How Good is Wood? Facts and Myths Regarding Wood as a Green Building Material

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Abstract Sustainability has been the key driver for decisions concerning building materials. Environmental awareness has increased, and the conscious society and citizens of this world demand more accountability. This has been the driver of the green building movement. The green building programs have been immensely successful—few more than the others. The success has been attributed to their attempt of validating peoples' efforts toward sustainable development by assigning a tangible metrics. Green buildings, in modern vernacular, have become similar to sustainable development. Although similar, sustainable development and green buildings are not the same rather similar. This paper presents author's view on how green building is a subset of sustainable development, which is an all-encompassing concept. An explanation of what constitutes a green building material is discussed, while objectively assessing wood with regard to those criteria. Myths and facts regarding the use of wood in green buildings will be discussed using a life cycle approach. Wood is arguably one of the most sustainable materials. However, there are some facets of wood that impede its acceptance in construction. These impediments and their mitigation strategies are discussed in the paper. Statements concerning sustainability require validation, which can be provided by life cycle analysis (LCA). Many green building programs have certain pitfall and challenges —mostly with respect to practices on material selection and lack of performance monitoring. Materials regardless of its origin have a common starting point, neglecting the environmental benefits of certain materials vis-à-vis another. This paper presents how beneficial LCA can be, when included and integrated into the green building rating system and introduces an integrated design concept for green buildings, especially from a material selection standpoint. Since writing of this article, the major green building programs have altered their methodologies to incorporate LCA in their rating program.

Keywords Carbon sequestration · Life cycle analysis · LEED

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Introduction

Increasing world population coupled with increased economic development of many nations has caused added strain on world's resources. Often economic development is achieved by stressing the environment. Thus, there is increased awareness and realization to conserve energy and resources (Garcia 2011) and use renewable materials (Sinha et al. 2013). Globally, the built environment consumes 60% of the raw materials that are produced by mining the Earth's crust (Bribian et al. 2011). Therefore, sustainability has been a major consideration when choosing building materials. Environmental awareness has increased over time and citizens of this world are demanding more accountability. This has been the driver of the green building movement. The green building programs emerging from the green building movement have been immensely successful. A few more than the others. The success has been attributed to their attempt of validating peoples' efforts toward sustainable development by assigning a tangible metrics.

Current green building standards address a wide array of areas but focus mostly on energy efficiency and indoor air quality. Other areas of consideration in these programs are water management, material production, construction issues, occupant health quality, recycling, reusability, and waste management (Bowyer 2008). In the USA, there are more than 40 green building programs including independent programs led by many local counties. The National Association of Homebuilders (NAHB) worked with these counties and designed their own green building program in 2008 called the National Green Building Program (NAHB 2010). Since the introduction of National Green Building Program, it has emerged as the market leader in the residential sector. On the other hand, in the commercial sector, Leadership in Energy and Environmental Design (LEED) administered by US Green Building Council (USGBC) has been the market leader by a huge margin. At the time of writing the article, LEED for homes was gaining grounds on the NAHB-administered program for residential construction. It is projected that LEED for Homes will soon take over NAHB-administered program.

To earn certification under the LEED program, a building must meet certain prerequisites and performance benchmarks within each category. LEED (2009) contains the following specific rating systems: (1) New Construction (NC); (2) Existing Buildings: Operations and Maintenance; (3) Commercial Interiors; (4) Core and Shell; (5) Retail; (6) Healthcare; (7) Homes; and (8) Neighborhood Development. At the time of writing this article, LEED 2009 was the current version. However, at the time publication of this article, LEED v4.0 has been released and changed some of the point system. This article deals with LEED (2009). Each of the rating systems within the LEED domain is composed of 100 points, which are divided among five categories: Sustainable Sites (26 points); Water Efficiency (10 points); Energy and Atmosphere (35 points); Materials and Resources (14 points); and Indoor Environmental Quality (15 points). Additionally, up to 10 bonus points are possible through innovative design and consideration of regional priorities. To obtain points in LEED, certain prerequisites are mandatory in

