Guide to Sustainable Design with Concrete

Bill McEwen P.Eng., LEED A.P.
Masonry Institute of BC

CIRCA
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Design Tools:

110 page Guide - includes masonry
Cement Association of Canada
www.cement.ca

4 Page Summary Report
from Masonry Canada
www.masonrycanada.ca

Industry Segments

- Cement Manufacturing

- Ready Mixed Concrete
- Precast Concrete
- Masonry

LEED® System

- A measurement system is required if buildings are to be evaluated for their environmental performance, and choices made between alternatives.
- LEED (Leadership in Energy and Environmental Design) is the system that has become the most accepted in North America. It was developed in the U.S. and has been chosen for adaptation in Canada.
- The Canada Green Building Council (CaGBC) was established in 2003, and has been authorized to develop and administer LEED in Canada.

LEED Liability?

For Manufacturers, Suppliers, Contractors:

- Not supplying specified or certified recycled content
- Changing product source to outside Region, etc.
- Could disqualify a credit, and miss LEED Gold or Silver rating for project.
- Resulting in financial liability to find other source for missing credit.

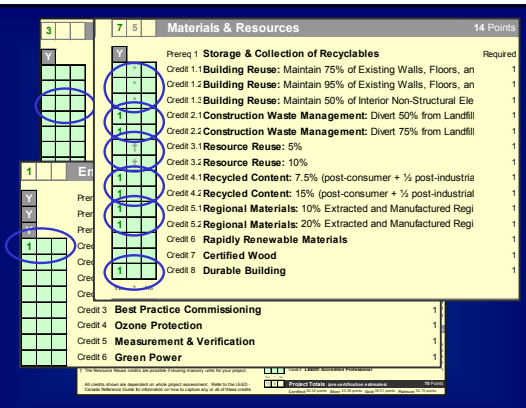
- LEED Canada-NC 1.0 was introduced in late 2004
- It looks very much like LEED 2.1 from the U.S., but includes numerous minor changes to reflect Canadian terminology, units and standards.
- It also contains several major changes to reflect more appropriate Canadian green building approaches
- It introduces provisions that are coming in the next LEED 2.2 and 3.0 in the U.S.

LEED Canada-NC 1.0

- Energy Performance
  - Alternate compliance path based on the Model National Energy Code for Buildings
  - Higher Prerequisite requirement
- Materials & Resources
  - Higher requirements for Recycled Content, and increased credit for fly ash & slag (SCM's) in concrete products
  - Addition of rail and water transport options for Regional Materials
  - Addition of a credit for Durable Building

Credit Category	Points Available
Sustainable Sites	14
Water Efficiency	5
Energy & Atmosphere	17
Materials & Resources	14
Indoor Environmental Quality	15
Innovation & Design Process	5
Total	70 (vs. 69)

LEED Certification Level	Points Required
Certified	26 - 32
Silver	33 - 38
Gold	39 - 51
Platinum	52 +



3 Sustainable Sites

- **Re-development of Contaminated Sites**
- **Stormwater Management**
- **Heat Island Effect**

Re-development of Contaminated Sites

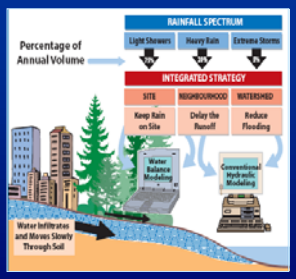
Treatment of a contaminated soil on an old industrial inner city site in Boston

Former Steel Mill
– Mitchell Island, Vancouver BC

Contaminates: Electric arc furnace dust
(50 000 tonnes)

Solution: On-site S/S using cement

Stormwater Management SS credit 6



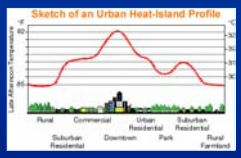
Design Approach

Solutions - using permeable concrete paving products:

