

BC Building Code

Overview

Earthen architecture has been used for centuries, and buildings of 500 and 700 years of age are still in use. Building codes and regulations did not exist at this time, but these ancient buildings co-exist beside and among new buildings that have been constructed under modern day regulations. The building codes and regulations evolved for primarily two purposes, to develop a set a minimum standard for construction and promote building practices that would allow buildings to meet minimum performance levels for energy efficiency. In Canada, we have seen the code change and respond to past failures, and increased demand for more energy efficient buildings. The 1970 Canadian Code for Residential Construction was 213 pages; there has been a lot of failures since then, as the 2006 BC Building Code has a whopping 870 pages.

A falsehood about the code, is that it sets the highest standard for buildings to be built to... quite the contrary, as it is the minimum standard that must be obtained. Many of the homes and buildings that have been built under the code have had early deaths as a result of sealing up buildings in an effort to make them more efficient, thus they rot and mold from trapped moisture in the process of achieving this efficiency[Lstiburek]. It is a common understanding that the lifespan of a new construction is vastly shorter than that of a building built 100 years earlier. A testament that “new” isn’t always better. What we need to address is how do we utilize traditional construction styles, to meet the energy performance required, and do so within an ever increasing narrowing set of standards.

There has been a resurgence through many parts of the world to try and re-incorporate earthen building systems into the codes and standards, which include a volumes of research on moisture durability and performance, seismic durability, and thermal performance. The new ASTM standard for Earthen Building ASTM E2392M-10, released in 2010 refers to some of the standards of which it drew upon to develop its standard:

- Australian Earth Building Handbook
- California Historical Building Code
- Chinese Building Standards
- Ecuadorian Earthen Building Standards
- German Earthen Building Standards
- Indian Earthen Building Standards
- International Building Code / provisions for adobe construction
- New Mexico Earthen Building Materials Code
- New Zealand Earthen Building Standards
- Peruvian Earthen Building Standards

The challenge we face with comparing cob or other earthen building materials to conventional codes, is that the materials have vastly different qualities and behaviours when it comes to how it responds with moisture and thermal performance. It is for this very reason that new codes have been written focusing specifically on earthen construction.

The following discussion touches on these discrepancies, and in comparing how the Eco-Sense Cob home addresses the issues of heat transfer, air leakage and condensation control.

Section 9.25 BC Building Code

This section relates standards and regulations pertaining to Heat Transfer, Air Leakage, and Condensation Control.

The Building code sets out the required thermal insulation, air barrier and vapour control that is required in “Assemblies”. The assembly that we will focus on is the cob mass wall system, as all other components of the home are considered conventional. The cob wall assembly is a core of cob 56 cm thick, with earthen clay plasters 3cm thick on either side in direct contact with the cob, then an exterior skin of lime plaster 1 cm thick; total wall thickness varies but is approximately 63 cm (24.5”).

The wall system was monitored for a complete year, via soil moisture sensors and soil temperature sensors placed 5 cm inside the wall on a north wall and a south wall (8 sensors total). With this data, indoor and outdoor temperature and RH data was collected. Data was measured every 5 minutes for a period of one year.

In conjunction a KD2 Pro Thermal property Analyzer was used to test sample of the wall, to garner RSI and K values.

Thermal Insulation Section 9.25.2

Thermal Insulation minimum requirement

For framed wall assemblies in this region (below 3500 HDD), walls must be a minimum of 2.45 RSI (or R13.9) (BC Building Code: Notes to Table 9.25.2.1). Cob walls have traditionally had an R value of R 0.6/inch, with the wall assembly being a nominal 61 cm (24”) thick. Traditional cob would dictate that the wall thickness requirement should be increased to 71 cm (28”) thick to meet minimum code. Data taken from the KD2 Pro thermal Properties Analyzer places the R value at an average of R 0.9/inch for an assembly value of R21.6.

In addition, note (3) table 9.25.2.1, the Code goes on to state that the above noted RSI requirements are not intended to apply to masonry or construction without a cavity, and that alternative to the stated requirements “may be determined through the use of energy consumption estimation, computer modeling, or using other acceptable good engineering principles” [9.25.2.1.2]. The Code does not specify the

energy intensity (kWhr/m²) that they deem acceptable for energy consumption. The code could set out a minimum standard of energy intensity in kWhrs/m² dedicated to heat inputs to make it easier to determine if the “modeling or energy consumption estimate” are acceptable.

This is well within the code.

Thermal Insulation with relation to Mass Wall/Dew Point

In BCBC Appendix A: A-9.25.1.2 discussion on thermal insulation notes that if a low permeance product like foam is used then the temperature of the inner surface of this product will be similar to the interior temperature of the building, and thus no additional vapour barrier is required, that the dew point will not be achieved.

Though Cob is vastly different than insulative foam, the theory has been demonstrated through the research on the mass wall that the interior of the wall, (5 cm or 2” in), maintains a temperature that is the same as the interior of the home. Therefore the applicability of a dew point on a mass wall is not of relevance. It should also be pointed out that based on the discussion in the BC Building Code, a vapour barrier is NOT required.

