Taiwan Green Building Material and its Applications to Eco-City in Subtropical Zone

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Abstract

The Green Building Material (GBM) Labeling System of Taiwan proposed by the Architecture and Building Research Institute was officially launched in 2004 to systematically and effectively evaluate the performance of green building materials (Chiang 2004). The connotation of the GBM Label is mainly to enhance the built environment and to provide the actual benefit toward the concept of human health and earth sustainability. The system carries out quantitative assessments and laboratory tests based on a variety of measures in different stages of the life cycle of a building. Its criteria and standards are established accommodating with the subtropical climatic condition. In addition, the regulation of at least 30% mandatory green building material utilization has also been involved into Taiwan's Building Code and become effective since July 2009.

The GBM system covers four major aspects, including Health, Ecology, Recycling, and High-performance (ABRI, 2007a). The Healthy GBM for improving the indoor environmental quality requires low emission, odor free, and no asbestos. The Ecological GBM typically includes low toxicity processing and natural materials without shortage crisis. The Recycling GBM aims to reduce wastes and to reuse abandoned materials and recycling aggregates. As for High-performance, it basically refers to the materials with high permeability and high noise insulation. By the end of July 2009, 245 Labels have been conferred covering 1997 green products. Among these products, the healthy material occupies 76.93%, and followed by the high-performance category 14.53%, recycling 8.11%, and ecological 0.43%. The percentage distribution indicates the health issue has been highly emphasized and points out the development trend of the building

material market in Taiwan. The latest statistics and relevant studies also show that the GBM Labeling System is well coordinated with the current local sustainable building evaluation practices and can be further applied to the development of the eco-community and eco-city in subtropical zone.

Keywords

Green Building Material, Life Cycle Assessment, Eco-city

1. Introduction

Green building material is one of the basic elements of a sustainable building. The serious energy and natural resources shortage that our living environment is currently facing shows an imperious demand on developing a better building material certification and management mechanism. Followed by the promotion of green building evaluation and labeling more than a decade, the Architecture and Building Research Institute (ABRI) of Taiwan proposed the Green Building Material (GBM) Labeling system in 2003 and officially launched in 2004, shown in figure 1. The system aimed to promote a sustainable built environment for the earth and a healthier living quality for human beings. It was established based on ISO15686 series, ISO21930 series,ISO14040 series, as well as the Integrated Building Performance (IBP) system proposed by the EU, to ensure the evaluation criteria and standards meeting the current development trend of the world. Both of the global and local environmental issues, such as anticipated exhaustion of fossil fuels, increasing and fluctuated energy prices (Meadows et al., 2006), environmental pollution problems, high dependency on imported resources, high temperature and high humidity, a large amount of CO_2 emission from the building industry, as well as over 10 million-ton construction wastes generated annually, must also be taken into consideration to develop a comprehensive assessment tool for green building materials. In general, the assessment of green building materials begins with establishing criteria for evaluating the environmental performance of building materials. The criteria may incorporate low toxicity, minimal emissions, low-VOC assembly, recycled content,resource efficiency, recyclable and reusable materials, energy efficiency, water conservation, IAQ improvement, locally products, etc (Froeschle, 1999). The GBM evaluation system of Taiwan systematically comprises of four categories, including health, ecology, recycling, and high-performance. Its assessment mainly adopts the life cycle assessment approach, covering four stages of the life cycle

of a building: resource exploitation, production, usage, and disposal and recycling.

Fig. 1 - Taiwan green building material label.

Among the above categories, healthy green building material is the major promotional emphasis in the system. With extensive material usage of indoor decoration and remodeling for housing, the formaldehyde(HCHO) in building materials and volatile organic compounds(VOCs) emitted in a warm environment can result in fairly high risk to be harmful to health (Shao et al,2003). According to relevant research results (Wu et al., 2003), the risk values of carcinogens such as the formaldehyde in building materials and VOCs in office spaces in Taiwan are 100 to 1,000 folds over the WHO standard, causing people to suffer from respiratory and skin diseases. With respect to the relationship between the GBM labeling system and the current EEWH green building evaluation system in Taiwan, analyzed as table 1, the GBM system can typically contribute to a healthier indoor environmental quality. The issues of indoor air quality (IAQ) (Wolkoff 1998), indoor environmental quality (IEQ), and indoor environmental health (IEH) have been addressed and being further studied. From the perspective of the "Architecture Doctor (AD)" concept, now researchers and experts would diagnose causes of IEQ problems and prescribe recipes, for instance, strategies of green building and green building material application. The GBM labeling system can thus provide for architects or designers with proper measures that are capable of accommodating local climatic conditions and meeting people's health needs. For ecology, recycling, and high-performance, the GBM evaluation items can also effectively correspond to green building evaluation indicators and feed back to green building design.

