GREEN DESIGN: GOING BEYOND MATERIAL ISSUES

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ABSTRACT

When discussing sustainability, the steel industry has often responded by pointing to the recycled content of steel and the potential for reusing steel components. This is an important environmental benefit of steel but does not address a variety of other factors related to sustainability. Although the LEED™ (See USGBC 2002) green building rating system has its faults and critics it is nevertheless the most widespread and well understood method for rating the sustainability of buildings and has been an effective market transformation tool. This paper discusses the opportunities that are offered by steel construction for addressing sections of the LEED™ green building rating system; where steel can help score points, and where further development by the steel industry may offer further opportunities. The second part of the paper also discussed the need for developing a strategy to address and influence the steel supply chain to address wider issues of sustainability, including economic and social as well as environmental issues.

INTRODUCTION

In recent years the steel industry has made significant improvements in its environmental performance such as reducing energy use in manufacture, reducing pollution and waste. Furthermore, some of the characteristics of steel as a material offer considerable opportunities for more sustainable ways of construction. Nevertheless, when discussing positive aspects of sustainable steel in buildings is seems that the focus inevitably turns to the material's recycling characteristics. These are clearly very significant and research has shown the clear environmental benefits of recycling of steel, and of reusing steel components in construction. However, as the sustainability debate matures and as clients, designers and contractors begin to want more comprehensive answers to questions about a material's green characteristics, the steel industry needs to develop a more holistic approach and stop hiding behind the positive yet narrow benefits of recycling.

This paper discusses the opportunities that are offered by steel construction for addressing sections of the LEED™ green building rating system; where steel can help score points, and where further development by the steel industry may offer further opportunities. The paper also touches on the development for the steel construction industry of a fundamentally more green supply chain.

DEVELOPING A GREEN STEEL SUPPLY CHAIN

A sustainable business must be a well run, efficient and profitable enterprise; its long term viability relies upon its relationships with its stakeholders. Whether investors, owners, suppliers, employees or customers, the aspirations of all stakeholder groups need to be understood and balanced to ensure the long-term success of an organisation.

Investors

The business benefits of sustainability are increasingly recognised by investors. Socially responsible investment, increasingly being adopted by large institutional investors, is putting pressure on companies to adopt more sustainable practices. As the financial sector continues to adopt environmental and social issues in its investment decision-making, the message is clear; companies will increasingly need to demonstrate their sustainable credentials to secure investment.

Financial markets throughout the world now monitor the sustainability performance of companies and the evidence is mounting that sustainability pays. The Dow Jones Sustainability Index (DJSI), which includes the world's most sustainably managed companies, has significantly outperformed the standard Dow Jones Index over recent years.

Suppliers

Businesses committed to corporate social responsibility are passing their commitment down their supply chains. This means that suppliers are being required to consider, and often improve, their sustainability performance to match the highest standards within their supply chain.

The construction industry comprises many long, diverse and complex supply chains. As companies implement more sustainable strategies, those suppliers not improving, measuring and reporting their sustainability credentials to their customers will lose business.

Employees

Awareness of the importance of the social agenda is also increasing. Employees are a central part of any successful sustainable business or sector and how they are looked after and managed is a key constituent of any corporate sustainability strategy. Health and safety of employees is of paramount importance, particularly within the construction industry which, relative to most other sectors, has a poor track record. Staff skills, personal development and retention are also key issues which need to be considered to ensure the sustainability of construction companies.

Customers

Customers are key drivers in implementing change. Not only should companies understand the needs and wishes of their customers, but also they need to be able to respond to this by offering new products and services at affordable prices. Everybody uses products supplied by the construction industry. Therefore, as sustainable development becomes more widely and publicly accepted, the construction industry must respond to this new agenda. This challenge represents significant opportunities to the industry.

LEADERSHIP IN ENERGY AND ENVIRONMENTAL DESIGN (LEED™)

One way in which the steel construction industry can demonstrate seriousness to its stakeholders about sustainability is to engage in the current debate about how to achieve more sustainable buildings, and to develop components, methods and systems that can demonstrate improved environmental performance. The LEED™ green building rating system was developed to provide standard for what constitutes a "sustainable building" and to transform existing building markets so that sustainable design, construction and operation become mainstream practices. Although LEED™ should not be seen as the definitive description of sustainable building, there is considerable discussion about its structure and the values it espouses, currently LEED™ is the dominant method for assessing sustainability in buildings, and the steel industry can benefit by showing engagement in addressing the goals as set out in LEED™.

