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Taiwan Green Building Material Labeling System and its Sound Insulating Assessment

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ABSTRACT

The serious energy and natural resource shortage that our living environment is currently facing shows a strong demand to develop a better building material certification and management mechanism. Following a twelve-year green building material evaluation and labelling research program which started around 1998, the Architecture and Building Research Institute (ABRI) of Taiwan proposed the Green Building Material (GBM) Labeling system in 2003 and was officially launched in 2004. The GBM system aims to promote a sustainable built environment for the Earth and a healthier living quality for human beings. It was established based on the ISO15686 series, ISO21930 series, ISO14040 series, as well as the Integrated Building Performance (IBP) system proposed by the EU to ensure that the evaluation criteria and standards meet the current development trends of the world.The Taiwan GBM evaluation system incorporates low toxicity, minimal emissions, low-VOC during assembly, recycled content, resource efficiency, recyclable and reusable materials, energy efficiency, water conservation, IAQ improvement, and use of locally products, among others (Froeschle, 1999). The criteria are systematically comprised of four categories, including health, ecology, high-performance and recycling. The 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.This paper shows the sound insulating assessment as for High-performance GBM, it incorporates the well sound insulating materials, well energy saving glass and well permeable materials.By the end of April 2010, 323 Labels have been conferred covering 3000 green products. Among these products, the high-performance category occupies 14.53% (the well sound insulating materials occupies 2%) and the healthy material occupies 76.93%, followed by recycling 8.11% and ecological 0.43%. The percentage distribution indicates that the well sound insulating materials have been needed but the health issue has been highly emphasized and points out the development trend of the building material market in Taiwan. 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.

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.

Figure 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."

Table11. 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)
		High-performance GBM
	Water conservation	--
	Sewage and garbage improvement	

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:

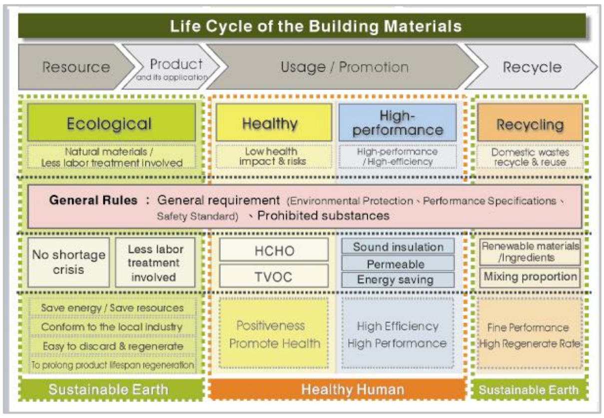

Figure 2. Framework of Taiwan green building material evaluation system.

Upholding "Humanistic Health; Earth Sustainability", the goal of "Green Building Material Label" is to facilitate "human health", maintain the "ecological environment", and enhance "industrial competitiveness." Four scopes are covered in terms of "building lifecycle", including: "resource acquisition, manufacture, use, and waste regeneration."

1.Ecolgical GBM- low risk to human health.

2.Healthy GBM- no risk of shortage and low manual processing requirement.

3.High-Performance GBM- high efficiency and high quality.

4.Recycling GBM- reutilized from domestic waste.

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.

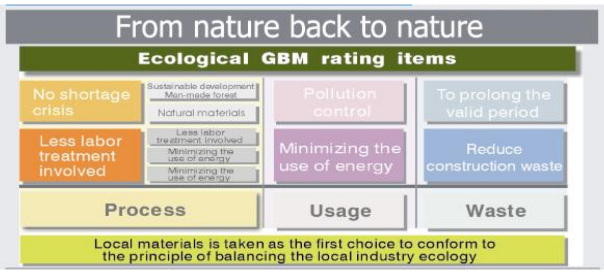

Figure 3. Evaluation of ecological green building material

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 / $m^2 \cdot hr$ and TVOC less than 0.19 mg / $m^2 \cdot hr$, shown as figure 4.

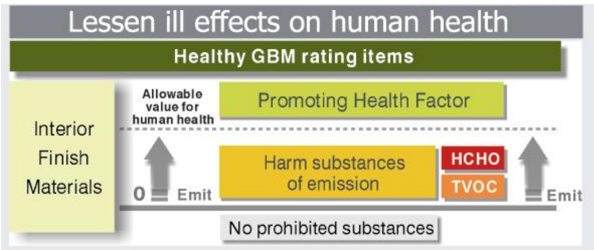

Figure 4. Evaluation of healthy green building material

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.