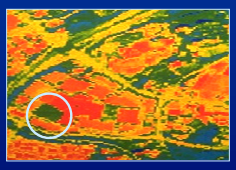
- **Open grid precast concrete pavers**
- **Pervious (no fines) concrete pavement**
- **Permeable precast concrete paving stones**

Surface parking lot paved with pervious concrete

Heat Island Effect — SS credit 7



Concrete parking garage in Cumberland Mall, Smyrna, Georgia



Solution – specify highly reflective concrete pavement (with Albedo of over 0.3)

- Use light colored aggregates in the mix
- Use SCMs (fly ash) known to lighten the color of concrete
- Carry out periodic maintenance of surfaces by power washing
- Reseal the cleaned surfaces

4 Energy & Atmosphere

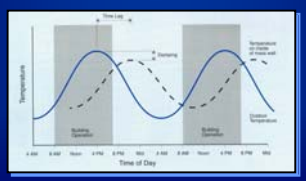
- Energy is the first "E" in LEED, and is a major category in the LEED™ Green Building Rating system.
- The Optimise Energy Performance credit category contains 10 points out of the 70 available in LEED Canada. There is also a Minimum Energy Performance prerequisite.
- There are also five smaller credit categories in this section that address issues such as green power, renewable power and building commissioning.

Energy & Atmosphere

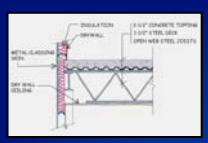
- Energy is the first "E" in LEED, and is a major category in the LEED® Green Building Rating system.
- The Optimise Energy Performance credit category contains 10 points out of the 70 available in LEED Canada.
- The Thermal Mass provided by concrete and masonry can help to achieve points in this category.
  - Passive
  - Active

How Thermal Mass Affects Energy Performance

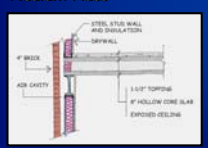
- Mass moderates indoor temperature fluctuations, reducing spikes in temperature (Damping).
- Massive wall and roof elements slow the transfer of heat through the building envelope.
- Mass can store energy thus shifting demand to off-peak time periods.



Low Mass

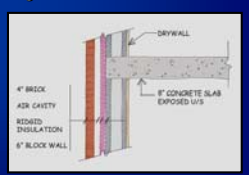


Medium Mass



An energy simulation using computer modeling was performed for a 4 storey building using 3 wall/floor systems in 5 cities across Canada:

High Mass



Energy Simulation Results:

- Vancouver (others similar)

Vancouver, BC

	Heating (kWh/m2)	Cooling (kWh/m2)	Pumps / Aux. (kWh/m2)	Fans (kWh/m2)
Option 1 - Low Mass	51.5	6.2	7.7	12.3
Option 2 - Medium Mass	47.9	6.2	7.7	12.2
Option 3 - High Mass	44.9	6.1	7.6	11.9

HVAC Systems

Points	MNEBC	ASHRAE/IE SNA90.1
1	**24%**	15%
2	**29%**	20%
3	33%	25%
4	38%	30%
5	42%	35%
6	47%	40%
7	51%	45%
8	55%	50%
9	60%	55%
10	64%	60%

Total Building Consumption

Vancouver, BC - Annual Utility Cost ($/m²)

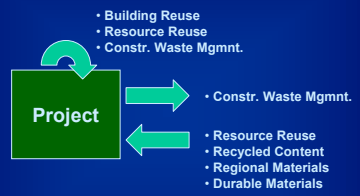
	Lights	Equipment	Heating	Cooling	Pumps / Aux	Fans	Total*	Savings	Savings (%)	LEED Points
Option 1 - Low Mass	$2.51	$2.07	$2.10	$0.46	$0.36	$0.91	$6.34	$2.35	27.0%	1
Option 2 - Medium Mass	$2.51	$2.07	$1.95	$0.46	$0.36	$0.90	$6.19	$2.50	28.8%	1
Option 3 - High Mass	$2.51	$2.07	$1.83	$0.45	$0.35	$0.89	$6.03	$2.66	30.6%	2

* excluding equipment cost

5 Materials & Resources

- The first four MR credits each utilize recycling in different forms – from reusing whole buildings, to exporting or importing recycled components or materials for the project.
- Note that individual products or materials do not "Qualify" for credit points under this section, but they can contribute as part of the total percentage of materials on a project.