LEED™ is a "voluntary, consensus based, market-driven building rating system based on proven technology". LEED™ aims to improve occupant well-being, environmental performance and economic returns from buildings, using both established and innovative practices, standards and technologies. It is also intended to prevent exaggerated or false claims of sustainability, and to provide a common standard of measurement. LEED™ was first developed by the US Green Building Council (USGBC) and adopted in the USA. In 2004, the Canadian Green Building Council (CaGBC) created LEED™ Canada - NC version 1.0 and this is now the document used for Canadian buildings. The original LEED™ NC applies to new designs and major renovations of commercial, institutional or high-rise residential buildings. A variety of more targeted versions of LEED™ have been developed or are under development, including: homes, commercial interiors, existing buildings, schools, retail, healthcare and neighbourhood development.

LEED™ offers a third-party certification process whereby points are collected within five main environmental performance categories: Sustainable Sites, Water Efficiency, Energy & Atmosphere, Materials and Resources, and Indoor Environmental Quality. A sixth category deals with Innovation and Design Process and aims to promote whole-building integrated design practices.

LEED™ AND STEEL

It is useful to consider what opportunities LEED™ offers for steel construction. Below is a review of the LEED™ sections and how they relate to steel.

Sustainable Sites (14 Points)

This section deals primarily with issues of site selection (brownfield v greenfield), site design (materials, density, drainage), and site access (transport issues and availability of facilities). Also considered are heat island and light pollution effects.

Using steel structures and components can help address many of the problems of building in urban centres. Engineered, prefabricated steel components can be speedily installed reducing construction time and disruption on site. Furthermore, the flexibility that steel design offers enables difficult urban sites to be more readily exploited. The wide spanning capabilities, fast track construction, integration of services, just in time delivery, reduced storage requirements, less disruption on cramped sites, and lighter weight of steel buildings leading to smaller foundations, all contribute to more workable steel solutions on difficult urban sites. In addition, many steel technologies such roof and wall claddings require little removal of waste from site.

As with urban sites, contaminated (brownfield) site developments can benefit from the use of lightweight structures that require less ground works and large scale prefabrication using steel components which can reduce disturbance of the polluted ground. In some cases this can lead to more cost effective remediation solutions to deal with the contamination.

The use of steel structures and components allows much more prefabrication. A key feature of prefabrication is that much of the process is removed from the site to controlled factory conditions. Reducing the amount of time spent on site can lead to less detrimental impacts on the site and locality. The development of appropriate prefabrication systems and management systems may allow difficult brownfield sites to be more easily developed.

Steel roofing & cladding materials with reflectance greater than 0.65 and emissivity greater than 0.9 that meet the Energy Star labelled requirement can be used to meet the Heat Island credit.

Water Efficiency (5 points)

This section deals with landscaping, wastewater treatment and water use reduction. A point is available for reducing potable water used for irrigation by 50% a second if 100% reduction is achieved. Other credits are available for reducing indoor water use by 20% or 30%, and for reducing waste water.

This section is not particularly relevant to the steel industry.

Energy and Atmosphere (17 points)

This section deals with strategies to help reduce energy use and protect the ozone layer. A minimum energy standard that must be achieved is established and Up to 10 credits are available for energy efficiency, with 3 additional credits for renewable energy. Further credits are available for purchasing green power, additional building monitoring, avoidance of ozone depleting materials, and additional commissioning.

Meeting the increased energy standards is generally cost-effective and good business practice. Steel structures can be readily designed to achieve the higher levels of energy efficiency required and score additional points depending on the detail design of the building, its location and fuel type used. Examples in Canada include the many light steel frame residential buildings constructed to the demanding R2000 and EnergyStar energy efficiency standards.

*One issue that is often raised about steel frame buildings is the lack of thermal mass. This is less of an issue in low rise residential housing where timber frame housing has a similar lack of thermal mass, but is a significant issue in commercial buildings. Thermal mass is important in buildings for its heat storage capacity, particularly in the cooling season. However, it is not the absolute amount of mass that is most important but how well it is distributed, and how well it is connected with the occupied spaces. Studies have shown that sufficient thermal mass can readily be incorporated in steel frame office buildings to reduce cooling loads, and that the structural framing makes little difference to cooling loads (*Barnard 1999*). The steel industry needs to develop design guidance for appropriate integration of thermal mass and exposure of mass in buildings. This means careful specification of finishes to ensure that the mass is not insulated from the internal spaces.*

The energy calculations required for this credit entail the use of thermal modelling software such as DOE 2.1 to enable designers to investigate, optimize and demonstrate the full annual energy performance. These models allow the effects of thermal mass to be accurately modelled to demonstrate and maximize the potential benefits.

The steel industry also has an opportunity to develop cladding systems with integrated renewable energy collection such as photo voltaic systems on their surface which can generate on-site electricity. These are gradually becoming available and can be used to gain points under this credit.

