BUILDING SAFETY AND CONDITIONS INDEX: A BENCHMARKING TOOL FOR MAINTENANCE MANAGERS

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Abstract
The recent occasional accidents of falling concrete pieces and windows in Hong Kong have aroused public concern over the possible dire consequences of building neglect. There is increasing pressure on maintenance managers to inspect and assess the level of safety performance in buildings. Being an abstract notion, ‘safety’ presents different perceptions to people with different backgrounds. There is a need to standardize a benchmarking tool to measure and compare building performance in terms of safety and conditions.

The Building Safety and Conditions Index (BSCI), developed by the Faculty of Architecture of the University of Hong Kong, is a benchmarking tool for classifying buildings in respect of safety and physical conditions of buildings. Objectiveness can be achieved in the formulation of the BSCI by adopting rigorous multi-attribute decision-making techniques such as the Analytical Hierarchy Process. Through the BSCI, occupants and the public will be informed of the safety risk associated with their living environments. Besides, the BSCI can be used as a key performance indicator for maintenance services providers. For organizations with large property portfolios, the BSCI can serve as a priority setting tool to facilitate resource allocation to repair or upgrade buildings with the most urgent needs.

Keywords: benchmarking, building classification, building labeling, safety and conditions

BACKGROUND
The purpose of creating a building is to provide an improved environment for individuals, organizations, and communities (Halliday, 1997). It is a common belief of ours. Paradoxically, the problems of building disrepair and unauthorized building works (UBW) have long been the eyesores of the cityscape in Hong Kong, like many other developed cities. According to the Housing, Planning and Lands Bureau (2004), there are around 42,000 private buildings territory-wide. About 11,400 are 20 to 40 years old and are more susceptible to maintenance problems, particularly those without proper management.¹ The dire consequences of building neglect have been reflected in fatal accidents of fallen external renderings, spalling concrete pieces, and collapsed misused canopies. From 1990 to 2002, accidents related to UBW resulted in at least 21 deaths and 135 injuries (Leung and Yiu, 2004). Thus, the pitfalls in our living environment threatening the occupants and the public have been revealed. Requests for addressing the prolonged problems of inadequate building management and maintenance in Hong Kong have become more frequent than ever.

As a response, the government initiated a public consultation on ways for the proper upkeep of private buildings throughout the territory in 2004. Among the suggestions proposed by the authority, such as mandatory building safety inspection and building management, one of particular interest was the formulation of a voluntary building classification scheme. It was believed that the classification scheme would give positive recognition and encouragement to well-designed and properly managed buildings.

As a matter of fact, cries for a building classification system to address the problem of building neglect in Hong Kong were first recorded in 2000. The former Planning and Lands Bureau suggested classifying private buildings by their standards of safety, management, and

¹ According to Team Clean (2003), there are still some 8,000 private buildings without any form of management either by the owners or management companies.
maintenance. A task force was then set up to study the viability of the proposal. In January 2001, the task force considered a voluntary building classification scheme viable. However, there has not been any concrete implementation plan so far. Recently, a consultancy study on a broad framework of building classification based on safety and conditions, which was commissioned by the Buildings Department, has been completed. Details have yet to be released.

**The Building Safety and Conditions Index (BSCI)**

In view of the need to enhance the living environment of our city, the Faculty of Architecture of the University of Hong Kong in mid-2003 launched a series of research projects that focused on formulating a vigorous, yet simple, building classification framework on building performance on various aspects. In particular, vast emphasis has been cast on the safety of multi-storey residential buildings. Therefore, a Building Safety and Conditions Index (BSCI) was developed as a benchmarking tool for classifying buildings in respect of their safety and physical conditions, while serving to indicate the level of achievement of individual buildings in enhancing the safety of both occupants and the general public. The BSCI assessment scheme is backed up by rigorous and sound theoretical foundation. Thus, the creditability and practicality of the BSCI can be achieved. Besides, what makes the BSCI distinguishable is that its assessment framework is tailored to the mass assessment of buildings.2

**DEVELOPMENT OF AN ASSESSMENT FRAMEWORK**

The assessment framework of the BSCI is divided into three levels. The first level is a vision, which sets the assessment principles and delimits the scope of the assessment. The second level assumes a strategic role, which defines the safety attributes that contribute to building safety and conditions. The third level deals with operational issues by transforming the safety attributes into a hierarchy of building factors for devising a location and time-specific assessment scheme.

