# CHAPTER 2

# LITERATURE REVIEW

## 2.1 What Are Green Building Materials

Green building materials are those that use the Earths resources in an environmentally responsible way. Green building materials respect the limitations of non-renewable resources such as coal and metal ores. They work within the pattern of natures cycles and the interrelationships of ecosystems. Green building materials are nontoxic. They are made from recycle materials and are themselves recyclable. They are energy-efficient and water efficient. They are green in the way they are manufactured, the way they are used and the way they are reclaimed after use. Green building materials are those that earn high marks for resource management, impact on indoor environment quality (IEQ) and performance

While people may recognize that the term green means "environmentally friendly," most have several misperceptions about how environmentally friendly products perform relative to the standard, more familiar products. It is politically correct to express concern for the environment. Paradoxically, it is equally acceptable to express apprehension at implementing green approaches rather than standard approaches.

The correlating education and support network that would enable people to respond actively and positively to the environmental warnings

is still forming Partial information, outdated information and misinformation plague the successful development of green building. The majority of building owners, designers, engineers, contractors, manufacturers and building officials are receptive to protecting the environment but are not receptive to using green materials to accomplish the task. The unfortunate perception is that green building materials look bad, cost a lot and do not perform well. Understanding this perceptive is essential for effectively resolving such concerns. Therefore, in order to better understand what green building materials are, it is necessary to clarify what they are not. It is important to get rid of the pervasive misperceptions about green building materials. (Spigel and Meadows, 2010)

## 2.2 Why Use Green Building Materials

Using green building materials can help divert indoor air quality (IAQ) liability claims, respond to consumer demand and provide for compliance with certain regulatory requirements. Liability concerns regarding healthy buildings and healthy sites are rising in proportion to our growing understanding of the potential hazards associated with certain materials. Asbestos and lead are classic examples. Green building products, especially those fabricated from non-toxic, natural and organic materials can reduce IAQ contaminants and the accompanying complaints and claims.

Consumer demand for healthy buildings and for energy efficient structures also drives manufacturers and designers to explore options for green products. Meeting consumer demand is good business. Failure to meet consumer expectations is likely to remind about the liability concerns.

Altruism, however, is the most frequently cited reason to use green building materials. As custodians of the built environment, daily decisions that make with respect to product selection have a ripple effect on the natural environment that merits a significant level of profe ssional care. Selection of materials used in buildings impacts the Earth directly and indirectly. The building industry is a major consumer of raw materials. Obviously, the type and quantity of raw materials that are extracted and how they are processed co nstitute the direct impact. Which materials are selected also affects how the building occupants use the building.

By obligating occupants, neighbors and the community to use buildings in certain way, the selection of building materials constitutes to indirect impact. For example, a building uses a membrane roofing system, the installation is likely to involve the release of solvents in the air. If the membrane is black, it is likely to have a negative impact on the energy demands of the building of the building and of the adjacent structures because of the albedo (the reflected heat that raises temperatures in the microclimate). If it is a single-ply membrane system, it is likely to be fabricated entirely from synthetic chemicals and virgin

materials rather than recycled materials. Single-ply systems, especially adhered systems, make future disassembly and recycling unfeasible.

Altruism is certainly the most laudable reason to use green building products. Self interest, however, is generally the most compelling. Using green building materials can satisfy some very self-interested motives: deflection of liability, economic gain and simple regulatory compliance. Self interested motives beautifully illustrate the relative worth of an ounce of prevention and a pound of cure. (Spigel and Meadows, 2010)

## 2.3 The Construction Processes

According to Spigel and Meadows (2010), they stated that every building construction project, green or not, goes through several phases, beginning with the planning phase and concluding with the post construction phase. The bidding and construction phases are where the rubber meets the road for the buildings design professionals. By examining the process of bidding and construction, the actions required to ensure the successful incorporation of green building materials into a project.

### 2.3.1 The Bidding Phase

Using the construction documents prepared by the design professional during the preceding phase, the owner solicits construction bids either by advertisement, in the case of public projects or by invitation in the case of private projects.

