Emerald Hills Urban Village

FOUNDATION RESEARCH BULLETIN

Design Centre for
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MATERIALS

1.0 Why is Materials a key theme?

Forty percent of the raw materials entering the world economy are used for building and construction activities.[1] These materials are produced from non-renewable resources, converted though energy intensive processes and transported over long distances. The increasing demand for housing and construction worldwide is therefore a clear threat to the dwindling supply of the resources and the impacts of transporting materials are felt everywhere – even on the local roads where movement of goods are clogging roads.

Buildings are not typically designed to survive and adapt the fast pace of change in our urban environments. They are demolished because they become functionally, economically or technologically obsolete. This contributes large quantities of waste to landfills and it is wasteful of the precious resources.

There are many strategies to mitigate the environmental loading of building and infrastructure materials. These include specifying materials harvested and manufactured locally, reducing the amount of materials used in the construction process, and specifying

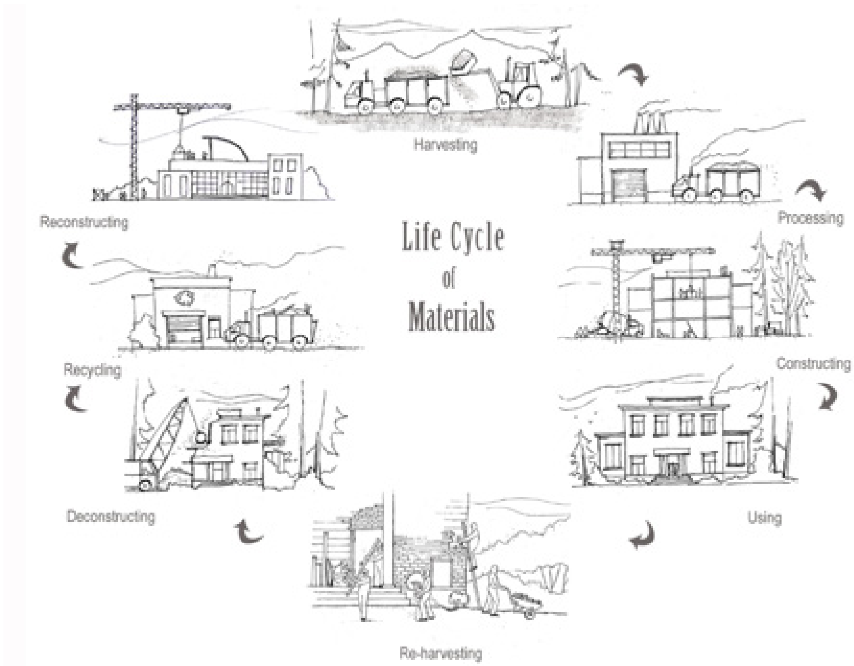

Figure 1: Cradle to cradle look at the life cycle of materials

[1] Busby, 2001, p. 6.1

materials that have a low embodied energy, come from rapidly renewable resources.

2.0 Why are Materials important to Emerald Hills Urban Village?

Building materials are not all created equal. Depending on which materials are selected, the overall building or development can encourage sustainable harvesting practices, support local manufacturing companies, reduce the overall carbon dioxide emissions of the product, or create the conditions for a healthy indoor environment. As Emerald Hills is a greenfield development, the environmental impact of the overall development is very much tied to careful material selection.

3.0 How can EHUV impact on this theme?

Using recycled, reclaimed, renewable, local, and low environmental impact materials for development can significantly lower construction costs, and reduce the need for costly material disposal. It will also reduce waste sent to landfills thereby conserving water, land and air resources. Materials with low-toxicity qualifications can ensure the health and well-being of citizens.

3.1 What strategies are relevant for EHUV?

Material Reduction and Efficiency

Reducing the amount of materials used within the project, will lesson the resource extraction, waste production, and embodied energy associated with manufacturing and transportation of building materials.

Design smaller, compact buildings

Design Measures:

Reducing the overall size of the house will lead to material savings. This can be accomplished by removing areas not frequently used – for example the formal living room – and by redesigning the interior layout of the space. Utilizing mixed-use/flex space planning in an open concept design allows for multiple functions and eliminates unneeded corridors and hallways. This is the concept behind the *Not So Big House* idea proposed by Sarah Susanka where the total square footage of a house is reduced and that liberated money is used to create well designed living spaces.