Figure 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.

Figure 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.

EVALUATION RESULTS AND MARKET TREND ANALYSIS

By the end of April 2010, 323 Labels have been conferred covering 3000 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.

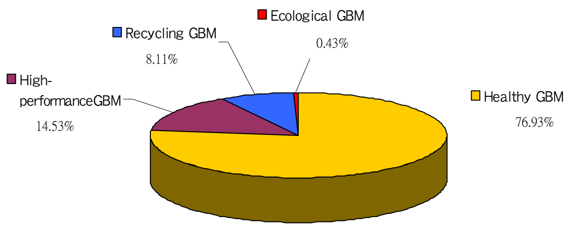

Figure 7. Percentage of four categories of GBM labeling promotion.

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.

SOUND PREVENTING ASSESSMENT

The high-performance sound preventing GBM refer to the building materials and the building material modules which can effectively prevent the noise that affect our life. "Sound Prevention" is usually through the three methods: " Sound insulation ", "Sound absorption " and " Anti-vibration " to achieve. According to the different construction parts, we shall choose suitable sound insulating GBM to reach the sound preventing requirement.

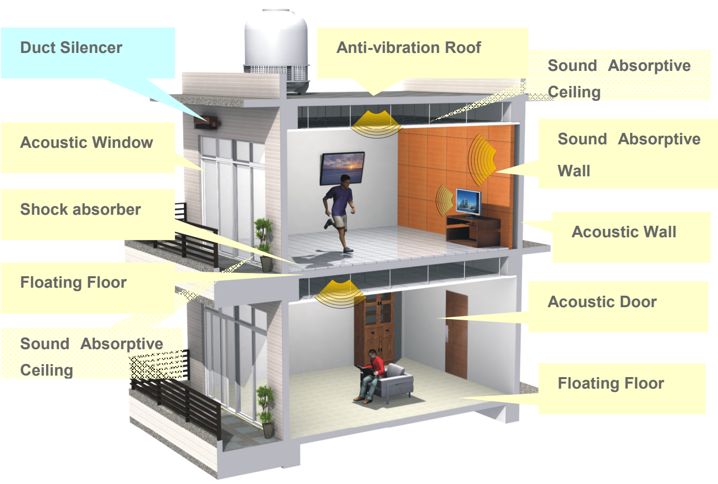

Figure 8. Room & building acoustic

Assessment Items

The high-performance sound preventing GBM assessment items are according to the noise source,and the floor impact sound norms is in the context of sound-insulated category of the system at present.

Table 2. Sound Prevention Rating & Criteria

Item	Criteria	Testing method	Assessment method
Wall and roofing	Rw≧50dB	ISO140-3	ISO717-1
Window	Rw≧35dB	ISO140-3	ISO717-1
Door	Rw≧35dB	ISO140-3	ISO717-1
Shock absorber	ΔLw≧15dB	ISO140-8	ISO717-2
Sound absorber	αw≧0.8	ISO354	ISO11654

1. Sound Insulation Rating & Criteria

(1) Wall and Roof：According to ISO140-3 Acoustics -- Measurement of sound insulation in buildings and of building elements - Part 3: Laboratory measurements of airborne sound insulation of building elements，and ISO 717-1 Acoustics -- Rating of sound insulation in buildings and of building elements - Part 1: Airborne sound insulation,Rw≧50dB。

(2) Window：According to ISO140-3 and ISO 717-1,Rw≧35dB。

(3) Door：According to ISO140-3 and ISO 717-1,Rw≧35dB。

(4) Shock absorber：According to ISO140-8 Acoustics Measurement of sound insulation in buildings and building elements. Laboratory measurements of the reduction of transmitted impact noise by floor coverings on a heavyweight standard floor and ISO 717-2, Δ Lw≧15dB。(figure 9)

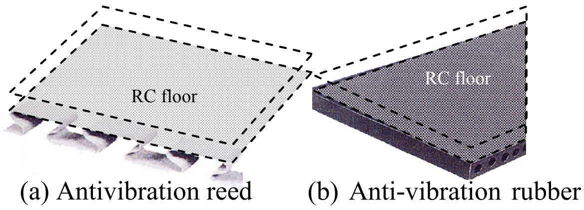

Figure 9. Shock absorber.

