Original Research Article

Environmental performance analysis of green building materials based on life cycle assessment

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Abstract: With the deepening of the concept of sustainable development, the application of green building materials in the field of construction is increasingly extensive. Based on the life cycle assessment (LCA) method, this paper analyzes the environmental performance of green building materials. First, the basic concept and framework of LCA are expounded, which lays a theoretical foundation for the subsequent research. Then, the environmental impact factors of green building materials in various life cycle stages are analyzed in detail, including raw material acquisition, production, use process and waste treatment. By comparing the environmental performance of different green building materials, the advantages and existing problems are revealed. The results of the study help the construction industry to further optimize the selection and application of green building materials to achieve sustainable development of buildings.

Keywords: Green building materials; Life cycle assessment; Environmental performance; Sustainable development; Building industry

With the global attention to sustainable development, the environmental performance evaluation of green building materials has become the focus of the construction industry. Life Cycle Assessment (LCA), as a scientific tool, can comprehensively quantify the environmental impact of building materials from raw material extraction, manufacturing, transportation and installation to use and scrap. This approach not only helps to identify major sources of environmental burden throughout the life cycle of building materials, but also provides data support for optimal design and material selection. Through in-depth analysis of key indicators such as carbon emissions, resource consumption and pollutant release of green building materials, its environmental friendliness can be more accurately assessed, so as to promote the transformation of the construction industry to the direction of low-carbon environmental protection. This is not only significant for reducing the ecological footprint of the construction industry, but also provides an important support for achieving the national "dual carbon" goal.

1. Overview of green building materials and life cycle evaluation

Life Cycle assessment (LCA) is a tool to assess the environmental impact of a product, process or activity throughout its life cycle, from raw material acquisition to final disposal. The framework consists of four main stages: objective and scope definition, inventory analysis, impact assessment and result interpretation. The objective and scope define the research object, functional unit and system boundary. Inventory analysis is the data collection and quantification of inputs and outputs in each stage of the product life cycle. Impact assessment classifies, characterizes and quantifies environmental impacts according to the results of inventory analysis. The result interpretation is to analyze and discuss the whole evaluation result and put forward suggestions for improvement.

2. Environmental factors affecting the life cycle of green building materials at all stages

2.1. Raw material acquisition stage

In the raw material acquisition stage of green building materials, there are many environmental factors. For natural materials such as wood, excessive logging will lead to the reduction of forest resources, destroy the ecological balance and affect biodiversity. While green building materials emphasize the use of renewable resources, they can also have negative effects if renewable resources are acquired faster than they can be regenerated. For example, the large collection of certain bamboo materials may affect the ecosystem of the bamboo forest, the soil fertility and the habitat of surrounding organisms. The mining process of raw materials may produce a lot of waste and pollutants, such as waste slag and dust in stone mining, which will pollute the surrounding environment[1].

2.2. Manufacturing stage

The manufacturing stage is the key link of the environmental impact of green building materials. At this stage, energy consumption and pollutant emissions are the main environmental impact factors. For example, the production process of cement needs to consume a lot of coal and other energy resources, and will release carbon dioxide, sulfur dioxide and other greenhouse gases and pollutants, causing serious pollution to the atmosphere. Even some building materials that are considered green, such as new insulation materials, may produce some harmful chemicals, such as volatile organic compounds (VOCs), if chemical synthesis processes are used in the production process, which have an impact on indoor air quality and the surrounding environment[2].

2.3. Use process stage

The environmental impact of green building materials in the process of use is mainly reflected in the energy efficiency and the impact on indoor environmental quality. Some green building materials with good thermal insulation performance can reduce the energy consumption of buildings during use, thereby reducing the pressure on the environment. For example, efficient exterior insulation materials can reduce the loss of indoor heat in winter and the introduction of outdoor heat in summer, reducing the energy demand for heating and cooling. However, if green building materials contain harmful substances, such as formaldehyde, they will be gradually released into the indoor environment during use, affecting the health of the occupants, which is contrary to the original intention of green building materials.