Material Movement:



Building Reuse MR credits 1.1, 1.1, 1.3

Wosk Centre for Dialogue: Vancouver heritage bank building converted to conference centre

Construction Waste Management
MR credits 2.1, 2.2

Crushing & Recycling Concrete

Construction Waste Management MR credits 2.1, 2.2

Modular precast panels & masonry units produce minimal waste. Demolition waste can be crushed and recycled as structural fill.

Table 5.4: Example of Recycled Wastes

Recycled & Salvaged Materials	Weight (tonnes)
Crushed Demolition Concrete	100
Masonry Cuts	5
Land clearing Debris	50
Wood	30
Cardboard	10
Metal	5
Drywall	20
Plastic	2
Total quantity of diverted waste:	**222 t**
Quantity of garbage to landfill:	**30 t**
Total quantity of waste:	**252 t**
Percentage of waste diverted:	**222 / 252 = 88%**

Qualifies for 2 points under MR credit 2 since % exceeds 75%.

Resource Reuse (Salvaged Materials) MR credits 3.1, 3.2

Crushed concrete and clay brick could both be incoming material from previously demolished or deconstructed projects, or be salvaged from a demolished building on the same site.

C.K. Choi Building – UBC
Reused brick pavers

Recycled Content **MR credits 4.1, 4.2**

Supplementary Cementing Materials (SCMs), such as fly ash and ground slag are often recycled as a cement replacements in concrete.

Fly Ash is a waste product from coal burning plants, slag is a produced in steel making.

LEED Credit for Recycled Content

Materials Credit 4 (1-2 points)

4.1 7.5% (post-consumer + ½ post-industrial)
4.2 15% (post-consumer + ½ post-industrial)

Intent
Increase demand for building products that incorporate recycled content materials, therefore reducing impacts resulting from extraction and processing of new virgin materials and by-passing energy and green house gas-intensive industrial and manufacturing processes

Table 5.9: Project Example – Recycled Content

Total value of materials: $500,000

Product Name	Vendor	Product Cost ($)	Post-Consumer		Post-Industrial	
			%	$	%	$
Cast Conc.	Ready Mix	90,000	0	0	72	64,800
Precast Conc.	Precast Co.	20,000	0	0	50	10,000
Conc. Block	Block Co.	30,000	5	1,500	40	12,000
Clay Brick	BricksR Us	30,000	0	0	10	3,000
Other A	Co. A	90,000	40	36,000	0	0
Other B	Co. B	20,000	20	4,000	10	2,000
Product Cost Subtotal		**280,000**		**41,500**		**91,800**

Total value of post-consumer content **$41,500**
Total value of post-consumer content as % of total value of materials 8.30%

Total value of post-industrial content **$91,800**
Total value of post-industrial content as % of total value of materials 16.36%

1/2

Combined value of post-consumer and half of post-industrial content **$87,400**

Combined value of post-consumer and half of post-industrial content as % of total value of all materials **17.48%**

Therefore this project qualifies for 2 points under Credits MR 4.1 and 4.2, as 17.48% exceeds 15.00 % minimum.