Use advanced framing techniques

Design Measures:

Advanced framing techniques (often called Optimum Value Engineering) is a set of strategies designed to reduce the quantity of lumber used in the construction of a wood-frame building where structurally unnecessary. In advanced framing, 2 x 6 studs are spaced 24 inches on center instead of the more common 16 inches. Reducing the amount of studs not only reduces waste generation and costs associated with less material, but with less thermal bridging and more room for insulation advance framing techniques also results in a better insulated wall. The US Department of Energy's Office of Energy Efficiency and Renewable Energy estimates that fully implementing advanced framing techniques can lead to: material cost savings of about $500 for a 1,200 square foot house, or $1000 for a 2,400 square foot house; labour cost savings between 3 and 5 percent; and annual heating and cooling savings of up to 5 percent.[2]

[2] US Department of Energy, Office of Energy Efficiency and Renewable Energy, 2005.

Figure 2: To reduce finishing materials, highly polished concrete flooring was used at the Liu Centre on the UBC campus.

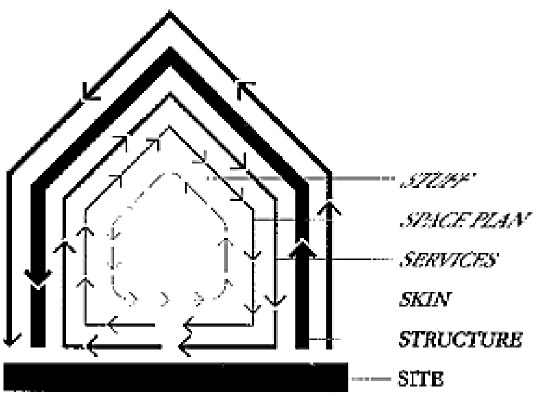

Figure 3: Approximate lifespan of building materials.

Eliminate unneeded finishing materials

Design Measures:

Eliminating finishing materials, such as dropped down ceilings in institutional buildings or floor coverings, reduces the total amount of materials used in the building. This strategy requires careful selection of materials that will be exposed and good craftsmanship during construction.

Layering functions

Design Measures:

Layering the functions of various materials can also help to reduce material use. For example, a building integrated photovoltaic system – in which the photovoltaic panels replace components of the building's envelope or structure – will reduced the amount of roofing materials, sun shades, and glazing required.

Design for a Longer Lifespan

Buildings should be designed and constructed with a projected lifespan of at least 100 plus years. This strategy brings into focus two strategies: selecting durable materials, and designing a flexible interior plan that can be adapted to changing needs over the building's lifespan.

Taken from Stewart Brand's work on *How Buildings Learn* figure 3 shows the approximate lifespan of various building elements.[3] This diagram illustrates that over time site is unchanging, whereas Structure, Skin, Services, Space Plan, and "Stuff" (i.e. furniture) change with increasing degrees of frequency. This diagram illustrates the importance of matching the quality of building materials with expectations of adaptation. That is, using high-quality durable building envelope with a strategy that allows for an adaptable interior.

Optimize material longevity

Design Measures:

Durability is a key consideration for how well a building can stand the test of time. Choosing durable building materials reduces the amount of waste generated by the building over its lifespan.

Buildings should be designed so materials with shorter lifespans can be replaced without compromising materials with longer lifespans. Table 1 lists the expected design service life of finishes (CSA Standard S478-95, Guidelines on Durability in Buildings).

[3] Brand, 1994, p. 13

Figure 4: the Afresh home at BCIT Campus incorporates a flexible floorplan that can be adapted from a four-bedroom single family home to a two-bedroom duplex.

	EMBODIED ENERGY	
MATERIAL	MJ/kg	MJ/m3
Aggregate	0.10	150
Straw bale	0.24	31
Soil-cement	0.42	819
Stone (local)	0.79	2030
Concrete block	0.94	2350
Concrete (30 Mpa)	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
Aluminum (recycled)	8.1	21870
Steel (recycled)	8.9	37210
Shingles (asphalt)	9.0	4930
Plywood	10.4	5720
Mineral wool insulation	14.6	139
Glass	15.9	37550
Fiberglass insulation	30.3	970
Steel	32.0	251200
Zinc	51.0	371280
Brass	62.0	519560
PVC	70.0	93620
Copper	70.6	631164
Paint	93.3	117500
Linoleum	116	150930
Polystyrene Insulation	117	3770
Carpet (synthetic)	148	84900
Aluminum	227	515700
NOTE: Embodied energy values based on several international sources - local values may vary.		