all the five categories. After achieving the prerequisites, the points are assigned in a progressive way for incremental level of documented efforts to increase environmental performance. LEED is also the world leader of green buildings. The LEED International Roundtable is composed of representatives from 38 countries (including India) who work to provide global consistency in regional approaches to green building. Each of these 38 countries utilizes LEED rating systems that are catered to the local conditions and practices in their country. LEED has registered projects in 133 countries. In India, the India Green Building Council (IGBC) provides leadership in the green building sector through several different rating systems. One of the primary systems, LEED India, evaluates sustainable site development, water savings, energy efficiency, materials selection, and indoor environmental quality for both new construction and the core and shell of buildings. For residential sector, Green Homes have gained popularity in India. Green Homes have system catered to individual homes, high-rise residential apartments, gated communities, row houses, and retrofit of existing residential buildings. Similarly, Green Townships rating system is for large developments and townships, and the Green Factory Building rating system for industrial complexes.

Green Material

Generally, three criteria are used for assessing whether a material is green—resource management, pollution or indoor environment quality, and performance (Milani 2005; Spiegel and Meadows 2006). These three evaluation categories have significant overlap. For an ideal green material from a resource management standpoint, it should be a natural material derived from renewable sources. The materials extraction and processing should be carried out in an environmentally conscious manner, i.e., process should have low emissions. This is important from a pollution or indoor environment quality standpoint. From a performance standpoint, two things are paramount. One, the material should perform its intended function for a long time, i.e., the material is durable. Durability is becoming a key factor. Materials with low durability cannot stand the test of time to be called green. Globally, the built environment consumes 60% of the raw materials that are produced by mining the Earth's crust (Bribian et al. 2011). Considering a building's life span, more than 90% of the building material's life cycle coincides with the operational phase of the building. This tends to make durability and performance somewhat more important factor for building materials than for many other kinds of products. Second, after the service life of material is over, it should offer value in terms of either full integration into the landscape or can be recycled or down-cycled for a different function. This is important to minimize the environmental impacts of the building material.

Wood is a renewable, strong, and a natural material that would be a natural fit for structures claiming to be green. Wooden structures are aesthetically pleasing. Wood, as a material, also has biophilic traits that help mitigate sick building

syndromes (Fell 2010; Nyrud and Bringlismark 2010). Above all, wood is a sustainable natural resource. Wood is a product of photosynthesis, which uses carbon dioxide and water in the presence of sunlight to build glucose molecule that is the backbone of wood. If sustainable forest practices are enforced, then wood is the most sustainable material on this planet from a resource management standpoint. From pollution standpoint also wood processing are not as energy-intensive processes as other building materials are and emits less pollution. Wood is the only building material that has the ability to sequester and store carbon for a number of years (Bowyer et al. 2007; Buchanan 2006). This makes wood an ideal material from an emissions or pollution standpoint. Because wood can be decomposed, recycled, or reused, wood is one of the rare materials that have the potential of full integration into the landscape after its service life is over.

There are certain impediments for wood being used as a building material of choice in many countries from a performance standpoint. First, wood shrinks and swells with moisture changes. Although the dimensional changes due to moisture can create serviceability issues in structures, these can be accounted for by the structural engineer during the design process. Second impediment is that wood decays. This is a fact but there are ways or provisions in the design to prevent decay. Even if certain degradation due to decay has been encountered proven, mitigating strategies are readily available. Another concern is that wood burns easily and it is a fuel for fire. Wood burns readily initially. However, once the outer layer of wood burns, it produces char, which is insulating in nature and prevents further burning of wood. Testing has shown that a wooden beam under fire can retain its shape and structural integrity for a significantly longer duration than an equivalent steel beam (AWC 1961). There are impediments in terms of physical characteristics but these can be easily dealt with. Wood perhaps exemplifies a green material. Given this wood should be the first choice material for all green building programs, especially the world leader LEED.

LEED and WOOD

The USGBC-administered LEED, although a comprehensive effort in quantifying sustainability metric, has certain pitfalls in terms of how it rates the materials. Certain provisions in LEED and other programs can lead to negative impact on wood and wood products (Bowyer 2008). Materials regardless of its origin have a common starting point in these programs, neglecting the environmental benefits of certain materials vis-à-vis another. For example, materials like concrete and wood are considered equal when being used in a building. While steel has an upper hand as recycled content, recyclability is accounted for (USGBC 2010). This attribute of steel should certainly be accounted for as it is a wonderful property that only steel possess. Similarly, wood should be given more emphasis as due to its biological origin. Moreover, life cycle analysis has shown that wood has less embodied energy and carbon footprint than several other building materials (Puettman et al.