3. Comparison of environmental performance of different green building materials

3.1. Wood materials and inorganic materials

Wood material is a common green building material, it has the advantages of renewable, degradable and so on. In life cycle assessment, wood materials can be sustainably harvested with relatively little impact on the environment if properly managed at the raw material acquisition stage. In the process of use, wood materials have good thermal insulation performance, which can reduce the energy consumption of buildings. However, wood materials are susceptible to moisture and decay, requiring anti-corrosion treatment, and some chemical agents may be used in the anti-corrosion treatment process, which may have a certain impact on the environment. Inorganic materials such as ceramics, glass, etc., most of their raw materials come from natural minerals, which will cause certain damage to land and water resources during the mining process. In the production process, the

firing of inorganic materials requires a large amount of energy and produces greenhouse gas emissions. However, inorganic materials have the advantages of good durability and not easy to burn, and have better applications in some special building environments[3].

3.2. New green materials and traditional building materials

New green materials such as solar photovoltaic materials, which can convert solar energy into electricity during use, provide clean energy for buildings, reduce dependence on traditional energy sources, and have great advantages in environmental performance. In the production process, although the current production energy consumption of solar photovoltaic materials is high, but with the continuous progress of technology, the environmental impact of the production process is expected to continue to reduce. Traditional building materials such as ordinary concrete, in terms of raw material acquisition, need a lot of non-renewable resources such as sand and stone, high energy consumption and pollution in the production process. In the process of use, the thermal insulation performance of concrete is poor, and additional thermal insulation measures are required, which also increases the energy consumption of the building[4].

3.3. Natural fiber composites and synthetic fiber composites

Natural fiber composite material is made of natural fiber such as hemp fiber, cotton fiber, etc. as reinforcement material, and matrix material. This material has the advantage of being renewable in terms of raw material acquisition and can degrade naturally during the waste treatment stage. In the production process, the energy consumption of natural fiber composites is relatively low. However, the mechanical properties of natural fiber composites are relatively poor, and their application is limited in some building parts with high structural strength requirements. Synthetic fiber composites have high mechanical properties and can meet the requirements of building structures, but most synthetic fibers come from non-renewable resources such as oil, which will produce a lot of pollutants in the production process, and it is difficult to degrade in the waste treatment stage, causing long-term pollution to the environment.

4. The strategy of environmental performance improvement of green building materials

4.1. Raw material management strategy

In order to improve the environmental performance of green building materials, a number of strategies need to be adopted in the management of raw materials. For renewable raw materials, scientific harvesting or collection plans should be established to ensure that the rate of regeneration is greater than the rate of acquisition. For example, for bamboo forest resources, a reasonable cutting plan should be formulated according to the growth cycle of bamboo, and the cultivation and management of bamboo forest should be strengthened to improve the quality and yield of bamboo forest. For non-renewable raw materials, the utilization rate should be increased as much as possible to reduce waste. For example, in the stone mining process, by optimizing the mining process, improve the stone yield and reduce the generation of waste slag[5].

4.2. Production process improvement

Improving the production process is the key to improve the environmental performance of green building materials. In the production process, we should actively promote the use of clean energy, such as solar energy, wind energy, etc., to reduce the dependence on traditional fossil energy. For example, some cement manufacturers

are trying to use solar energy to preheat and reduce energy consumption in the production process. Low pollution and low emission production processes should be developed and adopted to reduce the generation of pollutants. For example, in the production of insulation materials, a solvent-free production process is used to reduce volatile organic compounds (VOCs) emissions.

5. Conclusion

The environmental performance analysis of green building materials is an important link to realize the sustainable development of buildings. Based on the method of life cycle assessment, we can comprehensively understand the environmental impact factors of green building materials in each stage. By comparing the environmental performance of different green building materials, the advantages and disadvantages of them are found, so as to provide scientific basis for the selection and application of building materials. In the future, with the implementation of various strategies and the development of technologies, the environmental performance of green building materials will continue to be optimized and play a greater role in the construction field. We should also continue to improve the life cycle assessment system, so that it can better serve the research and development of green building materials, and promote the development of the entire construction industry towards a more green and sustainable direction.

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