**Level 1: Assessment Principles**

The assessment framework is intended for the first-tier screening of building safety and physical conditions. For this purpose, it must allow for a wide coverage of buildings within a short period of time at a reasonable low cost. Accordingly, the framework is designed with respect to the principles of generality, objectivity, practicability, and relevance to safety. Generality entails the applicability of the assessment framework to most residential buildings, be they low-rise or high-rise. To achieve objectivity, the factors to be assessed should be measurable and verifiable. If subjective judgments cannot be avoided, they should be validated by documentary evidence such as record photos.

The assessment methods should be practicable and simple, and the factors to be assessed should be easily acquired. Whenever possible, a building is assessed with reference to its basic configurations and conditions without the need to inspect individual flats. A site visit may be required, but generally is confined to common areas and the external environment only. In general, only characteristics of buildings easily assessable by the public are acquired, measured, and assessed. Furthermore, the factors to be considered should be directly related to building safety and conditions that pose hazards to occupants and the public.

**Level 2: Identifying Safety Attributes**

Based on the above principles, a number of safety attributes that affect the safety of occupants and the public have been identified through literature reviews and workshops with relevant professionals and experts. Intuitively, fire hazard is regarded as the most threatening to the occupants of a building. Lo (1999) developed a fire safety ranking system apt for Hong Kong’s situation, and the findings are valuable guidance for identifying fire safety attributes. Yet, building safety embraces not only fire safety, but also many other factors. Structural integrity and external finishes are also problematic areas identified by the Buildings Department (1997).

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2 There exist other building classification systems, but building safety is seldom their main focus. Notable examples are the Leadership in Energy and Environmental Design (LEED) scheme, the Building Research Establishment Environmental Assessment Method (BREEAM), the Hong Kong Building Environmental Assessment Method (HK-BEAM), and the Intelligent Building Index (IBI).
For the BSCI, several key safety attributes, namely fire resistant construction, means of escape, means of access for fire-fighting, fire services installations, internal defects, external defects, density, and special hazards, are identified. To come up with a practical assessment scheme for building classification, the safety attributes are decomposed into a list of building factors that can be, as far as possible, objectively measured. For an illustration, the building factors relevant to the safety attributes are shown in Table 1.

Table 1: List of Building Factors that Affect Safety Attributes.

<table>
<thead>
<tr>
<th>Safety Attributes</th>
<th>Building Factors</th>
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<tbody>
<tr>
<td>1. Fire Resistant Construction</td>
<td>compartment volume</td>
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<tr>
<td></td>
<td>staircase opening</td>
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<tr>
<td></td>
<td>fire-resisting doors</td>
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<tr>
<td>2. Means of Escape</td>
<td>travel distance</td>
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<td></td>
<td>direct distance</td>
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<tr>
<td></td>
<td>discharge value</td>
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<tr>
<td></td>
<td>obstacles</td>
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<tr>
<td></td>
<td>exit and directional signs</td>
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<tr>
<td>3. Means of Access for Fire-fighting</td>
<td>emergency vehicular access</td>
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<tr>
<td></td>
<td>fireman's lifts</td>
</tr>
<tr>
<td></td>
<td>distance between fire services access point and fireman's lift</td>
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<tr>
<td>4. Fire Services Installations</td>
<td>fire extinguishers</td>
</tr>
<tr>
<td></td>
<td>hose reels and fire hydrants</td>
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<tr>
<td></td>
<td>emergency lighting</td>
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<td>5. Hazards</td>
<td>incompatible uses</td>
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<tr>
<td></td>
<td>electrical installations</td>
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<td></td>
<td>gas installations</td>
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<tr>
<td>6. Density</td>
<td>population per floor</td>
</tr>
<tr>
<td></td>
<td>number of flat per floor</td>
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<tr>
<td>7. External Defects</td>
<td>canopies</td>
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<tr>
<td></td>
<td>detached elements</td>
</tr>
<tr>
<td></td>
<td>finishes</td>
</tr>
<tr>
<td>8. Internal Defects</td>
<td>debonded tiles</td>
</tr>
<tr>
<td></td>
<td>cracks</td>
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<tr>
<td></td>
<td>spalled concrete</td>
</tr>
</tbody>
</table>