Since July 2006, the mandatory green building material utilization has been involved into Taiwan's building code. For indoor decoration and floor materials in buildings, green building materials shall cover at least 30% of the total indoor decoration and floor material uses. Fulfilling the requirements of ecological, recycling, healthy, and high-performance attributes, the green building material regulation may effectively reduce environmental impacts and improve the IEQ, so as to gradually achieve "human

health and global sustainability."

Table 1 Relationship between Taiwan's Green Building Evaluation and Green Building Material Application

Green Building Rating System EEWH		Green Building Material
Category	Evaluation Indicators	Applications
Ecology	Bio-diversity	--
	Greenery	--
	Water Soil Content	High-performance GBM (permeability),
	(Water infiltration and retention)	Ecological GBM, Recycled GBM
Energy Saving	Energy conservation	High-performance GBM (energy saving)
Waste	CO2 emission reduction	Ecological GBM, Recycled GBM
Reduction	Construction waste reduction	Ecological GBM, Recycled GBM
Health	Indoor environment	Healthy GBM, Ecological GBM, Recycled GBM, High-performance GBM (sound insulation)
	Water conservation	High-performance GBM
	Sewage and garbage improvement	--

2. Evaluation system, implementation and management

The major purposes of the GBM labeling system can be described in three aspects: 1) promotion of high-quality and healthy life; 2) protection of ecological environment; and 3) enhancement of industry competition ability. The system focuses on the entire building quality and effective management and control of human health risk factors. Its general requirement includes basic environmental protection aspects, such as no asbestos, no heavy metal, no radioactivity, etc. The evaluation system consisting of four categories is illustrated as figure 2 and described as follows:

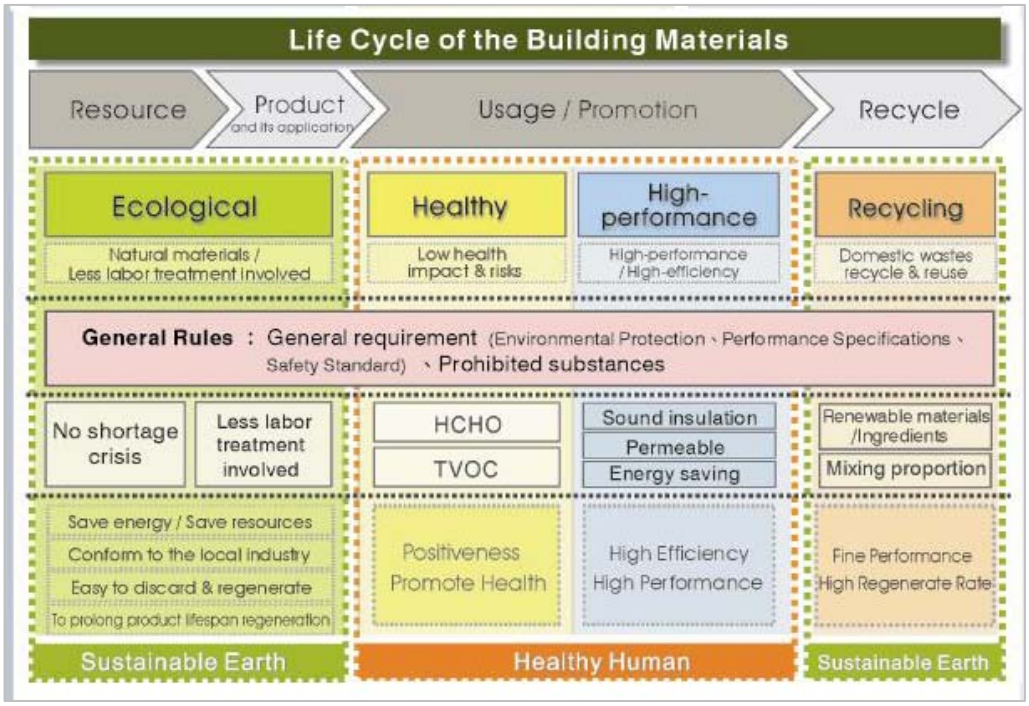

Fig. 2 - Framework of Taiwan green building material evaluation system.

Ecological GBM:

What is taken from nature shall be used in nature. The Ecological GBM is that, during its life cycle, the building material fulfills general requirements, uses natural materials (Berge 2001) without shortage crisis, consumes minimal resources and energy, requires less labor treatment, or possesses recycled characteristics after disposal. The goal is to promote the natural building material that is good for both the environment and human health. For example, ecological wooden structure materials shall come from the forest with sustainable management. The assessment includes the certificate of FSC (Forest Stewardship Council), PEFC (Programme for the Endorsement of Forest Certification schemes), or other certificates of origin, shown as figure 3.