During the bidding phase, each bidder solicits bids from subcontractors for the portions of the work they are not going to perform with their own forces. The purpose of the competitive bidding process is to determine the lowest responsive and responsible bidder who will be able to construct the project with the funds the owner has available. In public projects, the owner generally accepts the lowest bid. In private projects, the owner usually selects the bidders in advance and is free to choose any of them.

Whether bids are solicited by competitive bid or negotiation, it is during the bidding phase that bidders review project specifications and drawings to determine which products and systems are included. When green building materials and systems are specified, the design professional has two important responsibilities during bidding: (1) educating bidding general contractors, subcontractors, suppliers, manufacturers" representatives and others about green building materials and systems that may be relatively unknown to them and (2) processing substitution requests for green building materials and systems.

The reason because there are many green building materials are manufactured by small or new companies, many bidders may not be familiar with them or do not know how to contact them. In addition to the contact information the design professional provides either in the specifications or on the drawings, the subject should be covered at the pre-bid conference. Another issue that must be dealt with at that time is the tendency on the part of contractors to use materials with which they

are familiar. The fear of the new or untried is a powerful issue when the contractor is responsible for guaranteeing or warranting the entire building for a year.

The pre-bid conference, at which the design professional, owner and bidders are present, can be used to dispel some of these concerns. A full discussion should be conducted by the design professionals of the importance and reasons for using green building materials and systems on the project, along with a review of the materials and systems and how to contact the manufacturers. A discussion of alternates and substitution request procedures is also helpful. Bidders should be encouraged to raise questions or concerns they have about these products and systems at this time. Minutes of the pre-bid conference should be kept and distributed to all holders of bidding documents. Documentation information discussed during the conference is extremely important to prevent misunderstanding later in the project. Of course, clarifications of, revisions of, addition to, and deletions from the bidding documents should be incorporated in an addendum.

Another useful practice is to notify the manufacturers of the green building materials and systems when a building project that incorporates their products and system is released for bidding, so they can contact the bidders directly. To further encourage the dialogue between bidders and green building material and system manufacturers, the design professional can provide a list of bidders to the manufacturers. (Spigel and Meadows, 2010).

### 2.3.2 The Construction Phase

The construction phase of the project usually begins when the bid award is made by the appropriate authority on a publicly financed project or when the contract is signed on other projects. If the contract documents require it, the contractor must submit a list of proposed products and a schedule of submittals to the design professionals usually within 30 days after the contract is signed. In some cases, the owner may require that the list be submitted at the same time the bids are submitted.

The list of proposed products, prepared by the contractor, is reviews by the design professional and then forwarded to the owner for approval. The submittal of the list by the contractor to the design professional is a means of confirming that only specified products or approved substitutions are used. The preparation of the list also allows contractors to confirm that their suppliers and subcontractors are following the contract document requirements. The design professional must specify which products the contractor must include on the list, as the typical project includes a substantial number of products.

When green building materials are specified on a project, the submittal and review of the list takes on added significance. The design professional must clearly express in the contract documents that substitution requests cannot be proposed through the list of proposed products. If the list contains unapproved substitutions for specified green building materials, the design professional must quickly and clearly notify the contractor that the list is not in conformance with the contract

documents. The contractor must revise and resubmit the list until it is acceptable to the design professional and the owner.

Once the list is found acceptable, the design professional distributes the approved list to the contractor, owner and consultants. The contractor is responsible for distribution of the approved list to subcontractors and suppliers. The approved list serves as a checklist throughout the construction of the project to ensure that only specified green building materials and approved substitutions are incorporated into the completed building.

A schedule of submittals is another useful tool for the design professional to use to monitor the flow of information and tasks during the early stages of construction. The schedule of submittals is usually submitted in conjunction with the construction progress schedule. The design professional should review the schedule to confirm that the contractors have included all of the submittals required by the technical specification sections.

