–thaw durability when properly detailed (lime binder, drainage, breathable coatings). ⚠️ Thermal insulation is moderate but thicker walls enhance performance.
Wind	n/a - Because hempcrete is generally non-load bearing, performance depends primarily on the supporting frame.
Seismic	⚠️ Lightweight and flexible. Hempcrete's low density reduces seismic inertia loads, and when cast around flexible timber frames, it can absorb minor movements without cracking. However, overall seismic performance depends primarily on the engineering of the structural frame rather than the hempcrete infill itself.



Benefits & Risks

Aspect	Benefit of Hempcrete	Risk of Hempcrete
Environmental	Made from (renewable) hemp cores combined with lime binder, forming a low-carbon, carbon-sequestering material. Hemp absorbs significant CO_2 during growth, and the lime binder reabsorbs CO_2 as it cures, making hempcrete carbon-negative over its life cycle. Non-toxic, recyclable, and contributes to healthy indoor air quality.	Limited domestic hemp processing may also necessitate long-distance transport, increasing embodied emissions.
Durability	Long-lasting and resistant to mold, pests, and rot . Can dry out after moisture exposure without structural damage. Good freeze–thaw durability when properly detailed with breathable coatings.	Prolonged water exposure or poor detailing can lead to moisture accumulation and surface degradation. Requires careful design to avoid water ingress and ensure proper drying.
Energy Efficiency	Excellent thermal regulation. Combines insulation and thermal mass, maintaining stable indoor temperatures and reducing heating/cooling demand.	Insulation value is moderate compared to conventional insulations, so thicker walls are needed for equivalent R-values. Improper wall design can reduce efficiency if moisture barriers block breathability.
Economic	Can provide long-term energy savings and reduced lifecycle costs through lower heating/cooling demand. Materials are locally sourced where hemp is grown, reducing transportation emissions	Labor-intensive, with long building and drying times. Local soil and sand quality may require supplementation. Permitting and approval can be a challenge.
Social		Negative social perception & stigma due to misconceptions about the plant's legality and connections to marijuana.
Regulation & Codes	Increasing recognition and adoption in alternative building communities and others.	Still an 'alternative solution' (i.e., not formally recognized in the BC Building Code or National Building Code of Canada), requiring an engineer to sign off on its use.

Technical Feasibility

Materials:
Hempcrete is primarily composed of hemp hurds (the woody core of the hemp plant) and a lime-based binder. Lime is used for its compatibility with hemp's rapid water absorption, widespread availability, and relatively low carbon emissions compared to traditional cement. Other additives and binders such as hydraulic lime, pozzolans, or Roman cement may be incorporated to improve strength and durability for specific applications. Hempcrete can be cast in situ, formed into bricks, or used as loose fill, and is typically employed as insulation or infill in framed structures.

Lifespan:
Hempcrete buildings exhibit notable durability when properly constructed, particularly due to the antimicrobial and mold-resistant qualities provided by the lime binder. The material's vapor permeability ensures excellent indoor moisture regulation, while its resistance to pests and fire further contributes to longevity. Hempcrete's flexibility and lightweight nature also contributes to seismic resilience so long as there is suitable framing. Proper installation, drying, and detailing – such as limiting prolonged water exposure and ensuring ventilation – are crucial for maximizing lifespan and preventing durability issues.

Barriers: Building Codes & Limited Applicability
Hempcrete construction is still considered an 'alternative solution', thus requiring more extensive structural analysis and approval from engineers through the BC Building Code alternative solutions pathway. Ongoing research – such as experimental load bearing hempcrete structures and bricks – aims to expand its use, but most current applications are within infill or insulation frameworks.

Construction Methods

Hempcrete may be used as:

Non-load bearing infill Hempcrete is used as insulating, non-load bearing infill within timber, steel, or concrete frames.	**Frame insulation and enclosure** Hempcrete cast around or inside framed walls creates highly insulated, vapor-permeable building envelopes.	**Prefabricated hempcrete blocks/panels** Hempcrete can be factory-formed into pre-made blocks or panels for rapid wall assembly, often bonded with lime-based mortar.

Compared to other building materials, hempcrete is accessible to newer builders, as its components are easy to mix and handle. However, precise techniques for batch mixing, layering, and curing are key to ensure proper strength, moisture control, and finishing. Lime binder requires careful selection and mixing; hempcrete walls must be allowed to dry thoroughly before finishes are applied, which can extend construction timelines. It may be beneficial to include a ventilated rainscreen to protect the wall base from rain and splash.

Construction can take weeks to months, depending on drying conditions and wall type. While material cost can be competitive with mid-range insulation systems, labor requirements are higher due to the need for staged mixing, casting, and curing. Advances in prefabrication and use of integrated blocks are reducing onsite labor, improving speed and quality control.

Structural & Supply Limitations

- Despite promising experimental approaches, mainstream uses remain limited to insulation or non-structural infill. Hempcrete's low compressive strength means it generally cannot be used for load-bearing applications and should be paired with a structural frame such as timber or steel.
- As an emerging material, hempcrete may lack established and consistent suppliers, leading to supply chain challenges and higher upfront material costs in some locations.
- Hempcrete is considered a non-conventional building method, so builders may face complex permitting requirements.
- Moisture management remains critical: although highly vapor-permeable, improper detailing, prolonged liquid water exposure, or use of non-breathable finishes can result in long-term durability issues or reduced performance.

Example: BaleHaus@Bath

BaleHaus @ Bath is a two-storey project made from straw and hemp cladding panels that were locally manufactured in a factory and then delivered to the site. The University of Bath's BRE Centre for Innovative Construction Materials monitored the house for two years and found it maintained heat through frigid winters, stayed dry, and had good sound insulation.

More information about BaleHaus can be found on the ModCell website and the University of Bath's feature of the building.

Note Space: *Community & Personal Knowledge*

Photo credit: Agile Property and Homes Ltd and ModCell.