Note: Some strategic building management factors apply to all safety attributes and are not shown in the table. They include management organization (e.g. deeds governing common areas, owner’s corporations, and property management companies), documentation (e.g. the keeping of building records), emergency preparedness (e.g. plans for emergency situations, the provision of contingency funds), and evaluation systems (e.g. occupant survey).

**Level 3: Developing a Hierarchy of Building Factors**

The relationship between the safety attributes and various aspects of building factors is then mapped together to develop a hierarchy of building factors. Van Erdewijk (1988) stipulated that there were different categories of architectural elements, each of which was involved in accidents in a particular way. Heimplaetzer and Goossens (1991) confirmed the role of architectural features in the causation of accidents in the built environment. Therefore, building design should play an important role in building safety. Echoed by Al-Homoud and Khan (2004), apart from misuse and the lack of maintenance, poor design is one of the causes of building-related accidents. In this regard, building factors are grouped into two main categories, namely Design and Management at the top level, as shown in Figure 1.
The **Design** factors include three categories (**Architecture**, **Building Services**, and **External Environment**), which are further divided into 11 sub-categories. **Architecture** deals with the fire risk of buildings and the provision of the means of escape and means of access for fire-fighting and rescue in case of fire. Also, this category is assessed in respect of the measures against falling objects. For example, the provision of utility platforms and covered walkways at the street level can reduce the risk caused by falling objects. The design of **Building Services**, such as fire services, electrical installations, and fuel supply, also has a direct influence on the safety of users or occupants of buildings. As for the **External Environment**, hazards like the presence of a petrol filling station in the neighbourhood will be highlighted. Also, the location of buildings relative to certain civil services, like a fire station, is considered in this category. With regard to these design aspects, the safety issues of buildings can be addressed at the outset of a project.

Likewise, building factors under **Management** are grouped into two categories (**Operations & Maintenance** and **Building Management**), which in turn are sub-divided into seven sub-categories. **Maintenance** is the inspection and upkeep of various building fabrics and services; **Operations** refers to the tidiness and integrity of the exit routes and appendages to the building. **Building Management**, regarded as the software for improving the safety and condition of buildings, embraces strategic issues such as owner’s institution, arrangements of facilities management, emergency preparedness, and post-occupancy evaluation.

Each of the building factors at the bottom level was assessed in accordance with a scoring table, which was designed after a thorough consultation with experts in the relevant fields. The hierarchal representation facilitates the assessment of the relative importance of the building factors using the Analytical Hierarchy Process (AHP) (Saaty, 1982), which is essential for the construction of a single measure of the performance of building safety in the next stage.

