Buildcarbonneutral.org Construction Carbon calculator for Earthen Homes

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Calculator Inputs:

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Total square feet of building equals 2500, in two stories, above ground. Primary structure of system selected as 'wood' as there is no option for earthen construction. Eco region selected based on map provided (Marine west coast forest). Predominate existing vegetation considered forest (protected zones). Installed vegetation would include native plants, living roofs, and extensive food producing annual and perennial edible gardens (selected as shrubland). The space footprint of the building installed is 1500 sq. feet. This coincides with the amount of 'disturbed area'.

Results

Inputs	Earthen home	Earthen home	Oak Bay home
Total Square Feet	2500	2500	2500
Stories Above Grade	2	2	2
Stories Below Grade	0	0	0
System Type	Wood	Concrete	Mixed
Ecoregion	Marine West Coastal Forest	Marine West Coastal Forest	Marine West Coastal Forest
Existing Vegetation Type	Forest	Forest	Forest
Installed Vegetation Type	Shrubland	Shrubland	Short grass or lawn
Landscape Disturbed (SF)	1500	1500	10, 000
Landscape Installed (SF)	1500	1500	2500
Embodied CO2	62 Metric Tonnes	115 Metric Tonnes	65 Metric Tonnes

Calculator shortfalls for earthen homes:

Building carbon model:

The primary construction system for aboveground earthen home is not available for selection. There is no estimate of carbon intensity ratios for cob in the calculator, something that could presumably be added in the future. An estimation made by selecting (non-certified) wood has significant differences in material properties from a cob mixture but is the calculator's closest representation of cob as a natural biomass on-site building material. Certified wood changes the calculation as it compensates for carbon released and acts as a carbon sink. Earthen systems presumably would also act as a carbon sink or have a negligible comparable carbon impact, as natural biomass materials have negative carbon intensity ratios [1].

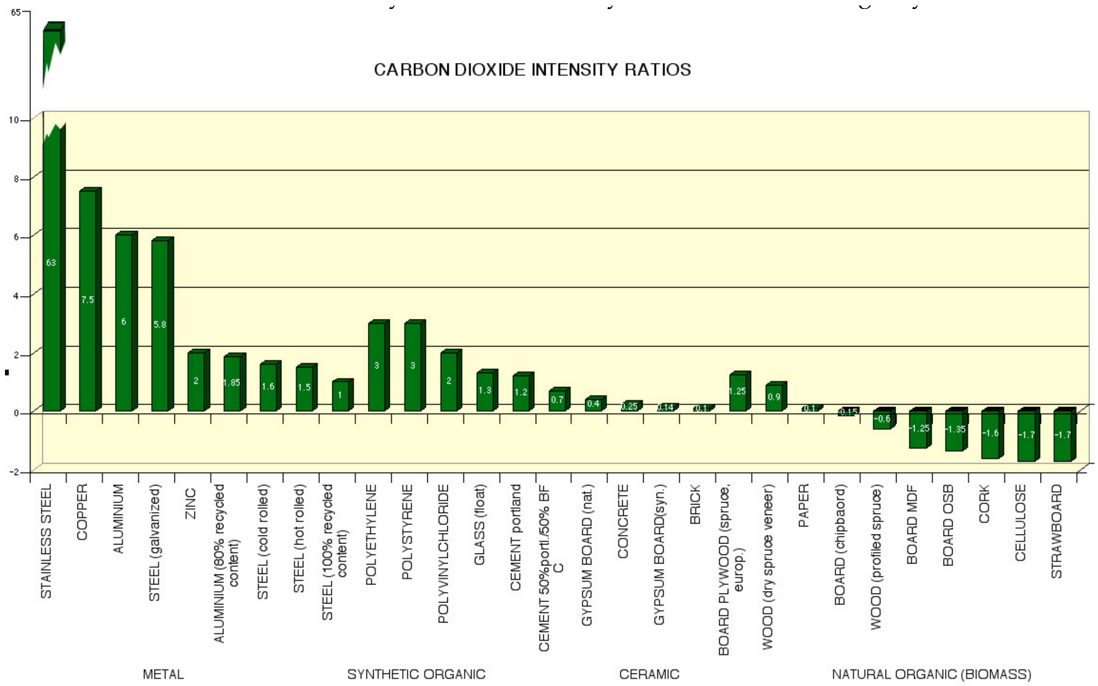

Figure 1 Carbon dioxide intensity ratios [2]

Note that a system selection of 'mixed' would presumably include large volumes of concrete and steel, which skews the estimation even farther then choosing wood, with an embodied CO2 estimate at 69 metric tonnes. If we were to choose concrete as a building material, for thermal mass similarities, the embodied CO2 estimate jumps to 115 metric tonnes. For comparison, we added our contemporary 1960s home in Oak Bay (drywall, wood frame, brick, concrete, lawn, etc.) and got a comparable 65 metric tonnes. The two homes could not be more different.

