HK-BEAM (HONG KONG BUILDING ENVIRONMENTAL ASSESSMENT METHOD) :
ASSESSING HEALTHY BUILDINGS

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Abstract

HK-BEAM was introduced to Hong Kong in 1996 and is an environmental performance based assessment scheme purpose designed for high-rise buildings in the community. The certification scheme is completely voluntary and is owned by the HK-BEAM Society, a non-profit making organisation consisting of industry professionals. The latest HK-BEAM standards (Version 4/04 and Version 5/04) covers all “New” and “Existing” building types, including office, residential, mall, hotel, school, hospital, institutional and mixed complexes – centrally air-conditioned, naturally ventilated or mixed mode. Responding to raised concerns of occupant health in buildings especially after the outbreak of SARS in 2003, the latest HK-BEAM standards have been evolved to address hygiene, health and other environmental issues in a holistic manner.

HK-BEAM assessment embraces a range of good practices into a pool of criteria using a life cycle approach. The comprehensive assessment framework encompasses exemplary environmental practices in planning, design, construction, commissioning, operation, maintenance, and management. Emphasis has also been placed on the wider attributes of a sustainable building, particularly hygiene, health, safety, security, amenity and overall quality. This approach encourages buildings that fulfil their intended functions whilst minimizing the resulting impacts on the environment. Finally, the scheme provides a benchmark for sustainable buildings and third party recognitions to building performance excellence.

This paper outlines the latest framework of HK-BEAM, including rationale on the assessment approach and criteria, with an emphasis on aspects associated occupant health.

1. Introduction

Health problems related to buildings are widespread. Typically, an adult in Hong Kong spent 80% of their time indoors, in a building and certain portions of them have the perception of being affected by the indoor environment to such an extent that they have symptoms. A poor indoor environment contributes to a number of related social economic costs such as increased sickness leaves and reduced productivity at work, increased hospital and treatment costs, and a lower quality of life. In order to solve these problems and avoid future occurrence, there is a need for a systematic framework to address and improve health aspects of buildings in Hong Kong. Assessing the environmental sustainability of buildings in a holistic approach, Hong Kong Building Environmental Assessment Method (HK-BEAM) framework also covers indoor environmental quality and other health aspect for occupant well-being.

HK-BEAM is the private sector initiative to promote environmental sustainability in different stages of buildings. One of the prime objectives of HK-BEAM is to address
sustainability in buildings and its definition of a sustainable building is one which adversely effects neither the health of its users nor that of the larger environment. Therefore, HK-BEAM focuses on indoor environmental quality and amenities, as well as local, regional and global environmental impacts. HK-BEAM is a comprehensive, fair and transparent assessment scheme, with the following attributes:

- embraces many areas of sustainability, particularly social and environmental;
- recognises best practices;
- provides for a comprehensive method of quantifying overall performance;
- demonstrates performance qualities to end users; and
- provides economic benefits to stakeholders.

HK-BEAM sets best practice criteria for environmental sustainability in buildings, against which performance is verified through a voluntary and independent assessment. ‘Credits’ are awarded where these criteria are satisfied, and guidance provided where performance can be improved. The assessment outcome is communicated through the voluntary HK-BEAM green building label as a rating of “Bronze”, “Silver”, “Gold” and “Platinum”.

2. The HK-BEAM Framework

HK-BEAM seeks to measure, improve and label the performance of buildings over their whole cycle through adoption of a set of best practice criteria. The first HK-BEAM standards were established in 1996, covering newly built office buildings and existing office premises. In 1999, a standard was introduced to appraise new residential developments. The latest advancement from HK-BEAM has lead to the establishment of two standards which covers all local buildings according to their life cycle stage:

- **HK-BEAM Version 4/04 for New Buildings** (for planning, design, construction and commissioning, with design and specification provisions for deconstruction);
- **HK-BEAM Version 5/04 for Existing Buildings** (for management, operation and maintenance, with some overlap on commissioning and inherent building design).