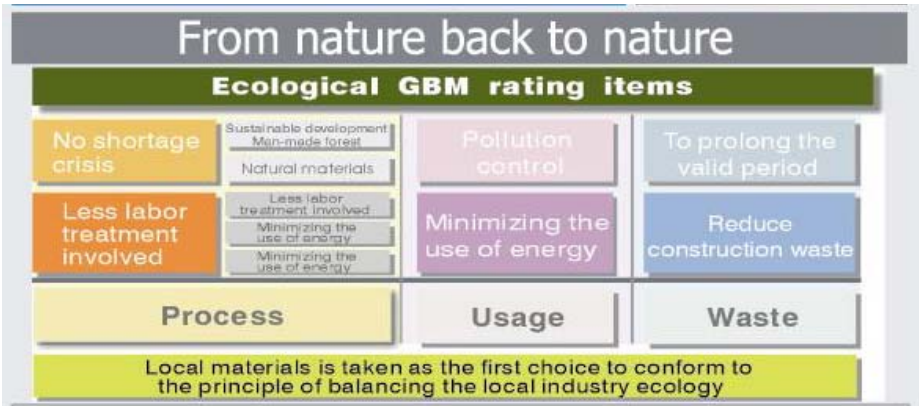

Fig. 3 - Evaluation of ecological green building material.

Healthy GBM:

Since formaldehyde contained in building materials, and VOCS added during the production of indoor construction materials, application and glue preparation, under the climate condition of high temperature and humidity, harmful chemical substances may be emitted in the air and directly affect human health and indoor environmental quality (Chen et al. 2006). Thus, the system focuses on the management and control of the relevant hazards. The test is based on ISO16000, and the standard is HCHO is less than 0.08 mg / m2˙hr and TVOC less than 0.19 mg / m^2 ˙hr, shown as figure 4.

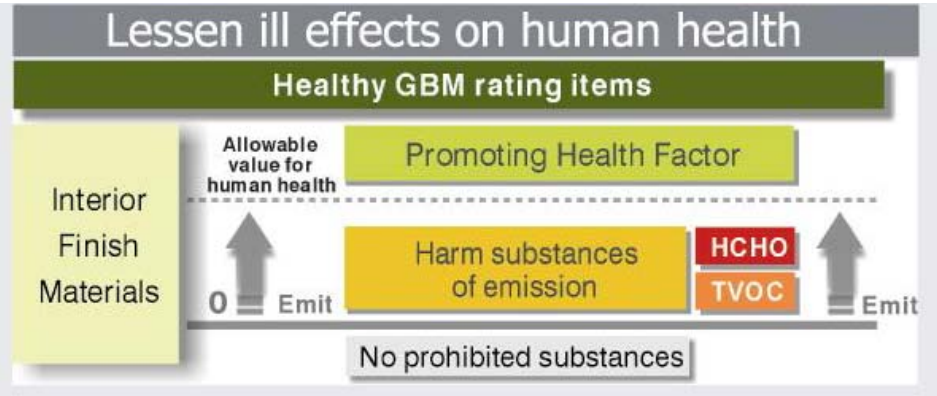

Fig. 4 - Evaluation of healthy green building material.

High-performance GBM:

In response to the green building design issues, such as building environment noise, poor ground water retention, glazed curtain wall causing energy consumption, and the problem of dazzling sunlight, the environmental performance of a building material should be concerned and involved. By improving building materials to resolve the problems and increase efficiency, the system intends to promote building quality and standard of the living environment (noise insulation, permeability, etc), and also reduce entire energy consumption, which is in the scope of high performance green building material. The assessment includes ISO717-1, ISO717-2, ISO11654, and the test follows ISO140-3, ISO140-8, ISO354, and ISO9050, shown as figure 5. The approach also presents the harmonization with the ISO standards in Taiwan's GBM system, shown as figure 5.

Fig. 5 - Evaluation of high-performance green building material.

Recycling GBM:

In order to reduce construction waste, and to reuse and recycle the materials, the system focuses on the regeneration of green building materials, in order to ensure basic functional demand, and improve reuse rate of waste materials, in order to achieve a sustainable society, which is in the scope of recycled green building materials. The assessment includes the types of recycled materials, their sources, and recycled content percentage, and its test is based on the ISO and Taiwan's CNS standards, shown as figure 6.

Fig. 6 - Evaluation of recycling green building material.

For the practical operation of the GBM labeling system, the testing departments are national grade laboratories passing TAF accreditation. The factory owners of building materials can file the application and supply test data with TAF certification, proofs of production, ingredient and quality control, and registration document of its legality. Through the review by the GBM Labeling Review Committee, suggestions of approval or rejection are given. For those who pass and obtain the green building material label conferred by the Architecture and Building Research Institute, the label is valid for 2 years and renewable. In terms of post-market management mechanism of green building material labeling, non-scheduled spot checks are implemented to ensure the use of the GBM labeling and the quality of green building materials.