Autoclaved Aerated Concrete (AAC)

Autoclaved aerated concrete (AAC) is a mineral-based building material made from sand, water, limestone, cement, and aluminum powder. The mixture is then hardened in an autoclave (pressurized steam chamber). It is a lightweight form of concrete best used as cladding to provide a protective exterior for new and existing buildings. AAC can also be used for low to mid-rise load-bearing walls.

Although AAC has many benefits as a climate-resilient, pest-resistant material, limited supply options and specialised training requirements have constrained its use in British Columbia.

Hazard Resilience

Wildfire

Fire-resistant, with a high hourly fire rating (> 4 hours)

Rain and Floods

Breathability of the material prevents mould.

Windy

Wind resistant with reinforcements

Extreme temperatures

Low/moderate temperature regulation but an excellent insulator.

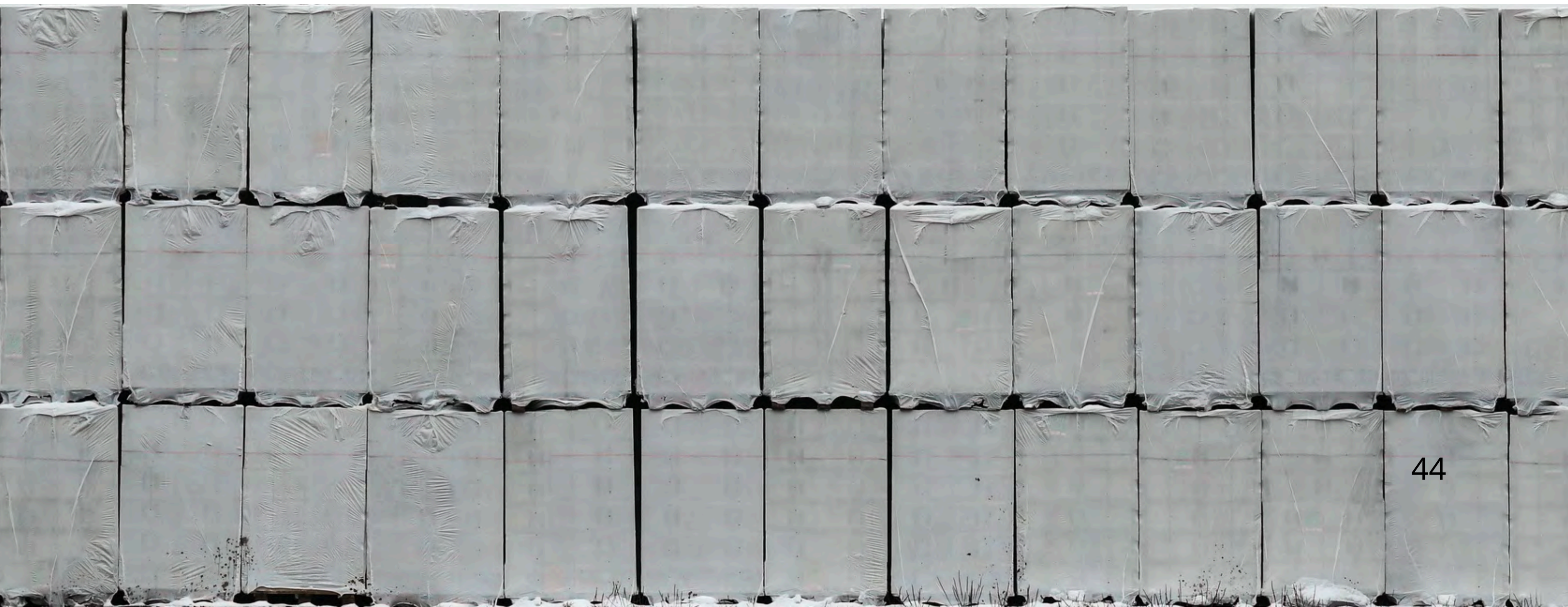
Seismic

Relatively high compressive strength and light weight contributes to seismic resilience.

As of 2025, recent and credible public estimates of costs were not available. Estimates may be available through local suppliers. The upfront cost of AAC may be higher than conventional concrete but its lightweight nature makes it more affordable to construct with.

Climate Resilience

Component	AAC
Fire	✅ High hourly fire rating, which means AAC can withstand fire for a long period (~4+ hours) before damage.
Floods	✅ Can absorb moisture and then dry out without lasting damage when surface treatments are used. An exterior waterproofing or dampproofing layer may be appropriate in flood-prone conditions.
Moisture	✅ Does not have interconnected porosity, which means moisture cannot pull very deeply into the material and only affects surfaces in direct contact with water. Inorganic - does not decay when exposed to moisture and provides no food for mold or mildew.
Extreme Temperatures	✅Excellent insulation. ⚠️However, freeze-thaw resistance requires an exterior coating, which could interfere with the breathability of the material. A waterproof but vapor permeable coating that allows for dissipation of moisture is recommended.
Wind	⚠️ Needs reinforcements for wind resistance, such as reinforced vertical, grout-filled cores and bond beams.
Seismic	✅The relatively high compressive strength and light weight of AAC blocks contributes to seismic resilience.



Benefits & Risks

Aspect	Benefit of AAC	Risk of AAC
Environmental	Non-toxic materials. Reduced weight of aerated concrete means less materials used and reduced waste. Pest-resistant.	Limited supply options may mean materials need to be transported long distances, which increases emissions. The high temperature kiln required for construction also increases associated emissions.
Durability		An exterior coating is required for durability. Using AAC in roofing is not recommended, as unreinforced AAC panels exposed to rain and snow can lead to water ingression and roof collapse.
Energy Efficiency	Excellent insulation contributes to thermal efficiency.	
Economic		There are limited supply options, which may increase transportation costs. Domestic AAC production has the potential to provide both economic and environmental opportunities.
Regulation & Codes		AAC was historically part of the National Building Code but currently, its use needs to be approved by a structural engineer.

Technical Feasibility & Construction

Materials:
Typical material requirements include sand, water, limestone, cement, and aluminum powder.