All buildings under single ownership can be assessed by HK-BEAM, including but not limited to offices, retail, catering and service establishments, libraries, educational establishments, industrial, hotels, residential and mixed complexes. Within each building type, HK-BEAM caters for central air conditioning, mechanical ventilation, and natural ventilation with supplementary cooling, or any combination of these.

Over 100 best practice criteria, described in more detail in the following sections, are applied to the assessment of each building at each life stage, as illustrated in Figure 1 overleaf.

The intention is that HK-BEAM for new buildings dovetails with that for existing buildings, such that a building rated under HK-BEAM ‘new’ and suitably operated and maintained would achieve a similar rating under HK-BEAM ‘existing’ some years later.

Both versions of HK-BEAM aim to reduce impacts of buildings using the best available techniques and within reasonable cost. It is not expected that a building will meet all of the requirements. By meeting some of the criteria, however, the building will have less impact than one in which the requirements have not been met.
3. The HK-BEAM Coverage of Issues

Despite its name, HK-BEAM extends beyond the environment. Since its inception and over time HK-BEAM has covered an increasing number of building related socio-economic issues such as, for example, land utilisation, site amenity and accessibility, pedestrian comfort, environmental health and hygiene, aesthetics, occupant health and well-being, etc. As such, HK-BEAM continues to evolve as an “environmental sustainability” assessment method and, as parameters become better understood and defined, ultimately towards a “building sustainability” assessment method.

The best practice criteria put forward by HK-BEAM are grouped within a general framework similar to other schemes in use worldwide, with due consideration of their relative importance:

- **Site Aspects** – land use and location, site layout optimisation, transportation, accessibility, ecology, amenity, site and neighbourhood interfaces, site emissions and management, etc
- **Materials Aspects** – optimisation in design and operation, innovative construction methods, building flexibility and durability, the avoidance of environment-damaging materials, waste minimisation, etc
- **Energy Aspects** – passive/low-energy design, microclimate, plant/equipment efficiency, renewable energy, annual energy consumption reduction, etc
- **Water Aspects** – potable water quality, water economy and recycling, and effluent management, etc
- **Indoor Environmental Quality** – safety, security, hygiene, amenities, thermal comfort, ventilation effectiveness, indoor air quality (internal and external pollutants), natural/artificial lighting, acoustics and vibration, etc
- **Innovative Techniques** – innovative techniques and enhancements beyond those stipulated in the HK-BEAM criteria indicated above
Credits allocations within the assessment framework have been formulated by taking into account of international and local consensus as given by analysis of weightings used in similar overseas assessment methods, as well as surveys and informed opinions of stakeholders whom have contributed to the development of HK-BEAM.

For more detail information on each of the aforementioned aspects and criteria, full versions of the two latest HK-BEAM standards can be downloaded from the HK-BEAM Society website (www.hk-beam.org.hk).

4. The HK-BEAM Certification Process

HK-BEAM is a voluntary scheme and the most important aspect of the assessment process is that it includes the provision of information and guidance from assessors (originating from ongoing research and previous assessments) for which clients and designers and building managers can use in their own projects, and future assignments. This two-way process is often cited as the most beneficial element of the assessment process by those that have been involved.

Premises are assessed against the criteria and ‘credits’ awarded where the criteria are satisfied. The assessment basically includes two stages, the “provisional assessment” and “final assessment” which is geared for buildings to improve their performance and upgrade their HK-BEAM rating.

Clients are provided with a questionnaire and supporting checklists that details the information required. In the Provisional Assessment, an initial scoping process is conducted to identify appropriate criteria for the premises under assessment, since HK-BEAM embraces over 100 criteria designed to cover all types of local buildings. For criteria which are not relevant due to particular circumstances or building type of the assessed premises, these are allocated as Not Applicable, and are excluded from the total number of credits available.

Based upon intended design features and construction/management practices, the performance of the premises is identified provisionally. The client and project team are also able to achieve credits through commitment at this stage if they are confident of fulfilling credit requirements during the course of the assessment. These credits will be designated as “Provisional Credits” which require submission of additional materials from the project team, site inspections and building surveys for further confirmation prior to the final assessment. Recommendations for improvement are also presented at this stage through which the performance of the premises could be enhanced.