2005). Wood is a renewable material, while the raw materials to make cement and then concrete are a product of energy-intensive process (PCA 2008; van Oss and Padovani 2002; Rajendran and Gambatese 2007). As discussed earlier, steel is preferred over wood and concrete, because of its recyclability and recycled content (USGBC 2010). Steel although is recyclable has higher environmental impacts than wood because the raw material has to be mined and then steel has to be extracted in a blast furnace (IISI 2000). Many experts (Bowyer 2008) consider this stand on steel being given more importance, as a serious error from an environmental standpoint.

LEED assigns extra credit for materials that are "rapidly renewable" (LEED 2009). A material is considered rapidly renewable if it has 10-year period of turn-around or less. For crops like bamboo and trees with smaller rotation, these points can be attained. However, for most wood species, a 10-year or less turn-around time is unheard of, and therefore, this credit is elusive to projects using predominantly wood. Bamboo on the other hand is considered rapidly renewable compared to any hardwood such as maple or oak, and therefore, bamboo flooring is preferred over hardwood flooring as it helps in attaining that credit. No consideration is provided to the amount of energy expended in processing of either material. The scientific background of this credit has been continuously challenged (Bowyer 2007; YPFPG 2008), but the credit criteria still remain in LEED 2009 as well as in the new version.

A challenge that LEED faces is to ensure that the wood used in a project is harvested legally and from sustainable sources. Forest certification ensures this. Forest certification helps LEED by ensuring that the wood has been sourced from a sustainably grown and managed asset after due economic, environmental, and social considerations. Combining forest certification in LEED also ensures that wood harvested illegally (outside the USA) will not receive any credits. Although there are several forest certification program active in the USA, Forest Stewardship Council (FSC) is the only one recognized by the USGBC (LEED 2009). Alternative programs are also very adept in promoting responsible and sustainable forestry practices but are not recognized for their efforts by the USGBC. With FSC wood being limited, it is difficult to earn credits for certified wood. Moreover, it is only wood that requires external validation or certification, while other materials in LEED do not (LEED 2009), despite social and environmental impacts associated with other materials (Bowyer 2007, 2008). The new version of LEED is a bit different in its approach toward certification, but FSC-certified wood is still receiving the highest credits in a new tiered point system that allows for a point for a recognized certification.

Life cycle assessment (LCA) is a tool that uses peer-reviewed aggregated data to provide a rational, quantified approach to determining specific environmental impacts of a product or system through its entire life cycle. If done correctly following all the standard protocols, LCA can provide an objective measure for comparing building design alternatives. LCA has all the facets of becoming a valuable asset in assessing the sustainability of green buildings. There is a widely expressed concern regarding a deficiency in green building standards to allocate

points based on life cycle performance of the products. This issue fundamentally emanates from the fact the material selection criteria do not form an important part of rating systems. Materials are most used in buildings and the built environment. Therefore, they have greater environmental implications. To be fully sustainable, strategies need to be designed for materials' reuse and recycling beyond the building service life. Measures are needed to not only divert material out of the landfills but also to reuse in the built environment albeit at a reduced functionality. Most green building programs neglect the beyond service life characteristics of building materials, which is an incongruity. This is, however, being addressed in the newest version of LEED, where the user will have an opportunity to earn more points with a full building LCA.

Architects Dilemma

An architect or material specifier for a project grapples about which material to specify. On one hand you have a sustainable material such as wood, while on the other steel or other structural material can help provide more credits in LEED to get you over the threshold of certification. An architect has no incentive to specify wood over steel or concrete. A prime example for this is the new Kempegowda International Airport in Bengaluru. It is a LEED gold certified airport with miniscule amount of wood used for structural or decorative purposes. It meets LEED gold standard mainly because biofuels are used for ground force vehicles and installed real-time performance monitoring tool. Both are commendable efforts. It leaves a question open—as to how a building can claim to be green without using natural and sustainable materials?