Figure 5: Embodied Energy of various building materials

Table 1: Lifespan of material finishes[4]

Painted materials	5 years
Carpet	10 years
Floor finishes	10 years
Interior partitions	20 years
Gypsum board	20 years
Masonry substrates	20 years

Design buildings with Flexible Floor Plans

Design Measures:

Creating buildings with a flexible floor plan enables the building to be easily adapted over time as the needs of the occupant changes. This is the principle behind CMHC's FlexHousing guidelines, where were utilized in the design of the Afresh Home. This demonstration project located at BCIT includes a flexible floorplan that can convert from a four-bedroom, single family house, to a duplex with two bedrooms per unit.

Make Sustainable Material Choices

When new building products are required, the environmental merits of the product should be considered.

Choosing materials low in embodied energy, rapidly renewable resources, wood products from sustainably harvested forests, salvaged materials, and recycled materials are some ways to reduce the environmental loading of the materials utilized.

Strategies that explicitly deal with waste reduction through material selection - for example incorporating salvaged, recycled, and recyclable materials - are covered in the Waste Technical Bulletin.

Choose Products with Low Embodied Energy

Design Measures:

Embodied energy refers to the amount of energy consumed over the entire lifecycle of the product – from raw material extraction, to manufacturing, to transportation, use, and eventually disposal. Embodied energy calculations (measured in megajoules of energy per kilogram MJ/kg) recognize that some materials require more energy to produce – and therefore carry a higher environmental impact – than others. Figure 5 lists building products in increasing order of embodied energy.

[4] Busby, 2001, p. 6.1.3

Figure 6: The Forest Stewardship Council's logo that indicates that the product was produced from sustainably managed forests

Figure 7: Of all construction materials for the new headquarters for LEED Silver Certified St. John Ambulance in Edmonton, 39% were manufactured locally

Choose Products made with Rapidly Renewable Resources

Design Measures:

Rapidly renewable resources are building products that come from biological sources that have a shorter harvest rotation (typically 10 years or less) than more conventional long-growth resources. As these products typically come from agricultural origins, they tend to have lower embodied energy. Examples of rapidly renewable resources include agricultural waste products (i.e. strawboard), cork, linoleum, natural paints, bamboo, poplar plywood, wool, and cotton. The most common applications for rapidly renewable materials are flooring and cabinetry. One concern with rapidly renewable resources is the transportation costs that can be associated with bringing the material from where it was produced, and where it will be used. For example, bamboo grows very rapidly and makes a durable and attractive flooring option, however, it is principally grown in China and shipped to Canada.

Choose wood products harvested from sustainably managed forests

Design Measures:

Choosing wood products that come from sustainably managed forests supports responsible forest management practices. Forest certification is voluntary - no one forces a company to become certified - and it is done by an independent organization. A forest company is certified once it can show that its practices through the entire chain of custody of the product meet a high standard for environmental protection, recognition of Indigenous Peoples and treaty rights, and social responsibility.

One such certification program is run by the Forest Stewardship Council (FSC). The FSC issues certifications for both forest management and chain of custody. Products that are made with FSC certified materials are differentiated by the use of the FSC logo. Alberta has 5,490,000 ha of forests certified under FSC.[7]

Source Regionally Manufactured and Extracted Materials

Design Measures:

Specifying materials that are manufactured or extracted within an 800 km radius of Emerald Hills can help to reduce the environmental and health impact associated with trucking building materials to the site. Not only does this strategy reduce the carbon footprint associated with transportation from non-local destinations, it also supports the local economy. Alternatively, if materials are shipped by rail or water – methods that have lower emissions than surface trucking – that radius can be increased to 2400km.[5]

3.2 What technologies are relevant for EHUV?

Use a Life Cycle Assessment decision support tool during building design

[5] Canadian Green Building Council, 2004, p. 61.

Material selection inherently requires tradeoffs and concessions. For example, a product may have low embodied energy, but not be durable. Or a product may be very durable, manufactured from a rapidly renewable resource, yet produced half way around the world. It is up to the discretion of the design team to decide which material best fits the objectives and priorities of their project.

To help assess the tradeoffs associated with material selection, there are two software programs available: the ATHENA v.3.0 Environmental Impact Estimator, and Building for Environmental and Economic Sustainability (BEES 3.0).

ATHENA Sustainable Materials Institute is a Canadian not-for-profit institute is a world leader in the life-cycle impact of buildings. Drawing from an extensive life-cycle inventory database, the ATHENA v.3.0 Environmental Impact Estimator can assess the environmental impacts from industrial, institutional, office, and both multi-unit and single family residential designs. Output measures include: energy consumption, solid waste emissions, air pollution index, water pollution index, global warming potential and weighed resource use. This comprehensive software is easy to use and enables the real time comparison between various design options –an invaluable tool during conceptual design.