Prior to the Final Assessment, the client and designers have the opportunity to undertake the recommended improvements of their choice to upgrade the building’s HK-BEAM rating. For a new building development, the assessors perform inspections during construction and upon completion of the property to verify allocation of credits. In the case of existing premises, the assessors appraise documentations and other relevant information submitted to demonstrate recommended improvement measures have been taken on board, and subsequently designate additional credits achieved. The final outcome of the assessment is presented on the HK-BEAM Final Assessment certificate as a rating of Bronze, Silver, Gold and Platinum, according to the number of credits achieved.
HK-BEAM intends to encourage clients to pursue outstanding environmental features, innovative technique or requirement above the norms by providing Bonus Credits for certain criteria throughout the assessment framework. Bonus credits are included as the total number of credits gained but excluded in the total number of credits available i.e. failure to comply will not be penalized.

When assessing a building complex with different parts e.g. a premises combining hotels, retails and office accommodations, an Area Weighting Method is introduced for the Energy Use and IEQ categories only, as the differences in these categories is much significant than others. Under the area weighting method, the credits achieved are weighted by the areas (in percentage of the overall normally occupied building areas) of a particular part of the building complex. Summation of credits of individual parts of the building complex results in the overall weighted credits.

The HK-BEAM assessment process is summarised in Figure 2 below:

**Figure 2**: Summarised of the HK-BEAM assessment process
5. **Assessing Healthy Buildings**

As mentioned, HK-BEAM assesses the environmental sustainability of buildings in a holistic approach. Hygiene, health, comfort and occupant well-being are integral and essential parts of the framework. In the following sections, more detailed explanations on how HK-BEAM address these issues for buildings are provided.

5.1 **Hygiene**

5.1.1 **Plumbing & Drainage**

Since the outbreak of the SARs virus a great deal of attention there has been paid to the design of plumbing and drainage system to improve building hygiene. Apart from complying with the Building Regulations, HK-BEAM seeks to ensure greater attention is allocated to the design and installation of plumbing and drainage systems in buildings to reduce the risk of transmission of bacteria, viruses and odours into occupied areas.

Water seal traps are recommended for all sanitary fitments before they are connected to a common drainage stack. Trap seal retention can be a problem in multi-level drainage systems. The main ways that air passes a trap are:

- system pressure variations cause air-entrained bubbles to pass through the water seal; and/or
- complete or partial trap seal loss.

Self priming type drainage traps or drainage pipe connections which ensure trap priming may be considered, e.g. connection of wash basin discharge to the pipe between the floor drain grating and its U-trap.

5.1.2 **Biological Contamination**

If not properly designed, air-conditioning and ventilation systems, or potable water systems is likely to give rise to biological contamination caused by Legionnaires’ Disease (LD). The majority of cases of LD, are caused by the bacterium Legionella Pneumophila. HK-BEAM seeks to ensure that the design, installation and facilities for operation and maintenance of air conditioning systems, and potable water systems and features, are such as to reduce the risk of biological contamination by meeting with the requirements and recommendation contained in the Code of Practice - Prevention of Legionnaires Disease or equivalent code. These include, for example, adequate drainage for drain trays at air-conditioning equipment with pipework connections at lowest point; cisterns be equipped with tight fitting lid and appropriately sized drain valve; overflow pipes & air vents be fitted with mesh; and provision of associated pipework to facilitate flushing, cleaning and decontamination.

5.1.3 **Waste Disposal Facilities**

Where refuse contains large amounts of food and other organic waste there are potential odours and health problems if refuse is not well contained from the points of disposal to the place of final collection. HK-BEAM seeks to ensure that the design, installation and waste disposal and recycling facilities are such as to reduce the risk of odours entering
occupied areas or public areas. Refuse should be disposed of in a hygienic manner and prevents any significantly discernable odours from entering occupied areas or public areas in or immediately adjacent to the building development. The refuse disposal system should comply with relevant practice note (PNAP 98) in respect of refuse storage (RS) and material recovery chambers (MRC). Air purifying devices such as ‘Chemical Air Scrubber’, ‘Bio-oxygen Generator’, ‘Photo-oxidation Generator’ or other appropriate devices should be provided within a RS & MRC.