There are currently a limited number of suppliers of AAC blocks in Canada.

Maintenance and Lifespan: When used in a load-bearing capacity, AAC is reinforced with steel (RAAC, reinforced aerated autoclaved concrete). The lifespan of RAAC is estimated at 30 years.

Building Codes: AAC was historically part of the National Building Code but currently, its use needs to be approved by a structural engineer.

Construction
Specialised training is required to work with AAC. A high-temperature kiln is required for construction. AAC should not be used for roofing. Unreinforced AAC panels exposed to rain and snow risk water ingression and roof collapse.

Construction time is lower compared to regular concrete. AAC is easier to cut, shape, and shave due to its lightweight and cellular properties. Rocksolid Building Products, a company looking to open a AAC manufacturing plant in Canada, estimates that using AAC for load-bearing blocks speeds up wall installation by up to 50%. They further note that AAC is lightweight and easy to install as cladding.

AAC may be used for:
- Exterior finishes and replacement
- As infill (contributing to thermal performance)
- Multi-story buildings, provided panels are used with connectors and confined frames.

Mechanical anchors and connections aid in seismic resilience.

Example: Historic AAC Block House (Radium Hot Springs, BC)

This home was originally constructed between 1963-1968 by a stonemason using AAC blocks for the load-bearing walls. Even without an exterior finish on the walls, the AAC walls have only experienced surface weathering over six decades. There is no rot and no risk of structural failure. The AAC block house demonstrates the resilience of this material to wind, fire, and other tough climactic conditions.

More information about the house can be found on the RockSolid Building Products building feature.

Note Space: *Community & Personal Knowledge*

Photo credit: Rocksolid Building Products.

Mass Timber

Mass timber construction uses engineered wood products, such as cross-laminated timber (CLT), glulam, and nail-laminated timber (NLT), which are formed by bonding layers of wood with adhesives or fasteners. Panels and beams are manufactured off-site for strength and speed, then assembled on location for tall buildings and other structures. This method offers significant environmental benefits, strong structural performance, and efficient construction. However, like other lumber products, mass timber is vulnerable to moisture damage and pest infestation.

Hazard Resilience

Wildfire

Fire resistant, as surface char forms a protective layer. Fire rating of 3+ hours.

Rain and Floods

Moisture management is needed. Risk of swelling or decay without protective detailing.

Windy

Strong wind resistance as engineered connections provide stability.

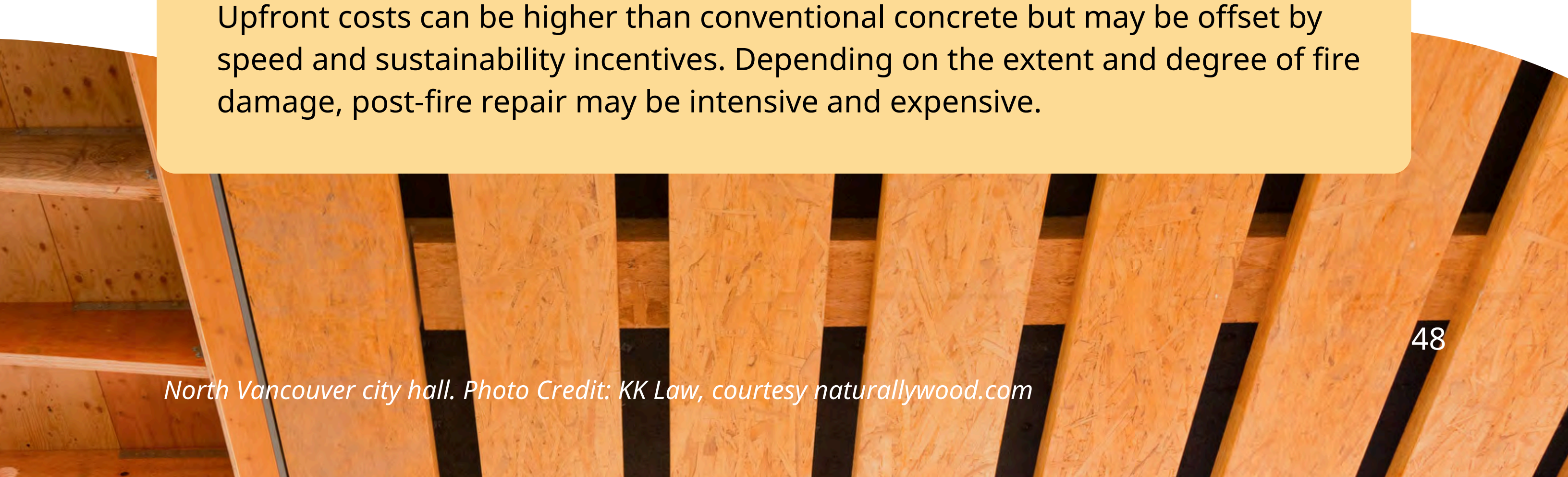
Extreme temperatures

High thermal efficiency and moderate insulation.

Seismic

Flexibility and engineered joints help withstand earthquakes.

Cost estimates for mass timber construction can vary by region, design, and supply factors. In British Columbia, current quoted costs for mass timber systems are in the range of $400–$450 per square foot, influenced by demand, manufacturing capacity, and regulatory support. Prefabrication reduces construction time and labor, while local sourcing supports regional economies. Upfront costs can be higher than conventional concrete but may be offset by speed and sustainability incentives. Depending on the extent and degree of fire damage, post-fire repair may be intensive and expensive.