Building for Environmental and Economic sustainability (BEES 3.0) was developed by the National Institute of Standards and Technology (NIST) Building and Fire Research Laboratory. BEES includes the lifecycle impacts from raw material acquisition, manufacture, transportation, installation, use and recycling and waste management for nearly 200 building products.

4.0 What Policies and/or programs will add value?

Create a Regional Materials Database

One way to help connect regional manufactures and suppliers of materials with the builders who could use those materials is by creating a regional materials database.

Institute Policies that Encourage Regionally Manufactured and Extracted Materials

Encouraging home owners, and residents to use regionally manufactured and/or extracted materials has numerous benefits. Sourcing products regionally will help strengthen the local economy, reduce reliance on outside resources, and reduce the embodied energy that results in shipping raw materials and finished products from source to building site.

Create a Green Design Information Centre

Choosing environmentally friendly building products is probably an interest among residents and home builders, however, without guidance green product selection can be intimidating. A Green Design Information Centre can showcase green products, knowledgeable staff can explain the merits and trade offs associated with each product, and help the designer or homeowner choose the product that is appropriate for the project. This type of information centre can build capacity within the local building and renovation community, while creating a gathering hub for like minded individuals. There are several models upon which this type of centre can be based upon: Vancouver's Light House Sustainable Building Centre, Calgary and Ottawa's Healthiest Home & Building Supplies, and London's Construction Resources Showroom.

5.0 What other resources are available?

Foundation Research Bulletins:
#8 Waste, for information on material selection that reduces waste.

ATHENA Sustainable Materials Institute
Produces software to help select building materials based on the life cycle assessment.
www.athenasmi.ca

Best Practices Guide: Material Choices for Sustainable Design
Published by the GVRD, this manual is a best practice guide outlining environmentally preferable building materials choices.
www.gvrd.bc.ca/buildsmart/pdfs/BestPractices.pdf
Building for Environmental and Economic Sustainability (BEES 3.0)
Decision support software for material selection based on life cycle assessment.
www.bfrl.nist.gov/oae/software/bees.html

Canadian Green Building Council, Leadership in Energy and Environmental Design Green Building Rating System for New Construction in Canada, Version 1.0 (LEED Canada N.C – 1.0).
www.cagbc.org

CMHC. (December 2000). *Flexhousing™: Building adaptable housing.* Available online at: www.cmhc-schl.gc.ca/publications/en/rh-pr/socio/socio073.pdf
This documents outlines the principles and techniques associated with CMHC's Flex-housing techniques.

Construction Resources
www.constructionresources.com
Environmental Choice Program
Administers the Eco-Logo program that recognizes products that have lower environmental costs.
www.environmentalchoice.ca

Forest Stewardship Council
Administers a certification system to encourage responsible forest management practices.
www.fsccanada.org

GVRD BuildSmart. (2002). *Old to new design guide: Salvaged materials in new construction.* Available online at: www.gvrd.bc.ca/buildsmart/pdfs/OldtoNewDesignGuideFull.pdf
This guide provides practical information on incorporating salvaged materials into a project.

Habitat for Humanity Edmonton ReStore
A local source for salvaged building materials.
8210 Yellowhead Trail North West Edmonton, Tel: (780) 471-4909 www.edmonton.hfh.org

The Healthiest Home & Building Supply
www.thehealthiesthome.com

Light House: the Sustainable Building Centre
www.sustainablebuildingcentre.com

Wilson, A. (2000). What makes a product green. *Environmental Building News*. 9 (1). Available online at: www.buildinggreen.com/auth/article.cfm?fileName=090101a.xml
A useful article from Environmental Building News that defines the attributes of a green product.

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Figure 1: Design Centre for Sustainability
Figure 2: Design Centre for Sustainability
Figure 3: Brand, S. (1994). *How buildings learn.* p. 7.
Figure 4: Afresh Home. http://commons.bcit.ca/chcc/intro.html
Figure 5: Canadian Architect. www.canadianarchitect.com/asf/perspectives_sustainibility/measures_of_sustainablity/measures_of_sustainablity_embodied.htm
Figure 6: Forest Stewardship Council. www.fsccanada.org
Figure 7: Meyer Boake, T. *Case Studies in Canadian Sustainable Design - St. John's Ambulance.* www.architecture.uwaterloo.ca/faculty_projects/terri/sustain_casestudies/stjohn_gallery.html

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