There is also no compensation in the calculator for substitution of low CO2 impact materials for high CO2 impact materials, or for the selection of high-recycled content materials. This is a particular factor in the consideration for the substitution of fly ash for Portland cement. Portland cement substitutes can significantly reduce the largest component of CO2 emissions in the life cycle of concrete production. The manufacture of portland cement accounts for about 95% of all CO2 emissions resulting from the production of concrete [2].

Landscape footprint:

What compensations are there to distinguish a contemporary build from an earthen home created practically on-site? How does the calculator compensate for the 2000 sq foot living roof made up with native plants suitable for climate location and plant life? Is there compensation for large vegetable gardens repurposed from a blasted rock dump that supports the family in residence? What compensations are included for self-sufficient levels of living, to include beehives, chickens, and other urban farming lifestyles created on the previously disturbed construction site? How does the calculator estimate restored site habitat? Though the calculator landscape data is for soil organic carbon and does not include above ground biomass, there should be compensation for restored soil habitat.

Total carbon footprint:

Since the embodied CO_2 calculator's purpose is presumably used as a measure to estimate the global warming potential of construction materials, it seems the calculator falls drastically short of the capability to produce a number for earthen materials used: earth walls, floors, living roof, longevity, less wood, high flyash concrete, home made paint, lime plaster, earth plaster, virtually no caulking, natural materials, very little plastic. Noted about calculator: Tenant improvements, interiors or furniture, fixtures or equipment have not been included in version 0.01.

Calculator principles:

The principles behind the calculator suggest a change to a 'Reduce, Renew, and Offset' lifestyle. The current version of the calculator does not compensate for the embodiment of this philosophy in many natural homes, in this instance in particular the Baird Earthen Cob home, where the 'purchase' of carbon offsets in unnecessary. The Baird home has used less to build less, protects and restores the natural ecosystem, is built smart and built efficiently. They use renewable energy, have restored or significantly improved disturbed sites to return to native ecosystems, use natural building materials, and have incorporated recycled and recyclable materials. This has not been reflected in the construction carbon calculator result.

Note on Life Cycle Balancing used in calculator:

The conventional building data takes into account site excavation, shell and core (structural systems, building envelope and building systems). The building data is based on Life Cycle Balancing and is not applicable to earthen homes. The carbon intensity factors for the calculator are as follows: Shell Known - 12%, Shell Unknown - 12%, Service Systems - 22%, Service Sector - 14%, Substructure Known - 2%, Substructure Unknown - 3%, Other/ Miscellaneous - 5%. Are these suitable for earthen homes?

The carbon dioxide intensity ratio (CDIR) is defined here as the ratio between the upstream CO_2 impact (emissions minus storage) of a material and the weight of the material.
$CDIR = (CO_2e – CO_2s)$/material end use weight where CO_2e = the weight of upstream CO_2 emissions and CO_2s = the equivalent weight of CO_2 stored as carbon in the mass of the material. A material with a positive CDIR is a net CO_2 source and one with a negative CDIR is a net CO_2 sink.

Also, a material's initial embodied CO_2 and GWP is not the whole story of its environmental sustainability. It's necessary to look beyond that in order to measure a building's true environmental impact. Over 50% of the UK's carbon emissions result from the energy used to heat, cool and light buildings. Over the life of a building, the operational CO_2 emissions are far higher than the embodied CO_2 of the material used to build it. The whole-life performance and energy consumption of a building are, therefore, vitally important factors to consider when evaluating the sustainability of construction materials. [3]

Upstream CO_2 emissions (The upstream phase of processing and manufacturing building materials and products causes enormous off-site impacts prior to the building's use) Upstream CO_2 emissions are roughly 5 times greater than direct emissions (for construction of the building) and 10-20 times greater than the annual operation (use) of the building. [1] Some natural organic or biomass materials are net upstream CO_2 sinks. In general, the denser the biomass material, the greater the carbon content and the greater the CO_2 accumulation [2].

References

[1] MacMath, R. and P. Fisk III. 1999. *Life Cycle Balancing: Building Shell, Interiors, & Furnishings Sub-Systems: Nursing and Biomedical Sciences Building.* The University of Texas at Houston Health Sciences Center.

[2] MacMath, R. and P. Fisk III. 1999. *Carbon Dioxide Intensity Ratios: A Method of Evaluating the Upstream Global Warming Impact of Long-Life Building Materials.* Center for Maximum Potential Building Systems; Austin, TX.

[3] http://www.building.co.uk/comment/set-for-life/3083452.article