North Vancouver city hall. Photo Credit: KK Law, courtesy naturallywood.com

Climate Resilience

Component	Mass Timber
Fire	✅ Fire resilient, with asterisks. Extensive fire testing shows mass timber can achieve and exceed code-required fire ratings even when exposed. Panels char on the surface, forming a protective layer beneath, which preserves structural strength—often lasting 3+ hours in standard fire tests. The BC 2024 Building Code requires mass timber be encapsulated with a noncombustible material. The National Building Code 2020 requires the same. Additionally, sprinkler installations are required during construction process of mass timber buildings. Depending on the extent and degree of fire damage, post-fire repair may be intensive and expensive.
Floods	⚠️ Flood resilience is moderate. Water exposure can cause swelling or degrade timber over time. Well-detailed construction (protective coatings, ventilation, elevated foundations) can reduce risk, but mass timber, like all wood, requires moisture management to prevent decay and mold.
Moisture	⚠️ Moisture-sensitive, but manageable. Engineered wood (CLT, glulam) is less sensitive than solid lumber but still requires proper detailing. Vapor-permeable membranes, seals, and rain screens are used. Prolonged wetting can cause decay or structural weakening.
Extreme Temperatures	✅ Good thermal performance. Mass timber has significant thermal mass. Temperature swings are controlled via layered construction, air sealing, and panel thickness. With correct detailing, panels perform well in both heat and cold; freeze–thaw durability is good. ⚠️ Moderate insulation properties
Wind	✅ Strong wind resistance. Mass timber structures can withstand substantial wind loads. Tall timber buildings use engineered connections (steel anchor rods, lateral trusses) and composite/substrate systems to provide redundancy and stability, with demonstrated robustness in Canadian testing.
Seismic	✅ High seismic resilience. Mass timber is lightweight and flexible; walls and frames absorb and dissipate earthquake forces, with good ductility. Connections and panel systems are engineered to allow the structure to bend and return to normal after an earthquake, supporting resilience.

Benefits & Risks

Aspect	Benefit of Mass Timber	Risk of Mass Timber
Environmental	Renewable resource that stores carbon, with lower embodied emissions than concrete/steel. Biodegradable. Mass timber can reduce construction emissions by 25–45%.	Sourcing depends on sustainable forestry. Manufacturing energy and adhesives still contribute to emissions.
Durability	Durable, with proper detailing against moisture. Fire and pest-resistant engineered wood products (CLT, glulam) have strong performance.	Prolonged moisture or flooding can cause decay. Connections and coatings need regular inspection. Risk of pest infestation. Repairs or retrofits, especially post-fire, may be complex and costly.
Energy Efficiency	Moderate thermal insulation combined with thermal mass lowers energy use. Prefab panels reduce construction waste. Air sealing and layered assemblies enhance comfort and efficiency.	Insulation value (R-value) is lower than others, so layered wall systems or additional insulation may be needed.
Economic	Faster on-site assembly, reduced labor, and lower foundation costs. Materials are generally locally sourced, as forestry is a significant B.C. economic sector.	Cost volatility due to major supply/demand fluctuations, with current upfront cost estimates currently high ($400 – 450/ft2). Production volume may be limited by manufacturing capacity.
Regulation & Codes	B.C. building code was updated and mass timber buildings up to 18 storeys permitted	Navigating approvals remains complex. Insurance may be more expensive or difficult to secure for very tall or new mass timber buildings.

Technical Feasibility & Cost

Materials:
Mass timber refers to engineered wood products such as cross-laminated timber (CLT), glue-laminated beams (glulam), nail-laminated timber (NLT), or dowel-laminated timber (DLT). These are made by layering wood planks with adhesives (or mechanical fasteners), forming large panels/beams with high strength for structural use. Timber is typically manufactured off-site for precision and quality, then assembled on location.

Maintenance and Lifespan: Well-built mass timber structures can last for generations if protected from moisture and pests. Routine monitoring for leaks and connection wear is important. Repairs and retrofits may require expert oversight and specialty trades, but wood is generally easier to adapt than concrete.

Building Codes: BC’s building code allows mass timber buildings up to 18 storeys. It may still be considered innovative or 'alternative' in certain applications; insurance and permitting can be more complex for very tall projects.

Cost Estimate: *The cost of mass timber construction in Canada in 2025 typically ranges from $400 to $450 per square foot, with a 10–20% premium over concrete due to higher material and insurance costs, and external factors like lumber market fluctuations and tariffs adding further volatility.*

Bioenergy Research & Demonstration Facility at UBC.
Photo Credit: Don Erhardt, courtesy naturallywood.com

Construction

Construction

- Tall buildings use mass timber columns, beams, and floor/roof panels for the core and shell.
- Wall/floor systems connect via steel anchor rods, engineered connectors, and, in some cases, combined concrete/mass timber hybrid approaches.
- Prefabricated panels can enable faster assembly and less waste.

Method	Details
Prefabricated mass timber panels	CLT/glulam/NLT panels are made off-site, then delivered and assembled.
Hybrid timber-concrete systems	Mass timber is used for vertical/horizontal framing. Concrete is used for core or floors when needed.
Composite/substrate connection	Steel rods, engineered connectors used for lateral and vertical reinforcement.
Traditional frame with timber infill	Less common for high-rise but used for smaller buildings and residential applications.

Bioenergy Research & Demonstration Facility at UBC. Photo Credit: KK Law, courtesy naturallywood.com

Pit Houses

Pit houses are partially built into the ground. They historically provided warmth and shelter during the winter season for various Indigenous peoples in the Plateau region. While they are no longer common dwellings, they remain culturally important.

Advantages of pit house construction:

- Fire-resistant
- Excellent thermal insulation.

Potential drawbacks to be aware of:

- Risk of overheating, mold, and poor air quality due to poor ventilation.

Wildfire

Fire-resistant

Rain and Floods

Poor drainage can lead to flooding and rot. Mitigation measures are required.

Windy

Wind-resilient, but roof needs anchors.

Extreme temperatures

Good thermal insulation aids in heat retention.

Seismic

Reinforcements needed through bracing or panels.

Dodeca-Home under construction. Photo credit: Skeetchestn Dodeca-Homes

Recent information about the cost of construction pit houses in similar climates as BC's is unavailable. Estimates may be available through local suppliers.