It is because the contractor must take into consideration many factors when preparing the schedule, the design professional should verify that the submittals are not scheduled simultaneously, that submittals for materials in an assembly are submitted together, and that the contractor has allowed adequate time prior to the need for materials on the project for preparation of submittals, review by the design professionals, and re-submittal in the event that the submittal is not acceptable the first time. The design professional should encourage the

contractor to allow more time for submittals for green building materials because of the possibility that submittal information may be more difficult to obtain.

As mentioned earlier, many manufacturers of green building materials are either new or small or both and may required more time to assemble a submittal. With this understanding, the contractor and design professional can easily accommodate the green building material manufacture's submittal time schedule. (Spigel and Meadows, 2010)

### 2.3.3 The Construction Phase as the Successful End to the Project

Many design professionals, after investing a great deal of their energy and talent in the design and specification of a building project using green building materials, are disappointed when the materials are changed during the bidding and construction phases without agreement. By putting an equal amount of effort and care into the bidding and construction phases of the project, the design professional can ensure that the green building materials they selected and worked so hard to include in their project will actually be incorporated in it. By working to make the contractor's job of using relatively unknown materials easier, the design professional can serve both the owner's needs and those of the environment. (Spigel and Meadows, 2010).

## 2.4 Risk Management for Green Building Materials

Building materials make up the environment in which human live, work and play. That is a lot of exposure. As the percentage of green building materials utilized in building increases, so does their share of that exposure.

Still, most green building materials are relatively new to the marketplace and do not have much empirical data supporting their claims. Add to this, the risk of using building materials that may have been "green washed" by material manufacturers trying to cash in on the surge in green buildings. The combination of newness, lack of field testing, and "green washing" present a risk potential for all members of the project team - product manufacturers who pledge their company's support of a new formulation or novel widget, the design professional who selects and specifies the untried product, the owner of the building in which the green building materials have been incorporated and will effectively be beta tested and the insurer of all of the above.

The risk potential for each member of the design and construction team is different and requires a different response. Clearly, it is in every participants best interest to avoid or minimise risk wherever possible. Sometimes, that is interpreted to mean that it is better to avoid the risk. Hence, lets review the big picture risk. There is a real and very substantive risk and if fail to develop, market, purchase, use and reuse green materials. There is nobody who insures against that. Any

consideration of risk must include consideration for the larger, shared risk. (Spigel and Meadows, 2010)

## 2.5 Design and Construction Relationships

### 2.5.1 The Building Owner

The building owner is the person or company, either public or private, whose idea the building was in the first place. The owner is also responsible for funding the construction of the project and for operating it once it is complete. The owner is the one party who enters into separate contracts with both the design professional and the contractor. This creates a third-party relationship between the design professional and the contractor. For example, during construction, certain responsibilities of the design professional, acting on the owners behalf, are included in the owner-design professional contract. They are also included in the owner-contractor contract.

The building owner rarely cites environment concerns as a reason for building. The reason for buildings to meet a specific need of the owner. The owner also rarely cites spending money as a reason for building. Spending money is viewed as an unfortunate consequence of meeting the identified need. Another necessary evil is the time required to transform the owner's need into a building.

The building owner may be a single person, several persons, or an organization. The organization, public or private, is probably represented by several key contacts (e.g., director of construction), who may or may

not have a clear understanding of the hierarchy relationships among themselves. However, to successfully incorporate green building materials into a project, it is as important to understand the relationships of the owner to other parties on the project. (Spigel and Meadows, 2010)

### 2.5.2 The Building Official

The building official is the leader for the location at which the project is being constructed. The reason because the building officials primary responsibility is to ensure the health, safety and welfare of the buildings occupants after its completion, he or she takes a conservative approach to permitting new and unfamiliar building materials into projects.

Most building codes contain provisions governing the use of non-traditional and new materials in buildings. In order to avoid the delay in time in the approval of these materials, providing the building official with extensive testing reports and where available, engineering documentation, speeds the process of getting them approved for u se on a project. Providing a list of projects where the material has already been used is also beneficial. (Spigel and Meadows, 2010).