(1) Airborne Sound Insulation

Airborne Sound Insulation ''Rw''： Rw＝○○dB， According to ISO717-1 the standard Rw curve (Frequency 125Hz to 2000Hz(1/1 Octave;figure 10)or Frequency 100Hz to 3150Hz(1/3 Octave;figure 11)。

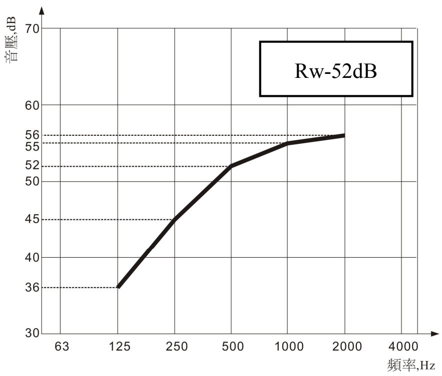

Figure 10.Rw curve (1/1 Octave)

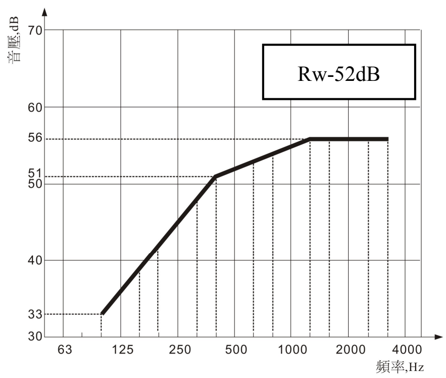

Figure 11.Rw curve (1/3 Octave)

（2）Vibration impact sound Sound Insulation

Shock absorber Sound Insulation“Lw” △ Lw = ○ ○ dB. According to ISO717-2 the standard Rw curve (Frequency 125Hz to 2000Hz(1/1 Octave;figure 12) or Frequency 100Hz to 3150Hz (1/3 Octave;figure 13), Decrease Lw =△Lw。

The Shock absorber material must be the union of material module, so that to consider the livability, including the pressure resistance performance, the waterproof performance, the fire protection performance, the lasting quality and so on, is not only the packing material that can decrease the vibration impact sound.

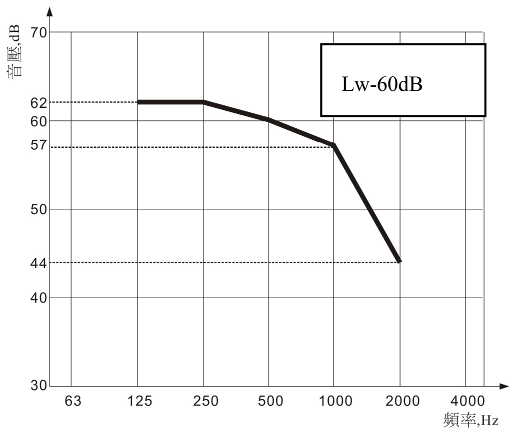

Figure 12.Lw curve (1/1 Octave)

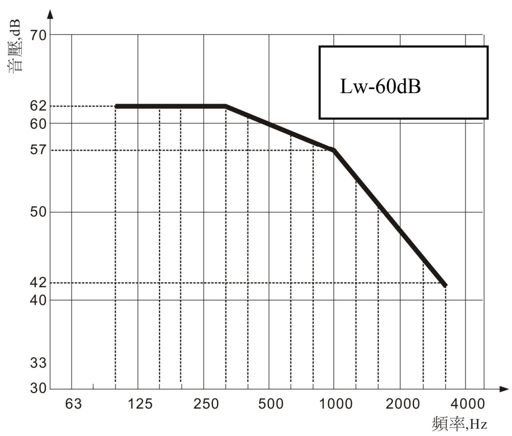

Figure 13.Lw curve (1/3 Octave)

2. Sound absorption Rating & Criteria

According to ISO 354 Acoustics -- Measurement of sound absorption in a reverberation room,and ISO 11654 Acoustics -- Measurement of sound absorption in a reverberation room “αw” (Weighted sound absorption coefficient) ≧0.8。

■ Acoustic absorptivity＝1-r, r=Ratio of the reflection sound

Test Method

To carry on the experiment in the same laboratory, reverberation time of sound absorptive materials is measured by using fixed sound source. Sound absorption coefficient of each frequency is calculated according to Sabine's equation. Based on αw curve appraisal in ISO11654, αw curve at frequency 250Hz to 4000Hz must be higher than αw curve in ISO11654.