Materials and Resources (13 points)

This section focuses on building reuse; waste management; reused, recycled or certified materials, and reducing travel distances for materials used in construction.. This section includes complex rules about definitions and measurement methods. A distance of 500 miles is used to classify a material as local.

This is perhaps the section that affects the steel industry most, but not all the sections are well understood. Steel's high recycled content is important in this section. LEED™ certification requires documentation from the steel suppliers verifying the recycled content and manufacturing process. However, other attributes of steel construction are also beneficial in this section. The potential for whole steel buildings and individual components to be reused is a major asset here. One credit deals with whole building reuse while another awards points for component reuse. Thus, the steel industry should focus its guidance on flexibility and adaptability in steel buildings, and the opportunities for deconstruction and component reuse.

The potential for extending and adapting steel buildings is beneficial here. In refurbishment, modifying and reinforcing of existing structures is an important attribute of steel structures. There are many examples of steel frame structures that have been adapted for a new use, while in some cases steel structures have been dismantled and reassembled in a new location. In addition, the lightweight characteristics of steel structures means that often additional floors can be added to existing buildings, extending their usefulness. Designers require guidance about how to maximise these benefits of steel construction.

Many steel components that are recovered from demolition or refurbishment projects are, or could, be suitable for reuse although most currently go to recycling. More components could readily be available if they were initially designed for more easily deconstruction. This includes structural sections, cladding, studs and smaller components. Increasingly, designers are sourcing recovered steel components and specifying their use in new projects. Examples of major projects where recovered steel has been used include the Students Center for the University of Toronto Scarborough Campus (UTSC). The engineers for this project were also working on renovations to the Royal Ontario Museum (ROM) where demolition work provided steel components suitable for use in the new Students Centre.. Another example is the Philips Ecoenterprise centre in Minneapolis which use 189 steel joists from a demolished warehouse saving an estimated 50 tonnes of new steel.

Figure 1 Deconstruction of Royal Ontario Museum for reuse in the University of Toronto Scarborough Campus Students Centre

In addition, the use of steel components on-site generates very little waste, as the components are generally manufactured to tight tolerances in a factory and delivered to site for assembly. Thus, using steel components should contribute significantly to reducing site waste.

The credit for Regional Materials) is intended to increase demand for locally manufactured materials thereby reducing the environmental impacts of transportation and supporting the local economy.
A regional material is defined as one that is extracted, processed and manufactured within 800 km (500 miles) of the site, or if rail or water transport is primarily used this distance is extended to 2,400 km (1,500 miles). For scrap steel this is likely to mean the location where the material last served a useful purpose. Thus, locally salvaged steel would contribute to this credit, and the steel industry should consider establishing an infrastructure to help designers and contractors identify appropriate local steel.

The credits in this section are calculated using the value of the reused or recycled material compared to the total value of materials. Since steel components often have a relatively high value compared to other building materials, they can contribute considerably to achieving this credit. LEED™ requires that the salvage status of each component be validated, but if the cost of reused components is lower than the new product equivalent it allows the equivalent market value of new products to be used in the calculations.

Indoor Environmental Quality (15 points)

This is a large section related to occupant comfort, air quality, thermal comfort, and access to daylight. The credits cover many issues including ventilation and carbon dioxide monitoring, low-emission materials (for paints, carpets and composite wood), construction indoor air quality (IAQ), controllability of systems, thermal comfort and daylight access.

There are limited opportunities for steel here, although construction components that are pre-finished off site and thus do not require paints and other finishes on site, or regular maintenance in furure offer some benefits in reducing indoor pollution from chemical finishes. The credit for using Low Emitting Materials – Paints and Coatings may affect steel components. It is only relevant to on site painting. Steel components are usually painted off-site under controlled conditions so they can avoid use of toxic paints on site. This reduces emissions into the building. Low emitting paints and coatings can be used on steel to meet this credit requirement.

One credit aims to maximize daylight and views from internal spaces. The adaptability of steel structures, cladding and partitioning can provide the designer with flexibility and scope to provide good daylighting, and the maintenance of unobstructed views, thus meeting the requirements of this credit.

Innovation and Design Process

This section allows a building to obtain up to four design innovation credits, as well as one additional credit for including a LEED™ accredited professional in the design process. The design innovation may be awarded for achievements such as lifecycle analysis, community development or education of occupants. Substantially exceeding one of the earlier credits may also warrant an innovation credit.

Steel opportunities:
This is where innovative steel solutions can claim additional credits. Possible options include design for future demountability and reusability, use of composite members to reduce material volume, use of innovative steel structural solutions that reduce material volume, and integration of structure and services.

For example the Utah Olympic Speed Skating Oval uses an innovative cable suspension system to support a very shallow steel truss roof, which weights about 600 tonnes (25%) less than competing solutions. The design also reduces the internal volume by about 20% which results in a smaller HVAC system and less energy used for heating and cooling.