Of special note – BC Building Code states in discussion in Appendix A: A-9.25.1.2:

“For locations in the BC Coastal Region, the warmer winter conditions are such that interior RH (Relative Humidity) levels higher than 35% can be tolerated. However, if the use of the space is such that indoor RH will be maintained above an average 60% over the entire heating season, the ratios in Table 9.25.1.2 should not be relied upon to provide protection from moisture accumulation due to vapour diffusion”

What this is in effect saying, is that in a conventional wall assembly system all bets are off; at Eco-Sense, where RH (relative humidity) levels consistently popped up to 63%, with no condensation, and no significant increase in wall water content (ranged from 1.8% to 2.025%) the wall system functioned beyond what the BC Building code could envision. This would be an example of far surpassing the minimum standard.

Insulation Materials 9.25.2.2 – Flame spread

Insulation materials must conform to a variety of standards (eg, CAN/ULC-S704, CAN/ULC-S706). Many of these ratings are to address the flammability of insulation products. Cob bluntly has no rating or standard. Earth has been used as a fireproof building material and as a fire suppressant, as seen in earthen ovens the world over, clay bakeware, and pottery, and the actions of firefighters using shovels and dirt to cover and smother out flames. Cob has no flame spread.

Air Barrier System Section 9.25.3

Air barriers are designed to stop air infiltration and exfiltration under differential air pressures, and must be continuous throughout the assembly, and sealed to where it meets other assemblies (roof, foundation, windows). Of particular weakness in air barriers are protrusions (eg electrical services, venting, plumbing).

The BC Building code states “The current requirements specify only a maximum air leakage rate for the material in the air barrier system that provides the principal resistance to air leakage”, A-5.4.1.2.(1) and (2). This explicitly points to the recognized problem of not looking at the whole system.

The Code then moves on to discuss recommended leakage rate for small sections of the exterior envelope. Table A-5.4.1.2.(1) and (2) denote air leakage recommendations for portions of a building envelope, and are not intended for whole building performance, and thus do not include the presence of windows, doors and other openings

Cob is by its very nature as a monolithic mass wall, a continuous air barrier assembly. This said all places where cob meets other assemblies, must be detailed to continue this air barrier. This is easily managed for protrusions, as the holes are backfilled with cob/plaster. Foundation to cob junctions are of no consequence as well as typically there is several tons of form fitted material atop the foundation. Roof structures are of issue. At the Eco-Sense home the roof vapour barrier is glued to the cob wall via acoustic sealant, and then as the cob wall is plastered (1.5 cm thick) the materials are applied over the plastic barrier, thus achieving a double seal to prevent air infiltration.

The Eco-Sense home had an air leakage test performed. The leakage results are exceptional particularly as it is not for a “section” of the assembly, but for the whole house. City Green Solutions in Victoria, at the time of the blower door test noted this was one of the most air tight homes they had ever tested.

Results:

Blower Door Results: 2.12 ACH@50Pa

Equivalent Leakage Area of 684 sq cm,

Vapour Barrier Section 9.25.4

The BC Building Code stipulates that “Thermally insulated wall, ceiling and floor assemblies shall be constructed with a vapour barrier so as to provide a barrier to diffusion of water vapour from the interior into wall spaces, floor spaces, or attic or roof spaces.”

The best research to date has been performed by John Straube in Canada and Gernot Minke in Germany.

Based on their findings lime plasters have a permeance rating of 500 ng/Pa s m² (9 US perms); Straw clay loam (cob) has a permeance of 1088 ng/Pa s m² (28.4 US perms), and earthen plasters a permeance of 1200 ng/Pa s m² (20 US perms). As Struabe points out, 38mm (1.5”) of earthen plaster has the equivalent perm rating as some building papers and house wraps (rated at 20 us perms).

The nature of the code would dictate that the earthen wall assembly does not conform as they allow a maximum permeance for a vapour barrier of only 60 ng/Pa s m².

This section of the code is the biggest stumbling block, as historical evidence has shown the effectiveness of these mass walls with high permeance, in which the wall, exterior plaster and interior plaster are a combined unit. A-927.2.2 describe the requirement for capillary breaks between components; this would in essence stop the mass wall from functioning by removing the permeance interaction between the mass wall components. In Appendix A: A-9.27.3.1 there is a discussion point on “Appropriate Level Of Protection” wherein it does state that local practice with demonstrated performance should be considered. We would like to point out that there is now local performance demonstrating superior functioning, beyond the descriptions as laid out in the BC Building code.

Summary of Building Code

The building code is a document that looks at individual components as parts of the larger systems. Its metrics specify individual requirements, yet fail to provide overall performance standards as seen with a lack of information to recommended energy intensities required for space heating, or whole house air leakage guidelines. The code also fails to recognize traditional materials and that these materials like cob, despite historic significance through the world, and thus uses metrics that do not apply to earthen building systems.

The issue of least or little concern within the code as it applies to Cob, is the structural issues. All cob buildings of load bearing capacity as Eco-Sense, required a structural engineer stamped plans and submission of Schedule B's to the overseeing building official, thus removing risk and liability from the city/district/municipality.

The issues of greatest concern are those listed in Section 9.25 of the code and pertain to thermal performance, vapour performance and air leakage. It can be shown that the Eco-Sense home excels in all aspects, despite the metrics being incongruent between vapour permeance standards of the code and actual performance.

It is apparent from trying to fit a “round house” into a square box, why so many jurisdictions throughout the world have moved to the development and creation of earthen building standards. It is our recommendation that the Government of BC

follow this route via adoption of the International Construction Codes newly released Green construction code (IgCC) which includes earthen building standards.

References

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