Because the sound absorptive materials are different thickness of Air Layer, this will make different on sound absorption coefficient. Therefore, application of high performance green materials must be marked with minimum thickness of air layer, and the higher αw value shows the better absorptive ability of the material.

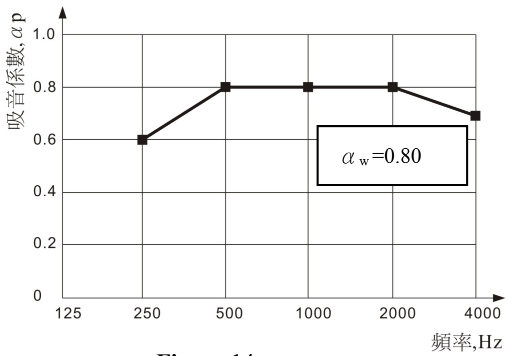

Figure 14.αW curve

CONCLUSION

By the end of April 2010, 323 Labels have been conferred covering 3000 green products. Among these products, the high-performance category occupies 14.53% (the well sound insulating materials occupies 2%) and the healthy material occupies 76.93%, followed by recycling 8.11% and ecological 0.43%. The percentage distribution indicates that the well sound insulating materials have been needed but the health issue has been highly emphasized and points out the development trend of the building material market in Taiwan.

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 2010 International Congress on Acoustics : “Sustainability in Acoustics” .

REFERENCES

1. Architecture and Building Research Institute (ABRI), *2007a ,Evaluation Manual for Green Building Material (2007 New Edition)*.
2. Architecture and Building Research Institute (ABRI), *2007b ,Evaluation Manual for Green Building in Taiwan (2007 New Edition)*.
3. Chiang C.M., Chen J.L., Tzeng P.C., 2004, *A study on the green building material label system in Taiwan*,2004 Sustainable Building Conference in Malaysia.
4. Meadows D., Rander J., Meadows D., 2006, *Limits to Growth: The 30-Year Update*.
6. Wu P.C., Li Y.Y., Lee C.C., Chiang C.M., Su H.J., 2003, R*isk Assessment of Formaldehyde at Typical Office Buildings in Taiwan,* 《*Indoor Air*》 Vol.13,No.4, pp.359-363.
7. Wolkoff P., 1998, *Impact Of Air Velocity, Temperature, Humidity, And Air On Long-Term VOC Emission From Building Products, Atmospheric Environment*, Vol. 32, No. 14/15, pp. 2659-2668.
8. Berge Bjorn, (translated from Norwegian by Filip Henley with Howard Liddell_, 2001, *The Ecology of Buildings Materials,* Great Britain: Reed Educational and Professional Publishing Ltd.
9. Chen C.C., Chiang C.M., Shao W.C., 2006, *A Study on VOCs Emitted Characteristics of Air Exchange Effect*

from Building Materials in Local Climate of Taiwan– Plywood and Varnish for Example, 2006 Healthy Buildings Conference in Lisbon (HB2006), Lisbon, Portugal.
10.Froeschle L.M., 1999, *Environmental Assessment and Specification of Green Building Materials*, the Construction Specifier, pp.53-56.
13.Wu P.C., Li Y.Y., Lee C.C., Li F.C., Huang C.Y., Chiang C.M., Su H.J., 2005, *Changing microbial concentrations associated with ventilation performance in Taiwan's air-conditioned office buildings, 《Indoor Air》*, Vo15., No.3-1, pp.19-26.
14. M.Chin,Ho,J.L,Chen, C.M,Chiang, C.Yu,Chiu, J.T,Yau, T.T,Hsieh(2008) *Taiwan green building material labeling system and its applications to sustainable building in subtropical zone*.World sustainable building conference SB08 (p44),Australia.