Figure 3 : Concept Diagram of Advanced Waste Handling System

5.1.4 Microclimatic around buildings

The microclimate around buildings can suffer as a result of the restricted natural ventilation from winds and breezes, leading to stagnant areas of pollution. Besides, reasonable breezes help diluting odours or contaminated air wherever possible in the re-entrant areas or surrounding of buildings. HK-BEAM seeks to ensure microclimate around and adjacent to buildings has been adequately considered through either wind tunnel measurement or relative wind computer airflow modelling (CFD).

Figure 4 : Simulation of microclimatic conditions around buildings using CFD (left) and wind tunnel test (right)

5.2 Indoor Air Quality

5.2.1 Outdoor and Indoor air pollutants

Outdoor air pollutants, contributing to IAQ problems, include carbon monoxide (CO), ozone (O₃), nitrogen oxides (NOₓ) and respirable suspended particles (RSP). CO is a toxic gas which interferes with the oxygen transport capacity of the blood, and at levels to which
people can be exposed in buildings, leads to symptoms such as headaches, nausea, chest constriction, etc, as well as affecting concentration. Exposure to O$_3$ and NO$_x$ can result in irritations to the eyes and respiratory systems. Sources in occupied areas include infiltration from vehicle exhausts and enclosed car parks, and incomplete combustion within premises. The health impacts from inhalation of RSP can be crucial depending on its size, shape and chemical reactivity.

Indoor air pollutants include volatile organic compounds (VOCs), formaldehyde and radon. VOCs includes hundreds of chemical compounds found in indoor environments that can cause various symptoms such as eye and throat irritations, respiratory problems, headaches, etc. Formaldehyde is a type of volatile organic compound which is commonly found in many building materials – adhesives, fabrics and carpets, etc. Formaldehyde is a suspected human carcinogen, and in sufficiently high concentrations is known to cause eye, nose and respiratory irritation and sensitisation. Radon is mainly emitted from granite and marble which are major building materials in Hong Kong. There is concern that exposure to elevated levels of radon increases the risk of lung cancer.

HK-BEAM seeks to ensure airborne contaminants from external and internal sources will not give rise to unacceptable levels of indoor air pollution in normally occupied spaces through IAQ measurement at these accommodations. HK-BEAM aligns with the HKSAR IAQ Certification Scheme and recommended indoor air pollutant levels which complies with the Good Class Grade of the government’s scheme. The measurement of IAQ should be based on the worst-case scenario in occupied areas under normal modes of operation. For example, when measuring outdoor air pollutants for residential buildings with decentralized air-conditioning system, tests should be undertaken under open window and naturally ventilated conditions at low level areas closets to main traffic roads. For the monitoring of indoor air pollutants, analysis should be undertaken in representative units with windows closed and mechanical ventilation switched off. For centralised air conditioned premises, measurements should be made at representative and normally occupied accommodations, with ventilation being provided at the normal modes of operation.

5.2.2 Ventilation

Adequate ventilation is important for occupant’s health and control of odours. For centralised air conditioned buildings, HK-BEAM seeks to ensure quality of ventilation systems to support the well being and comfort of occupants in normally occupied spaces through checking on the fresh air ventilation rate and air change effectiveness (effective distribution of fresh air).

