SUSTAINABLE DESIGN OF MASONRY BUILDINGS

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ABSTRACT

Owners, communities, universities, designers, producers, and contractors all profit from the sustainable or "green" design of buildings with concrete and masonry materials. Sustainability measures such as durability, extended life cycle, and energy efficiency can enhance building performance, reduce costs, increase health & safety and reduce potential liability & property loss. According to the Canada Green Building Council (CaGBC), the number of sustainable building projects is predicted to grow by 360% per year for the 2004 to 2009 period.

This paper will review masonry sustainable design by introducing the Guide to Sustainable Design with Concrete, which is a tool targeted to help the design industry select building products and choose systems that contribute to sustainable buildings. It introduces many possible energy and environmental credits, based on the provisions of LEED® Canada-NC 1.0. Several key credits that affect masonry are reviewed, including the new durable building credit.

KEYWORDS: sustainable design, green building, durability, LEED

INTRODUCTION

Interest in sustainable design is growing rapidly in Canada and around the world. Many projects are now being designed to "green building" principles, rating systems are increasingly being utilized to assess their expected performance, and membership in the Canada Green Building Council is currently growing by 10% per month.

The Guide to Sustainable Design with Concrete [1] was developed by the Cement Association of Canada to meet the need for information for a broad range of readers with different levels of knowledge of sustainable design principles and green building techniques. It includes detailed information on masonry products, and most of the following examples and information are drawn from this document. The Guide is based on the requirements of the assessment tool LEED® Canada-NC 1.0 [2], which was released in late 2004. This document, along with six key credits that involve masonry are discussed and reviewed in this paper.

LEED CANADA-NC 1.0 [2]

A measurement system is required if buildings are to be evaluated for their environmental performance, and choices made among alternatives. Such systems allow the many variables in a project to be quantified and assessed objectively. LEED (Leadership in Energy and Environmental Design) is the system that has become the most accepted in North America. It was developed in the United States, and has been chosen for adaptation for the Canadian market. It is a design guideline and third-party certification tool that aims to improve occupant wellbeing, environmental performance and economic returns. It is a voluntary, consensus based, market-driven, performance-oriented system, where points are earned in six categories for meeting specific credit requirements. There are four certification levels that can be achieved: certified, silver, gold and platinum.

Rather than creating its own standards, the LEED system document references existing third party standards. Each LEED credit is structured with sections on Intent, Requirements, Submittals and Technologies and Strategies. The basic LEED document is supplemented with an extensive system of Letter Templates, a Reference Guide and Credit Interpretations.

Although dozens of Canadian projects have been registered under the U.S. LEED system, the need for a specific Canadian system has been recognized and acted upon. The Canada Green Building Council (CaGBC) was established in 2003, and has been authorized to administer LEED in Canada.

LEED Canada-NC 1.0 looks very much like LEED-NC 2.1 [3], 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, while maintaining the intent of LEED 2.1. In many cases, the Canadian requirements are more stringent or broader than the U.S. version. Indeed, because LEED Canada reflects some of the latest thinking in rating green buildings, many of these changes are expected to be included in future versions of the U.S. LEED. These differences include:

- 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 a credit for Durable Building

The Durable Building credit in LEED Canada is an additional point over LEED 2.1, representing one point out of the 70 available. Concrete and masonry products are essential for designers and owners in their desire to construct durable buildings.

LEED Canada-NC 1.0 judges the environmental performance of new construction and major renovations. There are plans to issue a suite of LEED versions for different building types, including existing buildings, building interiors, building core and shell, and residential buildings.

The table below summarizes the categories, prerequisites and credits that can relate to masonry products under LEED Canada. Several of these are reviewed in more detail in the sections that follow this table.