### 2.5.3 The Design Professional

The design professional, who may be either an architect or engineer, is generally the primary consultant on a building project. Based on licensing laws and training, the primary design professional on a project is usually the architect. The architect typically subcontractors portions of the work to other design professionals, such as structural

engineers, landscape architects, electrical engineers, civil engineers, mechanical engineers and others as necessary. As the primary consultant, the architect usually has the most direct contact influence on the building owner. The architect is probably also involved in construction contract administration.

Many architects are interested in environmental issues. Some are concerned. Some do not place any priority on green at all. Others are actively attempting to improve the world to the extent they can. In short, architects are like everyone else. When the actively committed design professional and the inspired green product manufacturer meet, the synergy can be tremendous. On average, though, the architect typically experiences more frustration than usual when searching for green building materials Similarly, the manufacturer often feels frustrated trying to market a green product. This is true primarily for two reasons: Architects have extremely limited time in which to research new materials and green building material manufacturers often lack a working knowledge of the building industry.

Many architects do not know where to go to get information on green building materials or know how to evaluate it once they have it. For a small firm, the time involved in researching these materials is prohibitive. Further, green building materials represent a rapidly changing segment of the industry that must be constantly monit ored. Although a few small firms specialize in green architecture, many do not have the time or the expertise to follow the market changes regarding

green. Larger firms can support more overhead activities. The green building material manufacturer would do well to identify those firms, large or small, that have indicated a commitment to green architecture and market their products to them. (Spigel and Meadows, 2010).

### 2.5.4 The Construction Manager

The Construction Manager is either an individual or an entity hired by the owner to supplement the owner's role in a project. The construction manager may have a background as an architect, engineer, or contractor, however, most states do not require construction managers to be licensed. Construction managers can have different degrees of authority granted by the owner depending on how the project is organized. Construction managers are most likely to be found on projects with complex schedules or budgets, those that require extensive coordination between disciplines and those where the owner has limited experience with the design and construction projects.

The construction manager provides professional management services. These may run for the duration of the project, from design through post construction, or for any portion thereof. Typically, one of the duties is to oversee the process of submittals. On a green project, this becomes an even more important role since the accumulation of the proper documentation is one of the main factors enabling submittal o f the project for certification.

Another common duty is the coordination of the work of the various contractors. This is extremely important on green projects. For example,

where commissioning is required for certification, the construction manager must ensure that the commissioning agent's requirements are met by all project members, that scheduled testing and demonstration is performed in a timely manner, and that closeout documentation (required for certification) is properly prepared and assembled for delivery to the architect and commissioning agent. (Spigel and Meadows, 2010).

### 2.5.5 The Contractor

The contractor is the entirely that enters into a contract with the building owner to build the project. The responsibility, however, retains responsibility for completing the project in accordance with the contract documents. For this reason, it is important that contractors incorporate provisions of their contract into the contracts with their subcontractors and suppliers.

Provisions of the contract documents that should be incorporated include submittal procedures and substitution request procedures. The subcontract or purchase order should reference the relevant drawings and specifications that pertain to the portion of the work being performed or building material being supplied.

When green building materials are included in a project, the contractor must deal with the additional demands of purchasing and installing unfamiliar materials. The contractor must ensure that the subcontractors and suppliers are aware of and follow the environmental requirements associated with these products. The contractor must also be familiar with substitution request procedures.

To avoid conflicts with both the owner and the design professional, the contractor should be aware of the owner's reasons for requiring the use of green building materials on a project and understand how flexible or not the contract documents are with respect to substituting non green materials for green ones. (Spigel and Meadows, 2010)

### 2.5.6 The Subcontractor

The subcontractor is a company or individual that enters into an agreement with the contractor to perform a specific portion of the construction contract or to supply materials for a project.

As the use of the subcontractors has grown, the need to ensure that provisions of the construction contract are included in subcontracts has increased correspondingly. Subcontractors are usually selected in much the same manner as contractors, through competitive bidding. In some instances, contractors may select subcontractors based on past experience rather than purely on price.