Climate Resilience

Component	Pit Houses	Modular Building
Fire	✅Naturally fire-resistant. Can be further fire-proofed with steel roofing.	✅ / ⚠️ Short construction time can make it easier to avoid wildfires. Buildings can be made with fire-resilient materials.
Floods	⚠️Flooding can occur due to low structure (exact location of the house is important).	✅ Raising the foundation and waterproofing can improve flood resilience. Some modular buildings can float or be moved out of flood zones, such as Rotterdam's Floating Pavilion.
Moisture	⚠️Needs to be well ventilated to reduce buildup of moisture. Stagnant air can lead to mold growth.	⚠️Depending on materials used, buildings can be made to be more moisture resilient. Needs to be well ventilated to reduce buildup of moisture. Stagnant air can lead to mold growth.
Extreme Temperatures	✅Great natural insultation and less heat loss from wind due to low structure. For low to medium cost, roof overhangs or insulation (reflective roofing) can be added.	❗ Many modular homes reported overheating. Following energy modeling guidelines can mitigate this risk.
Wind	✅Natural protection due to being underground, and less affected by wind due to low structure. Resilient to high winds, hailstorms, and natural disasters such as hurricanes.	⚠️Wind resilience requires composite panels and robust connections. Debris-impact and connection fatigue may be issues.
Seismic	⚠️Reinforcements needed through bracing or panels, such as wood or metal frames or tyre foundations (earth-filled tires) below the walls.	⚠️Seismic performance dependent on design, particularly the strength of connections.

Cost-effective reinforcements to address moisture challenges

Gravel drainage surrounding the foundation, which prevents capillary rise and directs water away. *Low-medium cost*	**French Drain:** a pipe with gravel foundation to direct water away. They are implemented through exterior walls. *Low-medium cost*	**Water or moisture barrier,** such as lime plaster or clay (*low cost)* or EPDM liners underneath floors (*medium cost*).

Careful site selection can also reduce the risk of water damage. A site with natural drainage away from the building avoids water pressure against underground walls. Soil types that are permeable and allow water to drain efficiently are ideal.

Benefits & Risks

Aspect	Benefit of Pit Houses	Risk of Pit Houses
Environmental	Few materials needed and usually locally available. Low environmental impact.	Lack of proper drainage can cause degradation.
Durability	Provides protection against wind and extreme temperatures.	Risk of flooding, rot and cave-in if improperly constructed.
Energy Efficiency	Natural insulation and thermal abilities.	Without proper ventilation construction, poor air quality and moisture build-up are risks.
Economic	If local resources are available, can be a low-cost option.	Modern adaptations (insultation, HVAC systems etc.) can increase costs.
Social	Opportunities for community resilience and future capacity-building through labour, knowledge, and skill development.	Sometimes mislabelled as a non-permanent dwelling type.
Regulation & Codes	Standards could be included in nation-specific frameworks.	It is difficult to meet current code standards/regulations for attributes such as ventilation or ceiling height.

Technical Feasibility

Materials:
Typical material requirements include earth, timber, sod, natural insulation (moss, bark, etc.), and vapor barriers.

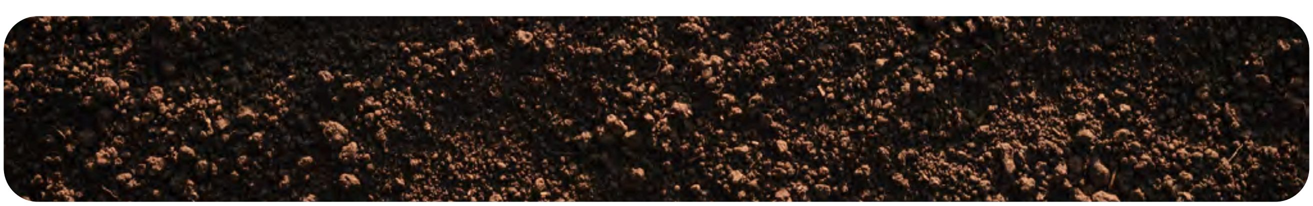
Lifespan:
Pit houses require moderate levels of maintenance. Their estimated lifespan ranges from 20-50+ years.

Barrier: Building Codes

There are various code barriers to pit house construction, including concerns about egress (exit points from a building), ventilation, structural safety, ceiling height, and moisture control. Additionally, **there are little to no standards or guidelines for integrating pit houses into modern design** using Indigenous Knowledges.

- The National Building Code of Canada and other codes do not recognise pit houses as a valid, regulated building form.
- There are little to no precedents for pit houses in residential zoning and safety laws.
- Limited or single points of access can violate fire safety codes, as can the lack of fire safety systems like sprinklers and alarms.
- Mechanical ventilation as required under code can be hard to implement.
- Walls and roofs for pit houses are often not covered in building codes.
- Plumbing and electrical systems are often not included in pit house design the way they are in modern codes.

This barrier might be addressed through codes that enable traditional architecture and designs with guidelines and standards specific to Indigenous cultures, traditions, and practices. Additionally, hybrid designs and modern adaptations can ensure pit houses meet building code requirements.



Constructing Pit Houses

Skills: Pit house construction requires traditional ecological knowledge (TEK), excavation skills, and basic carpentry. Further knowledge may be necessary for modern adaptations to improve insultation.

Equipment: Typical equipment requirements include shovels, digging equipment, chainsaws or axes, and tools for water drainage systems.

Time

- Construction time using traditional methods: 1-2 months.
- Construction time with modern adaptations: 2-3 months.

Methods: Pit house construction requires site-specific planning for drainage and heating/cooling purposes. Topography and microclimate affect site suitability and excavation needs. Proper excavation and soil stability analysis are both important considerations before beginning pit house construction. Granular soils that compact well and are permeable (and therefore will allow for efficient drainage) are preferred over cohesive soils that may expand when wet.

Improper construction can lead to:

- *Flooding, mold, and rot if waterproofing and drainage systems are insufficient.*
- *Roof collapse under snow and rain*
- *Smoke buildup, condensation, and poor air quality if there is a lack of ventilation.*
- *Wall deterioration, poor air quality, and pests if there is a lack of a moisture barrier.*
- *Soil cave-in or wall collapse if structural planning is poor.*

Maintenance & Retrofits

As pit houses are a less common building form now, retrofits are often focused on conserving archaeological and heritage sites. Priorities include non-intrusive maintenance and stabilization, moisture resilience, seismic/structural resilience, ventilation.