Table 1 – LEED Credit Summary

LEED Canada Credits	Masonry Products
Energy & Atmosphere	
Prereq. 2: Min. energy performance - Meet energy limit	Masonry/concrete mass effect
Credit 1: Optimise Energy - Reduce energy cost	Masonry/concrete mass effect
Materials & Resources	
Credit 1: Building Reuse - Reuse existing shell/structure and interior	Existing masonry/concrete walls & structure
Credit 2: Construction Waste Management - Collect & redirect recyclables from demolition , clearing and construction	Masonry/concrete demolition to recyclers, or crush and use on-site
Credit 3: Resource Reuse - Reuse salvaged materials and components	Savaged brick; Crushed masonry/concrete used on-site
Credit 4: Recycled Content - Use new products that include recycled materials	Supplementary cementing materials (SCM's) such as fly ash and slag; Aggregate replacements in masonry products
Credit 5: Regional Materials - Use materials extracted and manufactured locally	Most block, brick and stone
Credit 8: Durable Building - Use durable materials on building exteriors to minimize materials and waste over building life cycle	All masonry products

ENERGY & ATMOSPHERE SECTION

Prerequisite 2;
Credit 1 - Optimise Energy (1 To 10 Points)

Prerequisite 2 of LEED Canada-NC 1.0 [2] requires a substantially higher minimum energy performance level than LEED 2.1 [3]. This is intended to reflect both the impact of the colder Canadian climate, and the intention of government to achieve energy savings targets for buildings related to the Kyoto accord. The specified 25% saving over the Model National Energy Code for Buildings (MNECB) [4] matches the level set for the Commercial Incentive Building Program (CBIP) [5].

The intent of Credit 1 is to encourage increasing levels of energy performance above the prerequisite standard to reduce environmental impacts associated with excessive energy use.

Design approaches include one of two standards utilized in the LEED Canada system:

- The Model National Energy Code for Buildings (MNECB) [4], with guidance from Natural Resources Canada's Commercial Buildings Incentive Program (CBIP) [5].
- ASHRAE/IESNA 90.1-1999 [6] (also used in LEED 2.1)

The choice of one of these two compliance paths for Credit 1 must be consistent with the path taken to meet Prerequisite 2 for Minimum Energy Performance. Note that the prerequisite minimum requirements are similar to the first point level of the optimization credit.

Computer simulation models are typically used to assess energy savings compared to a reference version of the building. Various design strategies can be examined, including issues such as: building location, size, shape, layout and orientation; glazing; envelope insulation; mechanical and electrical systems; occupant and environmental loads; and building mass. A mechanical consultant experienced in this field typically provides this energy modelling.

Mass on both the exterior and interior of buildings can improve thermal performance, which results in energy savings that may help to achieve LEED credits. Under appropriate conditions, when compared with light weight buildings, thermally massive buildings are expected to show energy savings benefits for three reasons:

1) There are fewer spikes in heating and cooling requirements, since mass slows the building response time. (see Figure 1 below)
2) Thermal mass can shift some loads so that instead of superimposing, they are more spread out over a 24-hour cycle, with a resulting decrease in peak loads.
3) Energy for heating and cooling is reduced because heat flow in either direction through massive envelope elements is reduced.

To illustrate how these principles may pertain to the LEED energy credit requirements, a computer simulation model analysis was performed on three versions of a typical 4-storey office building. The three versions varied in their respective weights, based on increasing amounts of masonry and concrete for structural and cladding materials. The high thermal mass case included brick veneer over a block back-up wall, along with concrete columns, floors and roof.

The results of the whole building energy analysis for LEED purposes showed that with the use of high thermal mass, there is a potential to achieve an increase in energy savings in the order of 3%, for each of five sample locations across Canada. In the cases studied, the base building used was already achieving one LEED point for energy optimization by virtue of complying with CBIP requirements. The additional energy savings achieved by using a higher thermal mass building could lift the building into the next credit category, depending on the energy performance of the base building: for example, a light weight base building at 27% savings compared to the Model National Energy Code Building could be redesigned as a heavy weight building with 30% savings, and thus move from one point to two points in EA Credit 1.