With subcontractors performing more and more of the work on a project, it is not only contractors who must be sensitized to special requirements of projects that include green building materials. Because subcontractors compete for work through variances in labour costs and by the use of competing materials and products, they, too, must clearly understand the limitations placed on them when green building materials are specified, because acceptable alternates for green materials may not always exist. (Spigel and Meadows, 2010)

### 2.5.7 The Design Team

Ideally, a green building material is designed into a building such that it can function optimally. Good communication and a focused understanding of the environmental goals for the project help the design team identify, specify, and utilize green building materials affectively.

The relationship between the architect and the manufacturer is the most important in terms of successfully implementing green building materials. They must work together. Neither can fully implement green building materials without the other.

The architect relies on the manufacturer for applicable performance data, installation expertise and product service. The manufacturer relies on the architect for product considerations at the critical first moments of design when the green product can be implemented most efficiently, economically and successfully. Together, they can support a growing market and have the satisfaction of knowing they have done the right thing (Spigel and Meadows, 2010).

## 2.6 Environmental Materials Assessment

With the reference to Lynn (1999), she defined the assessment of environmental materials begins with establishing criteria for evaluating building materials. The criteria should compliment the overall environmental project goals. Often extensive research is necessary to evaluate prospective products. Based on the environmental material

criteria established for a green building project, selection of appropriate building products and systems can be accomplished.

The environmental material criteria may vary per project. Criteria may also vary depending on whether a project is new construction, a renovation of an existing building, or whether site work is associated with the project. The following are recommended environmental material criteria for use in green building product or system assessment and evaluation:

- ***Low toxicity*** : Materials the manufacturers demonstrates to have reduced toxicity or are nontoxic and avoid carcinogenic compounds and ingredients.
- ***Minimal emissions*** : Products that have minimal chemical emissions emit low or volatile organic compounds (VOCs) and avoid the use of chlorofluorocarbons (CFCs).
- ***Low-VOC assembly*** : Materials installed with minimal VOC-producing compounds or no-VOC mechanical attachment methods and minimal hazards.
- ***Recycled content*** : Products with identifiable recycled content in the material including post-industrial content with a preference for post-consumer content.
- ***Resource efficient*** : Products manufactured with resource-efficient processes including reducing energy consumption, minimizing waste and reducing greenhouse gases.

- ***Recyclable useful life*** : Materials those are recyclable at the end of their
- ***Reusable*** : Building components that can be reused or salvaged.
- ***Sustainable*** : Renewable natural materials harvested from sustainably managed sources and preferably that have an independent certification.
- ***Durable*** : Materials that are longer lasting or are comparable to conventional products with long life expectancies.
- ***Moisture*** : products and systems that resist moisture or inhibit the growth of biological contaminants in buildings.
- ***Energy efficient*** : Materials, components and systems that help reduce energy consumption in buildings and facilities.
- ***Water conserving*** : Products and systems that help reduce water consumption in buildings and conserve water in landscaped areas.
- ***Improves IAQ*** : Systems or equipment that promotes healthy IAQ by identifying indoor air pollutants or enhancing the air quality.
- ***Healthfully maintained*** : Materials, components or systems that required only simple, nontoxic or low-VOC methods or cleaning.

- ***Local product*** : Building materials, components and systems found locally or regionally saving energy and resources in transportation to the project site.
- ***Affordable*** : Building product life cycle costs comparable to conventional materials or as a whole, are within a project defined percentage of the overall budget.

The environmental assessment of green building materials can be broken into three phases: research, evaluation and selection. Research is the aspect that takes most time consuming amongst the three aspects. Evaluation can be equally difficult and dependent on product information provided by manufacturers that is often incomplete as it related to environmental issues. Since there is currently no standard format for providing environmental product information, interpreting and comparing product information can also be difficult. Environmental criteria and proper application of the materials should be considered when selecting green building materials. The following are the three phases of the environmental assessment process:

***i. Research***

This aspect includes gathering information which directly from manufacturers such obtaining material safety data sheets (MSDs), IAQ test data (if available), environmental statements, recycled content data, durability information and product warranties. Additional information sources include the various resource guides currently available. Due to the variability and in some cases,

inaccuracies in resources, most guides should be considered only as a starting point for which additional research is required. If a guide is not update, the information can become obsolete due to evolving nature of environmental building materials or modifications in green product lines.