Concluding Remarks

Climate change induced stresses to the built environment, especially buildings are motivating a paradigm shift toward sustainable development. Sustainable development is based on triple with its triple bottom-line, which is—economic optimization, reduction in environmental impacts, and improvement in human well-being. Green building rating systems are stemming from these transformations. Wood by virtue of its performance in the "greenness" evaluation criteria should be a natural fit for green structures. As wood sequesters carbon as it grows, wood products can have low or sometimes negative carbon footprint. Additionally, wood is a renewable resource provided the forest are sustainably managed. Therefore, the utilization of wood, in all aspects of human existence appears to be the most effective way to optimize the use of resources and to reduce the environmental impact associated with activities pertaining to the built environment. The indifference toward wood in the green building standards is an impediment for its

use in green structures. An architect is always faced with this dilemma of why to specify wood when steel or concrete buildings can earn similar level of green building certification? Green building rating systems need categorical improvements in their way of assessing materials. Need of the hour is an integrated approach to design, where along with energy concerns, long-term performance, environmental metrics, and social consideration are duly weighted. Adoption of life cycle approach to design can lead to this proposed integrated approach. This will mean a paradigm shift in processes and policies pertaining to selection of materials and their utilization since it will require manufacturers of various materials to publically divulge information regarding their environmental impacts over the product life cycle in the form of an environmental product declaration (EPD). Many countries and jurisdictions are now mandating and recommending EPDs for all mass-produced building products. As EPD becomes norm, wood should come out as an environmentally strong material when the entire life cycle is accounted for.

References

AWC Technical Report 1 (1961) American Wood Council. Washington D.C, USA

Bowyer JL (2007) The green building programs-are they really green? Forest Prod J 57(9):6–17

Bowyer JL (2008) The green Movement and the forest products industry. Forest Prod J 58(7/8):6–13

Bowyer J, Shmulsky R, Haygreen J (2007) Forest products and wood science—an introduction, 5th edn. Blackwell Publishing, Ames, p 558

Bribian IZ, Capilla AV, Uson AA (2011) Life cycle assessment of building materials: Comparative analysis of energy and environmental impacts and evaluation of the eco-efficiency improvement potential. Build Environ 46:1133–1140

Buchanan AH (2006) Can timber buildings help reduce global CO2 emissions? In Proceedings of world conference on timber engineering. Portland, Oregon, USA

Fell D (2010) Wood in the human environment: restorative properties of wood in the built indoor environment. Dissertation. Submitted to The University of British Columbia. Vancouver, B.C. 132

Garcia T (2011) The global construction industry: what can engineers expect in the coming years? Plumbing Systems and Design. December 2011. 22–25

International Iron and Steel Institution (IISI) (2000) Worldwide LCI database for steel industry products. IISI, Brussels, Belgium

LEED (2009) LEED 2009 for new construction and major renovation. US Green building Council, Washington, D.C., USA

Milani B (2005) Building materials in a green economy: community-based strategies for dematerialization. PhD Dissertation, University of Toronto, Canada

NAHB (2010). National Association of Home Builders

Nyrud AQ, Bringslimark T (2010) Is interior wood use psychologically beneficial? A review of psychological responses towards wood. Wood Fiber Sci 42(2):202–218

PCA (2008) Benchmarks 2008 survey of operating costs. Victorian Shopping Centres, PCA, Sydney, Australia 2008

Puettmann ME, Wilson JB (2005) Life-cycle Analysis of Wood Products: Cradle-to-gate LCI of Residential Wood Building Material. Wood Fiber Sci 37:18–29

Rajendran S, Gambatese JA (2007) Solid waste generation in asphalt and reinforced concrete roadway life cycles. J Infrast Syst 13(2):88–96

Sinha A, Gupta R, Kutnar A (2013) Green Buildings and Sustainable Development. Drvna Indstjia (Wood Industry) 64(1):45–53

Spiegel R, Meadows D (2006) Green building materials—a guide to product selection and specification, 2nd edn. John Wiley and Sons, Virginia, USA

United States Green Building Council (2010) Green Building and LEED core concepts. USGBC Washington DC

van Oss HG, Padovani AC (2002) Cement manufacture and the environment. Part I: chemistry and technology. J Ind Ecol 6(1):89–105

YPFPG (2008) Assessing USGBC's policy options for forest certification & the use of wood and other bio-based materials. A summary report prepared by the Yale Program on Forest Policy and Governance February 25, 2008