3. Evaluation results and market trend analysis

By the end of July, 2009, 245 Labels have been conferred covering 1,997 green products. Among these products, the healthy material occupies 76.93%, and followed by the high-performance category14.53%, recycling 8.11%, and ecological 0.43%, shown in figure 7. The percentage distribution indicates the health issue has been highly emphasized and points out the development trend of the building material market in Taiwan. For a non-toxic and healthy architectural environment, as well as sound-proof and permeable function of building materials, there are 1,997 green building material products, including 92 wooden floors, 208 wooden boards, 43 organic boards, 12 absorbent material systems, 1 floating floor, 155 compressed concrete paving units, 27 high pressure concrete ground bricks, 230 permeable bricks, 73 ceramic face bricks, 258 inorganic boards, 2 crack fillings, 3 aggregates, 3 energy saving glass, 650 building decoration paints, 23 soundproof door, window and wall systems, 7 tile glue, 3 floor coverings, 3 adhesive and 204 healthy PVC products. Mostly, paints ranked the highest, followed by permeable bricks, as well as wooden boards and gypsum wallboards.

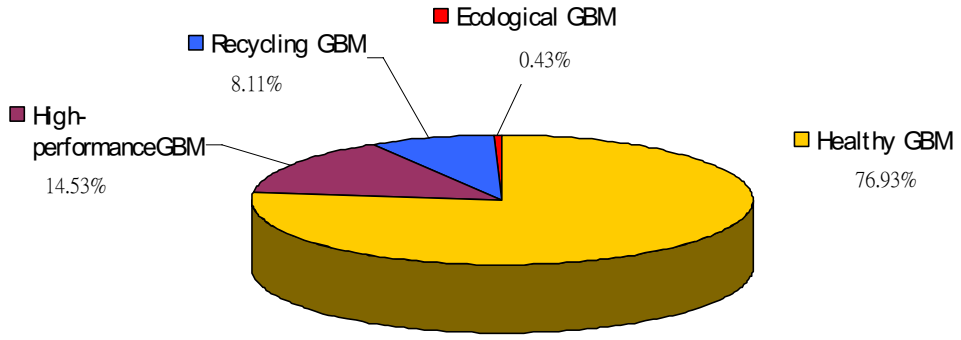

Fig. 7 - Percentage of four categories of GBM labeling promotion.

Currently, the ratio of new and existing buildings is 3% to 97% in Taiwan. Using green building materials and green technology to improve indoor environmental quality and architectural environment, people can renew, reuse and prolong the life cycle and value of old buildings. Meanwhile, interdisciplinary integration of architecture, medicine, ecology, interior design and material technology transform traditional construction into a sustainable and circulating industry. Starting from energy saving and resource efficiency by combining an ecological circulatory system, corresponding local environment, community civilization, as well as historic and regional features, the GBM system creates a core concept of sustainable built environment in Taiwan.

4. Applications to eco-city in the subtropical zone

Long-term research results indicated that the Taiwan green building material evaluation standard should be based on its local environmental condition in the subtropical and tropical zone, which is applicable to the climate of high temperature and humidity. The GBM system also should be able to be applied to green building design and IEQ improvement. Building materials that meet the standards of the GBM labeling system may be used in various green building evaluation indicators. For example, indoor building material construction evaluation and sound environment evaluation among indoor environment indicators encourage the use of all of healthy green building material, ecological green building material, recycled green building material, and high performance soundproof green building materials. Specifically, preferential credits are adopted in the green building rating system to reward ecological green building material uses. In addition, soil water content indicators may choose high performance permeable green building pavement materials to increase water retention and storage. It is to alleviate the effect of urban heat island effect and reduce the capacity of a public drainage facility, as well as the occurrence of city flooding. The recycled green building materials meet the demand of CO_2 and waste reduction indicators. It can reduce the environmental burden caused by waste accumulation and the expenditure resulting from new resource development. High performance energy-saving glasses may respond to the daily energy-saving indicator for reducing energy consumption. The application of Taiwan's GBM Labeling System on sustainable buildings in the subtropical zone focuses on the evaluation of chemical and physical building material evaluation. In response to the climate of high temperature and humidity, biological factors are added into items of evaluation (Wu et al, 2005). In a continuing effort of research and national policy, emphasis is on the eco-city in tropical zone. From green building materials, green construction, eco-community, and, furthermore, eco-city, a complete circle has been constructed to build a healthy and efficient sustainable homeland. The promotion experiences of green building materials and green building technology can be expanded to the living environment of countries in the subtropical/tropical zone and responded to the theme of the 2009 Conference on Green Building Towards Eco-City: **"Cross-Disciplinary Solutions, Successful Practices, Community Actions, Joint Efforts, and Creative Ideas"**

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6. Presentation of Author

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