***ii. Evaluation***

Evaluation can begin once research and information gathering is complete. Evaluation often includes confirmation of the information provided by manufacturers and requests for missing or incomplete data. Evaluation can be a frustrating process since some manufacturers may exaggerate product environmental qualities, whereas others may not recognize the environmental attributes that apply to their products.

Additional information to review includes MSDS and IAQ test data from independent laboratories. However, the MSDS may not indicate all the ingredients of a product nor include proprietary compounds material composition can often change, even within the course of the building project.

This can be alleviated by requesting letters of clarification from the manufacturer. It is important to review product warranty and durability test information. Based on the environmental criteria, the comparison of similar types of building materials can be accomplished by evaluation and assessment.

### *iii. Selection*

Green building material selection is based on the product that best meets established environmental criteria and the most appropriate application for the project. When comparing similar types of products, a rating system can be established by giving higher points to products that meet the environmental criteria and lower points to materials that do not meet the criteria. By totaling the points, an "environmental" score or rating can be ascertained. Sometimes a product may have strengths in some areas but may have a characteristic causing enough concern to not be selected if it does not meet the projects environmental goals. Selected green building materials are then incorporated into the project specifications. The matrix in Figure 2.1 can be used as a tool to compare and assess similar green building materials in like categories.

| Environmental Criteria | Prod. "A" | Prod. "B" | Prod. "C" |
|---|---|---|---|
| Low Toxicity | | | |
| Minimal Emissions | | | |
| Low-VOC Assembly | | | |
| Recycled Content | | | |
| Resource Efficient | | | |
| Recyclable Materials | | | |
| Reusable Components | | | |
| Sustainable Sources | | | |
| Durable Materials | | | |
| Moisture Resistant | | | |
| Energy Efficient | | | |
| Improved IAQ | | | |
| Water Conserving | | | |
| Healthful Maintenance | | | |
| Local Product | | | |
| Affordable Material | | | |
| Environmental Score: | | | |

Figure 2.1 : Environmental Material Assessment Matrix (compare similar product categories)

## 2.7 Green Building Materials

According to Spigel and Meadows (2010), they stated the range of green building materials that are currently available has grown exponentially in response to the growth in green building rating systems on the local, state, national and international level. Green Building Materials offer a range of aesthetic options. They perform well and cost - competitive. Many mainstream manufacturers have jumped on the bandwagon in response to the growth in demand and the realization that green building materials are not a fad that is soon going to fade away. It is not only possible to incorporate green building materials into the design and construction practices, it is imperative. The following sources are collect from Green Pages Malaysia.

**a) Cellulose Fibre Cement Boards (Prima)**

Figure 2.2: Prima Cellulose Fibre Cement Boards

- **Why is it green?**
  - Made from renewable resources such as pulp fibre from managed plantations & the minerals are from local resources with up to 20% recycled content.

- It goes through a green manufacturing process that meets the ISO 14001 Standard and is also aligned with the concept of Reduce, Reuse & Recycle of raw materials.
- It is non-hazardous, low VOC, has no formaldehyde and durable.
- It has been certified as Green Building Material by Global Eco - Label Certification Bodies such as Singapore Environmental Council, Good Environmental Choice Australia, Korea Environmental Industry & Technology Institution, etc.

➢ Product Features

- Strong (MoR 16MPa)
- Water Resistance
- Weather Resistance
- Fungus Resistance
- Termite Resistance
- Good Thermal Insulation
- Good Sound Insulation
- Fibre Cement Waste is non-toxic and easy to dispose
- Recyclable and Reusable
- 50 years durability

➢ **Applicable GBI credits**

| | |
|---|---|
| **NRNC** | EE1, EE5, EQ13, MR2, MR3 |
| **NREB** | EE1, EE5, EQ13, MR2 |
| **RNC** | EE1, EQ3, MR4, MR5 |

➢ **Green Labels / Accreditation**


**b) Autoclaved Aerated Concrete (AAC) Blocks**


Figure 2.3: Autoclaved Aerated Concrete (AAC) Blocks

➢ **Why is it green?**

- It contains a pore content of approximately 45%, the consumption of raw materials and the total energy consumed during the production is 2-3 times lower than other building materials such as burnt bricks.