Although results will vary for different buildings and environmental loadings, this information illustrates the kind of benefits that can be achieved by using the thermal mass characteristics of masonry and concrete products in the design of a building. There is a need for further analysis on this topic to expand and refine data for various building configurations and material options.

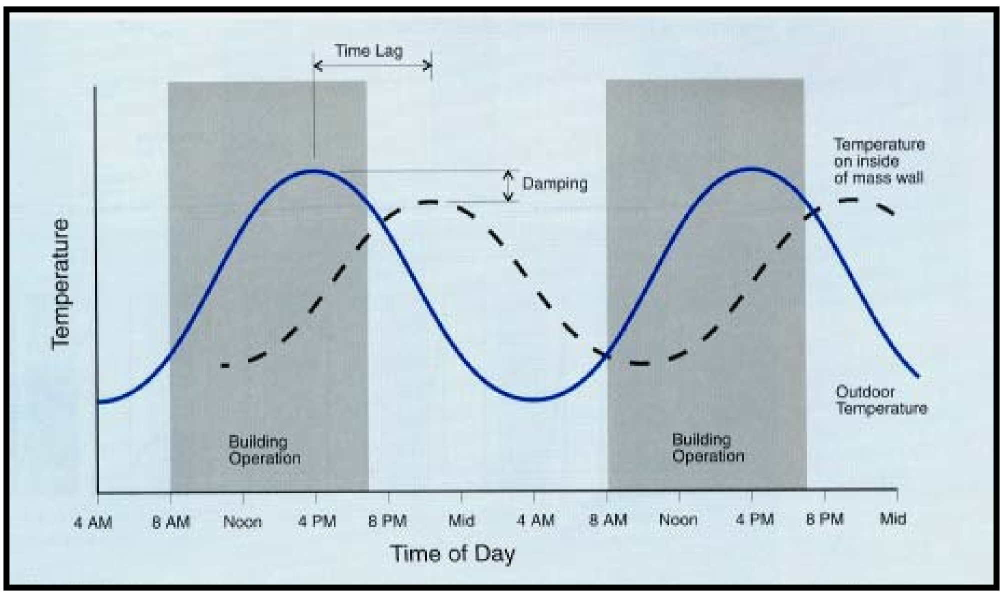

Figure 1 – Thermal Mass Effect

MATERIALS & RESOURCES SECTION

Credit 2 - Construction Waste Management (1 to 2 points)

The intent is to divert construction, demolition and land clearing debris from landfill disposal and redirect recyclable recovered resources back to the manufacturing process.

- 2.1 Divert 50% from Landfill
- 2.2 Divert 75% from Landfill

Design approaches include developing and implementing a waste management plan through the contractor, including: goals, documentation, materials, bins, and haulers and recyclers. Typical outgoing recycled materials include: land clearing debris, concrete and masonry, wood, cardboard, metal, drywall and plastic. Crushed masonry or concrete from demolition can be used either on or off-site. Masonry should generate relatively little waste due to its modularity.

Credit 3 - Resource Reuse (1 to 2 points)
The intent is to salvage and reuse building materials to reduce demand for virgin materials and reduce waste, thereby reducing impacts associated with the extraction and processing of virgin resources.

3.1 5% Resource Reuse
3.2 10% Resource Reuse

Design approaches would include identifying and specifying materials and sources that could be appropriate for the project, including incoming components from other buildings, such as brick; pre-cast, wood or steel beams; hollow core slabs; flooring, doors and cabinetry. Check for durability, code compliance and suitability. For instance, salvaged brick from the early 1900's could be checked for freeze/thaw resistance to ensure suitability for exterior use. An example of reused brick salvaged from a nearby site is shown below.

Figure 2 – Reused Brick, C.K. Choi Building, University of British Columbia

Credit 4 - Recycled Content (1 to 2 points)
The intent is to increase demand for building products that incorporate recycled content materials, therefore reducing impacts resulting from extraction and processing of new virgin materials and minimizing waste. These Canadian targets are higher than those in LEED 2.1.