Local/Regional Materials MR credit 5.1, 5.2

Concrete and masonry products usually comply with this credit due to their large number of manufacturing locations across Canada, and the local nature of their raw material supply. (see Appendix B)

Design Approach

- Identify and specify materials and products which are extracted, processed and manufactured within the region.
- A minimum of **80%** of the weight of constituent raw materials must be extracted within the same limiting distance from the project site.
- The definition of "Regional" is based on a transport radius (as the crow flies) of **800 km** (500 miles) by truck, or **2400 km** (1500 miles) by rail or water.
- Most concrete products meet both of these criteria. As discussed in Appendix B, ready mix concrete is available locally in almost all communities, while precast, block and brick plants are located within most well populated regions.

Table 5.11: Regional Materials Example

Total materials cost for this project $ 800,000

Product	Company	Cost ($)	Manuf. (km)	Extract. (km)	Eligible 800	Eligible 2400
Reclaimed Conc.	Crush Co.	10,000	1	1	Y	
Cast Conc.	Ready Mix	50,000	10	20	Y	
Precast Conc.	Precast Co.	20,000	50	60	Y	
Conc. Block	Block Co.	20,000	15	40	Y	
Salvaged Brick	Salvage Co.	10,000	10	80	Y	
New Brick	Bricks'R Us	30,000	200	200	Y	
Other A (rail)	A Co.	20,000	1500	2100		Y
Other B	B Co.	10,000	10	20	Y	
Subtotal		**$170,000**				

Total value of regionally extracted & manufactured products: $ 170,000
Value of regionally extr. & manuf. products as % of the total value: 21.25%
(170,000 / 800,000 = 21.25%)

Therefore this project qualifies for both points under Credits 5.1 and 5.2:
Regional Extraction & Manufacture: 21.25% exceeds 20% level

Durable Building MR credit 8

The omission of any credits for durability in LEED 2.1 was a source of concern for many designers and owners.

LEED-Canada has taken a step in the right direction with a new single point for durable building, based on *CSA S478-95 (R2001) – Guideline on Durability for Buildings.*

LEED Credit for Durable Building

Materials Credit 8 (1 point)

8 Durable Building

Intent
Minimize materials use and construction waste over a building's life resulting from premature failure of the building and its components and assemblies.

Design Approach

1. Establish the *Design Service Life* for the building - and for its components.
   (from owner or Table 2 in S478 as minimum)
2. Design the building components to ensure that the *Predicted Service Life* exceeds the *Design Service Life*.
   - although the whole building is considered, much of the focus is on the exterior building envelope

PREDICTED SERVICE LIFE (provided by materials) **>** **DESIGN SERVICE LIFE** (required for building)

⇨

DESIGN SERVICE LIFE

Minimum as per CSA S478 - Table 2:

Temporary (Up to ten years)
- Non-permanent construction buildings, sales offices
- Temporary exhibition buildings

Medium Life (25 to 49 years)
- Most industrial buildings
- Most parking structures

Long Life (**50 to 99** years)
- **Most residential, commercial, and office buildings**
- **Health and education buildings**
- Parking structures below buildings designed for long life

Permanent (Minimum period, 100 years)
- Monument buildings (e.g., national museums, art galleries)
- Heritage buildings

PREDICTED SERVICE LIFE

- Based on the assumed environmental conditions, installation, operation and maintenance procedures.
- Assessment can be conducted by:
  - Demonstrated effectiveness
    - meet code requirements
    - document performance
    (many masonry examples)
  - Modelling of deterioration process
  - Testing to validate modelling
- Demonstrate the above by completing Tables in S478
- Ensure the PSL is achieved through a Quality Assurance program.

Durability Credit Summary:

- The Durability credit should have a positive impact on building envelope design and performance.
- Possible Improvements:
  - A CaGBC task group is working on simplifying this credit – possibly including recognition of moisture tolerant materials such as masonry.
  - Durability will have more points in the future, or a complete life cycle analysis method will replace it.
- Numerous other credits can impose pressures to use "Green" materials that may have negative impacts – and these should receive careful review before use.

6 Other "Sustainable" Benefits

The sustainability goal should encompass other aspects of performance of a building, including:
Longevity and durability, resistance to fire and healthy indoor environment, not completely addressed by LEED.