Whilst for residential or similar buildings where centralized ventilation is not available, HK-BEAM seeks to encourage designs that provide for adequate background ventilation by natural means when windows are closed, i.e., through the provision of purpose designed ventilators. Background ventilation is intended to dilute unavoidable contaminant emissions from people and materials (e.g. radon) and for the control of internal moisture levels from occupant activities which may give rise to mould growth.
5.3 Water Quality

The Water Services Department has endeavoured lots of efforts to maintain safety and quality of our potable water supply. However, water quality is affected in some instances by inadequate maintenance of internal plumbing pipes or water tanks before it reaches customers’ taps and this can cause discolouration and contamination. In view of these, HK-BEAM seeks to ensure acceptable quality of potable water are being delivered to occupants through encouraging applicants to observe local best practices (Code of Practice for the Prevention of Legionnaire Disease and the Fresh Water Plumbing Quality Maintenance Recognition Scheme) in their plumbing designs. Furthermore, HK-BEAM also encourages systematic analysis of representative potable water samples taken at the furthest points of delivery from the storage tank, and design modifications if necessary to ensure the results comply with World Health Organisation guidelines.

5.4 Lighting Quality

Lack of daylight and views to the external environment contributes to discomfort and dissatisfaction to building users. However, in Hong Kong’s congested built form, rooms on lower floors of buildings may be considerably overshadowed. This can result in significantly reductions in natural light, and will incur increased electricity consumption for artificial lighting, and degradation of internal comfort and health conditions. HK-BEAM seeks to encourage a holistic examination of site layout, building design, and fenestration design, such as to maximise access to daylight for the purposes of improved health and comfort. The amount of daylight available for specific rooms is related to:

- window and room geometry and room surface finishes;
- sky obstruction due to the form of the building and its overshadowing from neighbouring buildings;
- glazing transmittance.

In order to take into account the above considerations, applicants should undertake vertical daylight factor (VDF) or average daylight factor (DF) analysis of the worst case scenarios, i.e. the most obstructed windows, to demonstrate compliance.

Artificial lighting is of equal importance for occupants especially for interior zones or at night. HK-BEAM seeks to ensure visual comfort and health conditions in occupied spaces by encouraging lighting designs to embrace both ‘quantity’ and ‘quality’ and these include, maintained horizontal, and where appropriate vertical, illuminance, illuminance variation, limiting glare index and colour rendering appropriate to the type and use of the premises/indoor spaces.

5.5 Acoustics and Noise

Noise can cause speech intelligibility, discomfort, irritation and interference with workplace activities. Exposing under noisy environment for certain period of time will lead to short and long term physiological effects such muscular response and heart attack. HK-BEAM addresses acoustics and noise issues in several aspects as follows:

- For certain rooms where speech intelligibility is important, acoustic design should be considered to avoid echoing of sound and meet relevant reverberation time guidelines.
The sound insulation properties of floors and internal walls are crucial in controlling noise propagation inside a building. The extent to which walls and floor can attenuate unwanted noise from neighbouring spaces is an important aspect of controlling noise levels. In HK-BEAM, sound insulation properties of floors and internal walls which fulfil international standards on Noise Isolation Class (NIC) or Sound Transmission Class (STC) are encouraged.

Background noise inside buildings comes from a number of sources, including noise break-in from the surrounding environment and noise produced inside the building, such as from building services equipment, adjoining premises and nearby traffic. Background noise should be limited to levels suitable for the use of the premises expressed as appropriate criteria such as $L_{A\text{max}}$ and $L_{A\text{eq},T}$.

Excessive vibration in buildings can also be a source of annoyance to building occupants. It is possible to mitigate against vibration caused by external sources, such as traffic, and internal sources, such as building services equipment, through proper acoustical designs which complies with ISO 2631-2.

6. Conclusion

Building design and management shape our indoor environment and control our overall healthiness and quality of life. HK-BEAM has provided a unique stepping-stone towards embracing such well-being and sustainability issues, through partnership of stakeholders in the building industry. The inherent comprehensive nature of the life cycle approach adopted in HK-BEAM has lead to the adoption of many building designs and management measures, which are beneficial to building occupants, and often financially rewarding, which might otherwise have been overlooked. HK-BEAM’s comprehensive assessment framework encompasses exemplary practices in planning, design, construction, commissioning, operation, maintenance, and management of properties. This approach encourages buildings which fulfil their intended functions, with strong emphasis on occupant health and comfort, whilst minimizing the resulting impacts on the environment.