Creative use of prefabrication to maximize environmental benefits and improve Health and Safety of the workforce is another option. Moving much of the process into more controlled and comfortable factory conditions enables safety requirements to be more easily met and policed, and healthy and comfortable working conditions are more readily maintained.

SUPPLY CHAIN MANAGEMENT – METHODS OF ENSURING RESPONSIBLE SUPPLIERS

Moving beyond LEED™, steel construction companies that are serious about addressing sustainability need to consider the impact of their supply chain on their activities and products. This is happening in other industries and examples such as Wallmart illustrate the power of this approach to changing industries and their environmental impact. This can include strategies to:

1. engage the whole supply chain
2. inform decision makers about what is important for sustainable steel construction
3. ensure that new initiatives align market solutions with national priorities
4. establish the means to measure and report progress.

Supply chain engagement

It is clear that no industrial sector or part of a sector can expect to advance the sustainability agenda in isolation. Economic growth, community involvement, environmental protection and resource use all involve commercial organisations in interaction with others. The parties involved in the steel supply chain need to engage all of the steel construction supply chain. The list below illustrates the diversity and breadth of the supply chain.

Supply Chain for Steel in Construction:

- Clients and their advisors
- Designers
- Detailers
- Steel producers
- Steel service centres
- Manufacturers of welded profiles
- Preprocessors – straightening, cambering, curving and bending steel products
- Manufacturers of proprietary products – Cold formed purlins and rails, Cellular beams, Fabsec beams, Porthole beams, Open-web joists, Durbar plate, Flooring systems, Handrailing, Steel staircases
- Suppliers and installers of metal decking, steel sheeting, roof and wall cladding
- Kits and systems suppliers – Light steel framing, Modular steel buildings
- Suppliers and processors of special steels – Stainless steel items, Machinists
- Manufacturers and stockists of bolt assemblies and other standard fasteners
- Proprietary fastener manufacturers
- Welding consumable suppliers and stockists
- Fabricators
- Erectors
- Applicators of metal treatment – Corrosion and Fire Protection
- Suppliers of paint and other metal coatings
- Transport companies
- Plant suppliers – Cranes, Access equipment
- Suppliers and installers of steel piling
- Suppliers and installers of complementary products – Precast slabs, Glazing
- Shoring contractors
- Demolition contractors
- Scrap merchants and processors
- Steel recyclers

There are many SMEs in the sector who are used to responding to changes in their business environment. To them the clearest business case is that they will lose clients if they do not respond to the increased attention being paid to sustainability. The widespread adoption of LEED and other programs to green the market are sending a strong signal throughout the construction supply chain. Clients expect the supply chain to address green issues and to demonstrate this in their products. What is required is not an abandonment of profit as an essential measure of success, but a shift of focus towards looking at business as part of the whole interdependent economic, social and environmental system.

Supply chain reporting

'What can you show to demonstrate a commitment to sustainability?' may soon become be a necessary pre-qualification to becoming a supplier to any organisation espousing sustainable objectives. Organisations within the steel sector may need to promote supply chain reporting by developing their own reporting policies. Questions to pose prospective suppliers may include (Based on SCI 2002):

Sustainability reporting: *Some questions to ask*

Economic issues

- What investment is being made for the future environmental technologies?

Social issues

- What commitment is there to health and safety?
- What training and development is given to the workforce?
- What involvement is there with local communities, educational establishments, charities, etc?

Environmental issues

- What commitment is there to environmental protection?
- What certified environmental management systems do you have?
- What measures are taken to improve energy efficiency and reduce the consumption of natural resources?

Stakeholder Engagement

- What partnerships does the company have?
- What environmental information does the company provide to customers?
- How does your company demonstrate transparent reporting?

CONCLUSIONS

The steel industry would benefit from developing a strategy for addressing issues of sustainable construction which demonstrates its commitment to the long term goals of sustainable construction. Such a strategy can demonstrate the commitment of the sector to become more sustainable, and can identify partners with whom the industry can working together including all parts of the supply chain to deliver more steel sustainable construction for the benefit of all. Implementation of such a strategy, throughout the supply chain, can produce a modern, efficient and viable industry responsive to the demands of its stakeholders and the evolving demands of sustainable development. Beneficiaries will include all owners and users of buildings, but the steel industry will also benefit by strengthening its position within the construction sector.

References

- Barnard, N (1999). Making the most of thermal mass, Architects Journal, 21 October 1999
- SCI (2002), Sustainable Steel Construction – Building a Better Future, Steel Construction Institute, UK
- USGBC (2002) Leadership in Energy and Environmental Design green building rating system for new constructions and major renovations (LEED NC) version 2.1, US Green Building Council, USA. See usgbc.org