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

Design approaches would include identifying and specifying types of materials and specific products with recycled raw material content that could be appropriate for the project. Check for durability, equivalent performance and suitability for other environmental concerns and credits.

For example, fly ash sources have been confirmed for quality assurance and reactivity. This credit applies to new products or materials that are produced off-site.

Supplementary Cementitious Materials (SCM), such as fly ash and slag, are being used more widely as a replacement for part of the cement in concrete products. The positive effects of this substitution are given a much higher weighting in LEED Canada by the application of a multiplier of 2 to the cement reduction percentage, and the application of this percentage to the total material cost of the concrete product, for input into the overall project template. The masonry industry is also using or exploring recycled raw materials as aggregate alternatives for use in block and brick.

Credit 5 - Regional Materials (1 to 2 points)
The intent is to increase demand for building materials and products that are extracted and manufactured within the region, thereby supporting the use of indigenous resources and reducing the environmental impacts resulting from transportation.

- 5.1 10% Extracted & Manufactured Regionally
- 5.2 20% Extracted & Manufactured Regionally

Design approaches would include identifying and specifying materials and products that 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 80% level recognizes that most products involve a variety of inputs, not all of which would typically qualify under the distance criteria.

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. The difference in the transport radius reflects the different fuel efficiencies and resulting environmental impacts of the various modes of transportation.

Most masonry products meet both of these criteria. Block and brick plants are located within most well-populated regions. For the raw materials extraction or production, sand and gravel aggregates and clay are always available locally, while cement – a manufactured sub-component for block and mortar - is produced within most regions. Minor additives from outside the region, such as admixtures or colour oxides, would easily fit under the 20% limit. Organizations such as Masonry Canada maintain lists of masonry product manufacturers across Canada.

Credit 8 - Durable Building (1 point)
This is a new credit introduced by LEED Canada to address a serious missing component in the LEED system. It is only 1 point, but is certainly a step in the right direction. The intent is to minimize the use of materials and construction waste over a building’s life resulting from premature failure of the building and its components and assemblies.

Design approaches would include recognizing that proper design and materials can provide components and assemblies that, over the life of a building, will use less material and create less waste. This life cycle approach is based on a long-term assessment of building structural and envelope systems to determine how much maintenance, repair and replacement will be required to resist the elements and to minimize premature deterioration. The environmental loads, and the means employed to achieve adequate resistance, will vary by climate.

Design strategies for durability must incorporate appropriate structural and cladding materials such as concrete and masonry. Other issues include rainscreens, drying potential, air barriers, overhangs and screens. The CSA S478-95 Guideline on Durability in Buildings assists in this process by providing definitions for various durability concepts, as well as process for the design, construction and operating phases of a building. The basic principle is that the Predicted Service Life of a component must exceed the Design Service Life defined for the building. The Predicted Service Life is determined from:

- Demonstrated Effectiveness
- Modelling
- Testing

The Design Service Life of the building is based on Table 2 from CSA S478, which provides for a "long life" of 50 to 99 years for most residential, commercial and institutional buildings. Masonry structural and cladding materials can be readily specified to meet these requirements based on the Demonstrated Effectiveness criteria.

Durability can also be an issue with numerous other credits where new products are specified to meet various LEED criteria. Caution should be used to ensure that building durability is not compromised by the use of these products. Examples could include: new white roofing materials to meet heat island requirements; untried raw materials for recycled content or rapidly renewable material credits; and unproven products to meet salvaged or regional material criteria. This concern can be addressed by providing for adequate testing and assessment of new products, or products that are being used in a new application or environment.

CONCLUSIONS

Owners, communities, educators, designers, material producers, and contractors benefit from the sustainable design of buildings in general, and through the use of masonry materials in particular. Continued research and education with regard to "green building" and LEED Canada should be key priorities of the Canadian masonry industry. The Guide to Sustainable Design with Concrete can be a worthwhile tool in the assessment of masonry as a sustainable design material.

Masonry can be effective in achieving numerous LEED credits in the Energy and Materials sections – including the new Durable Building credit.

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