<u>Retrofit & Reinforcement Guidelines</u>
Starting Point
To obtain guidance on culturally and technically appropriate conservation strategies, consult local communities and the BC Heritage Branch if you are working on an archaeological or heritage site.

Priority: Moisture Resilience
The low structure of a pit house and its earthern material can make it vulnerable to moisture damage. Retrofits such as waterproof membranes, drainage systems, and rainscreens can addess this risk.

Priority: Ventilation
Poorly ventilated pit homes are more vulnerable to moisture build-up. Moisture sensors can help with monitoring the dwelling. A mechanical ventilation system may be necessary.

Priority: Structural and Seismic Resilience
The structural integrity of a pit house may be improved through tying the roof to the walls with anchors and/or the addition of steel and concrete rods.

Dodeca-Home under construction. Photo credit: Skeetchestn Dodeca-Homes

Cost Analysis

Recent information about the cost of construction pit houses in similar climates as BC's is unavailable. Estimates may be available through local suppliers. The form and material of pit houses (and other forms of earth-sheltered housing) varies greatly, and initial costs of construction can be greater than a conventional house.

Geographic variance:
Costs may vary due to higher transportation costs in remote and special access areas. In Coastal BC communities with more moisture, the need for increased moisture barriers would increase costs. Northern BC villages would require extra insulation to address extreme cold temperatures, which would increase costs as well. Pit houses may be better suited for rural Indigenous areas where there is room for excavation and better soil suitability compared to urban areas. They are particularly cost-effective in climates with low humidity (reducing risk of damage from moisture) and temperature extremes, as the earth's temperature will vary much less than air temperatures, maintaining comfortable temperatures within the home.

Dodeca-Homes (Skeetchestn, BC)

Dodeca-Homes is a business developed by Skeetchestn community members that builds 12-sided post-and-beam buildings. They are not traditional pit houses but are inspired by traditional Secwepemc pit house design. Round homes are more energy efficient than square homes. Construction can be complete in 3-4 weeks and costs $220-250/square foot.

- Business website
- Feature from the Fraser Basin Council (First Nations Home EnergySave)

Dodeca-Home under construction. Photo credit: Skeetchestn Dodeca-Homes

Note Space: *Community & Personal Knowledge*

Modular Building

BC faces a growing housing supply and affordability gap. Communities are searching for solutions to accelerate the construction of new housing. Modular housing is a construction method that uses building modules that are built in-factory, then combined on-site. This method requires less on-site construction labour, which can speed up the construction process. The adoption of modular buildings is still relatively new in BC, and research on whether modular buildings are resilient to the effects of climate change is needed. However, the advantage of quick on-site construction provides several benefits for communities that experience short construction seasons and need quick and effective solutions to rebuild after extreme climate hazard events.

Modular homes are **flexible** options that can be built with **moisture** and **fire-resilient** materials.

However, **overheating** is a common concern, and building quality is highly **variable** based on the materials and design used.

Wildfire

Can be built with fire-resistant materials.

Rain and Floods

Can be built with moisture-resilient materials and/or constructed on a high foundation.

Windy

Performance depends on strength of connections.

Extreme temperatures

Heat loss and overheating depend on exterior insulation.

Seismic

Mixed seismic performance depending on design

Climate Resilience

Component	Modular Building	Pit Houses
Fire	✅ / ⚠️ Short construction time can make it easier to avoid wildfires. Buildings can be made with fire-resilient materials.	✅Naturally fire-resistant. Can be further fire-proofed with steel roofing.
Floods	✅ Raising the foundation and waterproofing can improve flood resilience. Some modular buildings can float or be moved out of flood zones, such as Rotterdam's Floating Pavilion.	⚠️Flooding can occur due to low structure (exact location of the house is important).
Moisture	⚠️Depending on materials used, buildings can be made to be more moisture resilient. Needs to be well ventilated to reduce buildup of moisture. Stagnant air can lead to mold growth.	⚠️Needs to be well ventilated to reduce buildup of moisture. Stagnant air can lead to mold growth.
Extreme Temperatures	❗ Many modular homes reported overheating. Following energy modeling guidelines can mitigate this risk.	✅Great natural insultation and less heat loss from wind due to low structure. For low to medium cost, roof overhangs or insulation (reflective roofing) can be added.
Wind	⚠️Wind resilience requires composite panels and robust connections. Debris-impact and connection fatigue may be issues.	✅Natural protection due to being underground, and less impact due to low structure.
Seismic	⚠️Seismic performance dependent on design, particularly the strength of connections.	⚠️Reinforcements needed through bracing or panels, such as wood or metal frames or tyre foundations (earth-filled tires) below the walls.

Benefits & Risks

Aspect	Benefit of Modular Construction	Risk of Modular Construction
Environmental	Reduced on-site construction means less material waste and fewer carbon emissions from labor force travel. Greater reuse and recycling of materials.	More research is needed on potential environmental risks.
Durability	Modules can be replaced and relocated during climate events.	Early iterations of modular buildings lacked durability.
Energy Efficiency	High energy efficiency.	
Economic	Up to 10% overall cost savings due to lower costs for materials, trades, and transportation.	A large investment is necessary for modular services. The front-loaded nature of construction can become a problem if there are delays or setbacks. Prefabricated units may be completed and ready but cannot be used or stored indefinitely. This can lead to additional costs for storing units.
Social	Improved on-site safety, high production quality due to controlled settings, adaptable in various contexts.	Lack of industry knowledge and awareness. Some of the most-used public procurement approaches can meet challenges when modules are not easily customizable for different needs and can incur costs.
Regulation & Codes	The inclusion/reference of new codes and standards in the building code streamlines paths for prefabricated designs to be expected.	Limited awareness among industry regulators. Current prefab standards are treated as admin docs rather than part of the code, which means provinces may or may not enforce them.