Concrete and masonry buildings offer these attributes:

- Durability and Life Cycle Assessment (LCA)
- Structure/Finish Combination
- Fire Resistance
- Low Emitting Materials (VOCs)

Structure/Finish Combination

Exposed interior/exterior concrete structure provide both the building structure and finish – eliminating additional materials.

Fire Resistance

- Minimum 2 hour fire separation provided by concrete block saves lives and properties from destruction – and reduces material use and landfill waste due to fire damage

Low Emitting Materials (VOC)

Volatile Organic Compounds (VOCs) are emitted from some products and building finishes, and may cause negative health impacts.

Most concrete products require no coatings or finishes in interior application and can be used as structure / finish combination

Table below shows VOC values of some selected finish materials:

Building Material	VOC Concentration (mg / m^3)	VOC Emission Rate ($mg / m^2 h$)
Linoleum	5.19	0.22
Acrylic latex paint	2.00	0.43
Concrete with water based form release agent	0.018	0.003

....and the balance of the Guide contains:

Appendix A: Sustainable Design Project Examples

Appendix B: Industry Segments and Contacts Information

Appendix C: Industry Environmental Footprint

Questions?

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Masonry Institute of BC

CIRCA
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Design Approach

- This credit applies to materials that are produced off-site. Materials such as crushed concrete that are processed for reuse onsite should be qualified under Credit MR 2 or MR 3.

- In addition to the use of SCMs, the use of other recycled materials as aggregate alternatives is under active investigation by the concrete product industry.

Calculations

1. Calculations for the recycled content % within each material or assembly are done by weight.
2. Calculation of the total recycled content % for all materials in the project is done on a cost basis.
3. **Post-consumer** recycled content is based on waste from products that have been recovered through the consumer market stream. (paper, cardboard, glass from curbside or business recycling; waste materials from building demolition)
4. **Post-industrial** recycled content is based on waste from industrial and manufacturing processes, but does not include scrap or trimmings from within the process. SCMs are post-industrial recycled content.

5. **SCMs** in concrete products are handled under LEED Canada as follows:

SCM replacement is calculated in terms of the amount of cement replaced, rather than the amount of SCM used. This focuses the calculation on the importance of the cement replacement, removes any concern about the lower weight of SCMs, and eliminates any question of cement reduction not matching SCM addition.

The reduction provided by the proposed SCM mix design is based on a comparison to a "Base Mix" without SCMs. The Base mix is determined from the following calculation:

Cement Content of **Base Mix** (kg/m3) = design strength in MPa at 28 days x **K**.

- where K = 10 for non-air-entrained concrete, or K =12.5 for air-entrained concrete

SCMs cont'd:

The % of cement reduction by weight is then determined from the mix design(s), and multiplied by 2.

This adjusted % is then applied to the total material cost of the concrete product (including formwork for cast-in-place), and input into the overall project recycled content template in the post-industrial column.

If there is also aggregate replacement by recycled material in a concrete product, it should be a separate line item from the SCM data.

6. Determine the total recycled content % by adding the material cost of post-consumer recycled content, plus ½ of post-industrial recycled content, and dividing that sum by the total materials cost.

Table 5.7: Base Mix Example

Mix Design	**Amount (kg/m³)**
Base Mix - 30 MPa @ 28 days, non-air-entrained	
Cement Content	300
SCM Mix – 30 MPa @ 56 days	
Cement Content	192
Fly Ash	158
Total Cementitious Content	350

Cement Reduction Factor

$$\left[\frac{(\text{Cement Content in Base Mix} - \text{Cement Content in Actual SCM Mix})}{\text{Cement Content of Base Mix}} \times 100\right] \times 2$$

$$= \left[\frac{(300-192)}{300} \times 100\right] \times 2 = 36\% \times 2 = 72\%$$