TECHNICAL NOTE #07

Embodied Energy of Masonry Walling in South Africa

A review of the principles of sustainable development as well as the Energetics Life Cycle Assessment for Clay Brick Masonry Walling in Australia. The Technical note references academic papers published during the proceedings of the SB10 and SB11 conferences

TECHNICAL CONTRIBUTOR

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Executive Summary

Greenhouse Gases & Sustainability Measurement

The pollution of the planet via heavy metals, radioactive waste, and other poisons such as oxides of nitrogen and sulphur, are all environmental hazards, capable of destroying life on earth. The poisoning of the earth's atmosphere with carbon dioxide, methane and other oxides is now recognised as causing the over-heating of our environment.

The so-called Greenhouse gases cause the absorption of infrared radiation that would have otherwise escaped into space and reduced environmental temperatures. Increased absorption of infrared radiation leads to an increase in the average temperature of the Earth's atmosphere.

Greenhouse gases are effectively emitted through land clearance, the production and consumption of food, the burning of fuels, the manufacture of goods, materials, wood, roads, buildings, and services. The emissions are often expressed in terms of the amount of carbon dioxide, or its equivalent of other GHGs, emitted.

A carbon footprint has been defined as a measure of the total amount of carbon dioxide (CO_2) and methane (CH_4) emissions of a defined population, system or activity, considering all relevant sources, sinks and storage within the spatial and temporal boundary of the population, system or activity of interest, calculated as carbon dioxide equivalent (CO_2e). Carbon has thus moved to centre stage in the measurement of sustainability.

Energy Component in Sustainable Building

All credible Sustainable Building systems give a significant portion of the credits for expected reduced energy usage in the operation of the building design, post construction. This is because the operating energy usage post construction is found to be more significant than the construction energy usage. These findings were made evident in the 'Energetics Life Cycle Assessment of Australian Housing' and the 'WSP Energy Modelling Study of 130m2 houses' in South Africa.

The localised sourcing of materials, or the minimisation of transport distances to site, and the use of materials already on-site or re-cycling, also earn credits. The reduction in energy content or energy savings contribution from the lesser transport as result of these activities is significant but not as material as the operational energies. These energy savings are out of the Embodied Energy of the building

Embodied Energy Forms

There are two forms of embodied energy in buildings:

- Initial Embodied Energy
- Recurring Embodied Energy

Initial Embodied Energy

The initial embodied energy in buildings represents the non-renewable energy consumed within the framework of the following two components.

Direct Energy: The energy used to transport building products to site, and then to construct the building.

Indirect Energy: The energy used to acquire, process, and manufacture the building materials, including any transportation related to these activities, as in the added cement, water and mixing energy for concrete.

Recurring Embodied Energy

The recurring embodied energy in buildings represents the non-renewable energy consumed to maintain, repair, restore, refurbish or replace materials, components or systems during the life of the building.

As buildings become more energy-efficient, or the longer they are in operation, the greater the ratio of embodied energy to operational energy, will be.

Measuring Embodied Energy

Embodied energy is measured as the quantity of non-renewable energy per unit of building material, component or system, in units of MJ/kg or GJ/m2 per unit of area.

Implicit in the measure of embodied energy are the associated environmental implications of resource depletion, Greenhouse gas emissions, environmental degradation and reduction of biodiversity. This is measured within the product boundaries as described in the concept of ‘cradle to gate’, for material inputs and with the added activity inputs to take the materials to completion within their systems, i.e. transforming bricks to masonry walls.

These indices must be weighed against the performance and durability of the products, as they may have a mitigating or compensatory effect on the initial environmental impacts associated with embodied energy.

Embodied Energy Expectations for Bricks & Masonry

The amount of embodied energy in buildings varies considerably.

Initial embodied energy consumption:

- Depends on the nature of the building, the materials used and the source of these materials.
- The data for a building material in one country may differ significantly from the same material manufactured in another country.

The recurring embodied energy:

- Is related to the durability of the building materials and systems installed in the building, how well these are maintained, and the life of the building.
- High maintenance designs and materials thus incur a significant recurring embodied energy premium, which may cancel out Initial low embodied energy.

Australian Source Embodied Energy

MATERIAL	MJ/kg
Air dried sawn hardwood	0.5
Concrete blocks	1.5
Precast tilt-up concrete	1.9
Insitu concrete	1.9
Precast steam-cured	2.0
Kiln dried hardwood	2.0
Clay Bricks	**2.5**
Gypsum Plaster	2.9
Autoclaved aerated	3.6
Plasterboard	4.4
Fibre Cement	4.8
Cement	5.6
Local granite	5.9
Particleboard	8.0
Plywood	10.4
Laminated veneer timber	11.0
MDF	11.3
Glass	12.7
Imported granite	13.9
Hardboard	25.5
Galvanised steel	38.0
Acrylic paint	61.5
Copper	100.0

Canadian Source Embodied Energy

MATERIAL	MJ/kg	MJ/m^3
Aggregate	0.10	150
Soil-cement	0.42	819
Stone (local)	0.79	2030
Concrete block	0.94	2350
Concrete (30Mpa)	1.3	3180
Concrete precast	2.0	2780
Lumber	2.5	1380
Brick	**2.5**	**5170**
Cellulose insulation	3.3	112
Gypsum wallboard	6.1	5890
Particle board	8.0	4400
Shingles (asphalt)	9.0	4930
Plywood	10.4	5720
Mineral Wool	14.6	139
Glass	15.9	37550
Fibreglass insulation	30.3	970
Steel	32.0	251200
Zinc	51.0	371280
Brass	62.0	519560
Copper	70.6	631164
Paint	93.3	117500
Polystyrene Insulation	117.0	3770
Carpet (synthetic)	148.0	84900

Aluminium	170.0

Australian Source Embodied Energy

Taken from Lawson (1996) Buildings, Materials, Energy and the Environment.

Key Observations

The Australian data shows the value for bricks to be the same as the Canadian data.

There is a wide difference between processed timber (plywood and particleboard) compared to air- dried hardwood.

Aluminium	227.0	515700

Canadian Source Embodied Energy

Note: Embodied energy values based on several international sources – local values may vary

Key Observations

The embodied energy of Canadian bricks and lumber are on par. This is partly due to a high renewable energy component in Canadian lumber. However, the recurring embodied energy of a building using a lumber-based construction design will be considerably higher than that of a masonry construction.

Conclusions as to the Value of Embodied Energy

Embodied energy can be a very useful measure provided it is not viewed in absolute terms. The initial embodied energy of various materials, components and systems can vary between projects, depending on suppliers, construction methods and site location.

The recurring embodied energy is difficult to estimate over the long term since the non-renewable energy contents of replacement materials, components or systems are difficult to predict. However, as buildings become more energy-efficient and the amount of operating energy decreases, embodied energy becomes a more important consideration.

There are also strong correlations between embodied energy and environmental impacts. It is widely acknowledged that embodied energy represents one of many useful measures of sustainability in building. However, this should not be used as the sole basis of material, component or system selection.

References

1. Full Life Cycle Assessment by Energetics, University of Newcastle, Australia
2. Cole, R.J. and Kernan, P.C. (1996), Life-Cycle Energy Use in Office Buildings, Building and the Environment, Vol. 31, No. 4, pp. 307-317

For further information:
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