- Emissions of gasses such as CO2, CO and NOx are also relatively low. By-products of AAC Production such as condensate from the autoclaving, hardened AAC waste and unhardened AAC mixture can be recycled back into the production of AAC. Besides that, other industrial waste like fly ash and slag can be utilised as main raw materials too.
- It has excellent thermal insulation properties, less energy is required to cool an AAC building. It is breathable and effective in moderating the moisture levels and maintaining the correct relative humidity.

➢ Product Features

- Lightweight
- Durable
- Thermal resistant
- Fire Resistant
- Acoustic
- Breathable
- Non-toxic
- Workability

**Product Compliance**

Applying for:

- Green Label Singapore
- IBS Status

- SIRIM
- ISO 9001 & ISO 14001

➢ **Applicable GBI credits**

| | |
|---|---|
| **NRNC** | EE1, EE5, MR2 |
| **NREB** | EE1, EE5, MR2 |
| **RNC** | EE1, EE3, MR4 |

**c) Ceiling Board (Queen Energy)**

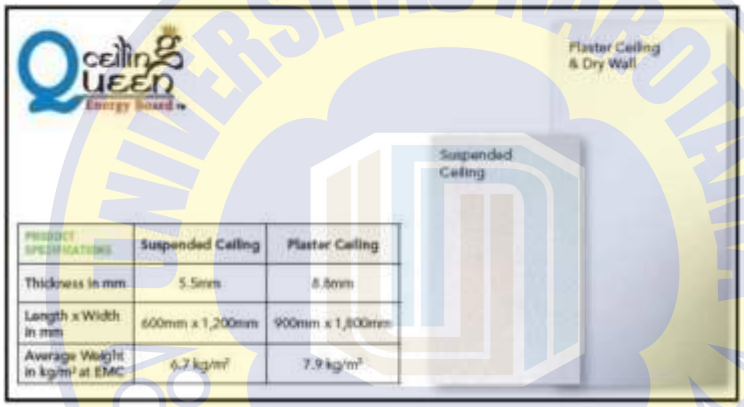


Figure 2.4: Ceiling Queen Energy Board

➢ **Why is it green?**

- Ceiling Queen Energy Board uses bio technology from Japan and Korea that can generate and emit negative ions and far infrared rays using natural radiation materials, i.e. Tourmaline, Radium, Thorium and Potassium.
- Its low thermal conductivity and excellent insulation properties can help to reduce heat generation and energy consumption of the air conditioning system.

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- The micro fiber or fiberglass can also be installed in contact with the ceiling to further enhance its thermal qualit ies and provide additional heat penetration control.

➢ **Product Features**

i. Safe

- Does not produce toxic fumes of hazardous substances that are harmful to health.
- Passed Emission Test and Formaldehyde Test from PSB Singapore.
- Passed ROHs (Restriction of Hazardous Substances) of Europe Standard.
- Passed heavy metal tests from SGS Malaysia and PSB Singapore.

ii. Energy Efficient

- Energy saving
- Heat/thermal insulation
- Alternative to ionizer and air purifier

iii. Improves Indoor Air Quality

- Purifies the air and provides a fresh environment
- Reduction on sensitiveness such as asthma and sinus
- Prevents the spread and protects from haze, secondary smoke, pollen, bacteria, viruses and fungi
- Neutralises odour, smoke, dust and CO2
- Neutralises volatile organic compounds (VOCs)

iv. Eco-friendly

- Made from reusable and recycled content materials

v. Economical

- Fire-resistant
- Multiple functions and longer usage

➢ **Applicable GBI credits**

| | |
|---|---|
| **NRNC** | EE1, EE5, EQ4, MR2 |
| **NREB** | EE1, EE5, EQ4, MR2 |
| **RNC** | EE1, EE3, EQ5, EQ6, MR4 |

➢ **Green Labels / Accreditation**