Technical Feasibility

Materials:
Material requirements vary widely depending on the specific design of the modular building.

Maintenance and Lifespan:
Modular homes are potentially more climate-resilient because rebuilding is more efficient and cost-effective. Shorter on-site construction time allows for the avoidance of natural disasters and is beneficial for places with short construction seasons. Modular homes can be relocated during climate hazards.

Barrier: Building Codes

Modular buildings are not referenced in the building code.

- Prefab standards are treated as admin docs rather than in code, which means provinces may or may not enforce them.
- Modular builders must prove that the building is up to the standard of the building code. The Canadian Standards Association (CSA) has guidelines to streamline this process.
- Generally, modular components are inspected and approved in-factory, then delivered to sites in an envelope. There is usually no need for on-site inspections.

Guidance materials for both industry and municipalities can help address these challenges.

CSA A277, Procedure for certification of prefabricated buildings, modules, and panels *is a document that can be used to certify a manufacturer's products, if referenced in the building code.*

Construction

Fewer on-site skills are needed to complete a modular home compared to traditional construction methods. Some work can be automated in factory environments. However, the lack of industry knowledge and awareness of modular building methods can be a barrier, as limited experience can lead to longer view and approval times.

Furthermore, procurement of modular units can be challenging if modules are not easily customisable for different needs. Less prescriptive designs and more collaborative procurement methods could make it easier for communities to acquire and use modular units.

Construction time varies. However, due to faster on-the-ground work, modular building can be 25-50% faster than conventional approaches.

Examples of Modular House Construction

Vancouver Coastal Health Staff Housing (Bella Bella, BC)

Constructed in 2015 to provide staff housing for Vancouver Coastal Health workers in Bella Bella, this modular construction project meets Passive House standards, which means that building uses minimal energy. Modular construction led to faster completion of the project (seven months) with minimal disruption to the quiet community.

Some of the challenges faced during this project included:

- Meeting Passive House standards, as the local construction team was new to this design approach. New enclosure details were needed. These specifications can be standardised for future projects.
- Bella Bella's wet conditions, which made completing air and water-sealing particularly challenging. The modules were protected on all six sides for shipping with a water-repellent but vapour-permeable sheathing membrane.
- Limited access to trades and materials on-site. Off-site construction addressed this barrier.

More information about the project is available in a technical bulletin from RDH Building Science (p18-22).

Aqsarniit Hotel (Iqaluit, NU)

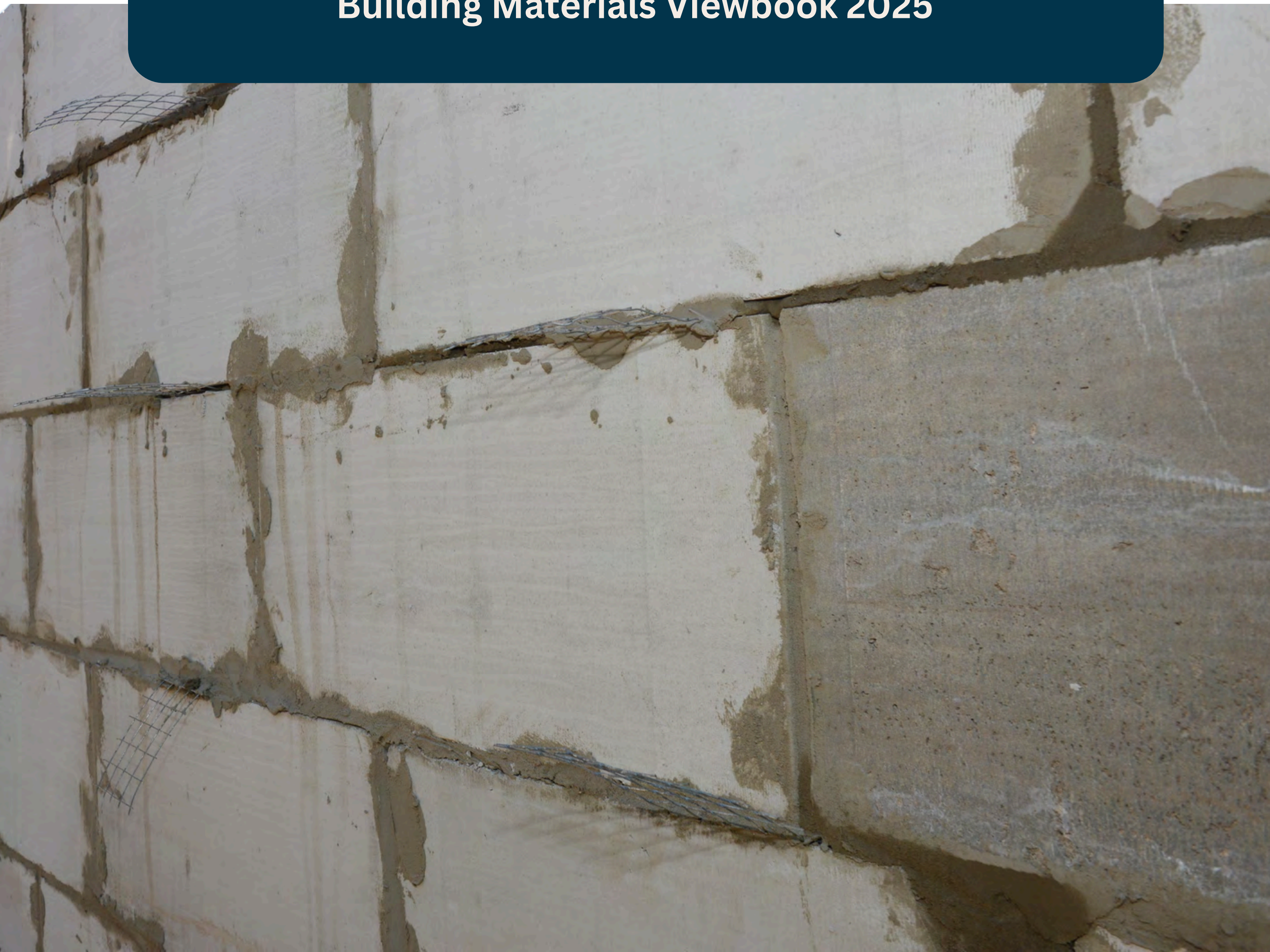
This hotel will be used for temporary residence and hotel guests. Modular construction was helpful because Iqaluit has a short construction season. Construction was started two years before the units were shipped to the site (by ocean) in the summer. Exterior insulation was installed in-site to ensure a continuous layer of insulation.

More information about the project is available in a technical bulletin from RDH Building Science (p23-26).

Note Space: *Community & Personal Knowledge*

PART 4: CODIFYING CLIMATE RESILIENCE

Building Materials Viewbook 2025



Codifying Climate Resilience

Behind the scenes, building codes and other regulations shape the resilience, strength, cost, and overall quality of construction. Inflexible, unclear, and outdated code requirements can pose a barrier, especially if they prevent communities from innovating or using climate-resilient building solutions. On the flip side, thoughtful and co-created building codes provide a framework for more environmentally and economically sustainable construction practices.

However, current building codes and standards do not consider future climate data and projections. **This section outlines the current barriers to codifying climate and disaster resilience in building codes, then proposes future steps to address these challenges.**

What are codes?
Building codes provide minimum standards for building design and construction.

<u>National Building Code</u>: The National Building Code is a model framework for adoption into provincial building codes.

<u>BC Building Code</u>: The BC Building Code is a provincial adoption of the national building code. It provides regulations to meet societal objectives as fire and structural protection, health, accessibility, and energy conservation (McBean et al., 2021). The Code is not comprehensive. Climate resiliency, disaster risk reduction, durability, culturally appropriate building design, and mental health are considered outside of the main objectives of the current BC Building Code.

Why codify climate resilience?

✅ Support **disaster risk reduction** through buildings that address the risk and effects of damage.

✅ Encourage the construction of **more durable and sustainable housing**, which reduces costs in the long run

✅ Build on the work done to create climate resilience standards by ensuring they are part of **effective legislation and regulatory frameworks,** such as the National Research Council of Canada's guidance on wildland-urban interface design and flood-resilient construction.

Barriers to Codifying Climate Resilience

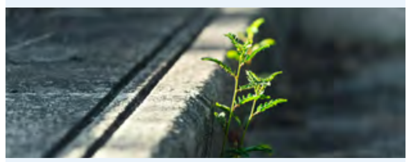
However, there are many barriers to more comprehensive consideration of climate resiliency in the building code.

There are **limited resources** to address competing priorities in the building code.

The 2015 code does not treat **durability** as a primary design goal – resistance to deterioration is addressed through individual material standards, not the building as a whole.

Measuring resilience and **defining** acceptable risks are both challenges.

Potential metrics of resilience include initial reliability, minimum annual reliability, average reliability over service life, reliability at the end of service life, minimum performance level through the structure's service life, etc.



Insurance policies generally do not cover the cost to replace buildings with new structures that meet new standards for resilience

Changes to the building code need to be accompanied by **training and resources** that ensure codes are consistently applied as-intended.

Code changes primarily apply to **new buildings, not existing ones.** Guidelines for altering existing buildings are currently being considered by the Canadian Commission on Building and Fire Codes.

Code changes are also only one part of the solution:

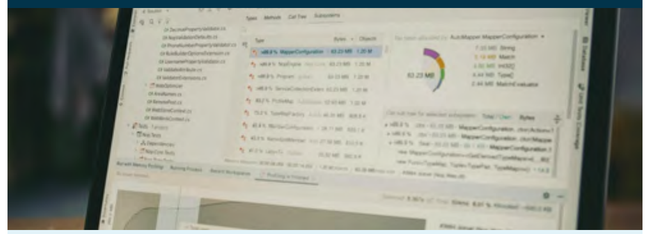
- Specific regional conditions still need to be addressed. The building code sets minimum requirements and does not account for regional variations.
- Land-use planning, climate data, and future projections also need to be considered. How communities are located, designed, and built matters.
- The building code and community planning currently work in silos. Both need to work together to build community resilience.

Principles and Steps to Address Barriers to Codifying Resiliency

1: Communication

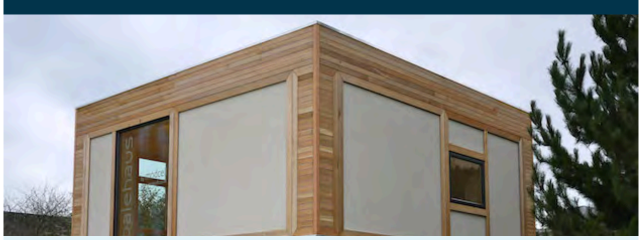
Engage with a wide group of stakeholders: municipal planners, insurers, financial institutions, public housing etc. Engage with Indigenous nations and their representatives.

2: Holistic Data



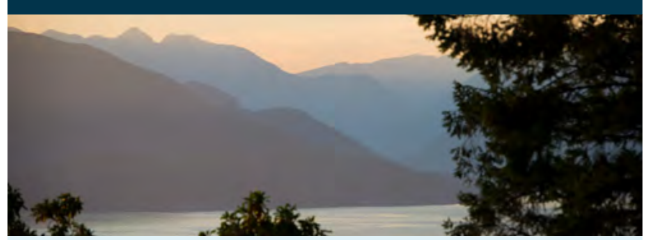
Incorporate insurance, finance, and climate models/data. Implement life cycle assessment at the design and procurement stages.

3: Provide Exemplars



Exemplar and demonstration buildings can illustrate what is possible.

4: Flexibility



Goals and requirements for climate resilience should be geographically and/or situationally dependent.

Lastly, it’s important to remember that building codes are not the only tools: Other policy tools such as zoning or retrofit programs may be more efficient at driving regulatory change regionally.

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