**CONSTRUCTION OF THE BSCI**

The assessment framework presented above allows for the assessment of the conditions and safety performance of individual building factors in a building. It is often useful, especially for the public, to aggregate the performance of these individual building factors into a simple and user-friendly index for each building, which in this case is the BSCI. The BSCI is essentially an aggregate figure of ratings and weightings of all building factors:

$$BSCI = g(w_1, w_2, \ldots, w_n; F_1, F_2, \ldots, F_n)$$

where $w_i$ ($i=1, 2, \ldots, n$) denotes the relative importance (weighting) of the $i^{th}$ building factor in affecting the safety and conditions of a building; $F_i$ denotes the rating of the $i^{th}$ building factor collected using the above assessment framework; $n$ is the total number of building factors; and $g$ is a function that combines all $w_i$'s and $F_i$'s. The simplest form is the weighted arithmetic mean,
with all \( w_i \)'s summed to unity:

\[
BSCI = \sum_{i=1}^{n} w_i F_i
\]  

(2)

Multiple decision criteria systems, such as the AHP developed by Saaty (1982), will be adopted to calculate the weighting \( w_i \). Workshops are organized to interview representatives from relevant professional bodies and universities to determine the weightings of building factors perceived by these interviewees. Through a pairwise comparison of the relative importance of all factors at the same level of the hierarchy, the building factors can be prioritized. This is a relatively expensive way of collecting information, but it would greatly improve the reliability of the weightings, which is one of the most crucial aspects of the assessment framework of this study. When all \( w_i \)s and \( F_i \)s are found, the overall index BSCI can be computed. For the easy consumption of ordinary people, the index can be presented in forms of grades A, B, and C. Based on the index or grade, the general public can be better informed of the performance of buildings in respect of safety and physical conditions.

**What are the Benefits?**

What is ‘safety’? Perhaps one can find out some quite universally accepted definitions in the literature. However, nearly all of these come from the regime of occupational safety. There has not yet been any widely accepted definition of ‘building safety’. Being a loosely defined term, ‘safety’ presents different perceptions to different people. Since the BSCI is the integration of people’s perception with different background in a scientific manner, it can help fill in the gap. The primary function of the BSCI is to provide an objective inter-building comparison for distinguishing the good from the bad. It is believed that a well-publicized and well-received BSCI can serve as a benchmarking tool to measure and compare building performance in terms of safety and conditions.

**Revelation of Hidden Information**

Apart from the absence of a universal definition, ‘safety’ is not apparent and easily compared. For building users or occupants, the BSCI provides a useful tool for evaluating different aspects of a building that are not easily observable. By grading every building, such an index serves to inform people on how each building performs in terms of safety. For example, owners, potential buyers, and potential tenants can refer to the grading to decide whether or not to make a property transaction. It is of paramount importance to these parties, because other than lethal or injurious effects, the failure to observe building safety brings about indirect costs to property owners and investors. Leung (2003), by means of court cases, exemplified the effects of the claims and compensations in building-related accidents on individual unit owners and on their investment returns. In general, a large amount of damages, ranging from approximately HK$60,000 to HK$350,000 per unit, had to be borne by the unit owners of relevant buildings, and this amount constituted quite a substantial portion of the average value of the units.

**Reward or Punishment by Property Prices**

Another advantage of the BSCI is to distinguish buildings of similar ages with different safety performances. At present, without information for the hidden attributes of buildings, the public places a high emphasis on the age of a building. In fact, buildings with a better safety record should be valued higher. Through the BSCI, positive recognition is awarded to well-managed and maintained buildings. The labeling effect on those better-performed buildings will be translated into higher property values, and accordingly for worse-performed ones.

With a reassessment mechanism, property owners of buildings with lower grades could implement improvement projects to their buildings in consideration of the potential monetary benefits. In particular, owners of buildings with excellent intrinsic properties, such as locality, do not want these advantages blemished by the poor hygiene and safety performance of their buildings. Chau, et al. (2003 and 2004) empirically showed that improvement works brought about a 9 percent increase in the market value of properties in large housing estates, which far exceeded the cost of upgrading. Also, well-maintained buildings may attract more favourable mortgage terms and rental income. Eventually, the desire of owners for enhanced property
values and lower insurance premiums will bring market forces into play to encourage most owners to exercise their management and maintenance responsibilities.

**Promotion of Good Practices in Maintenance Management**

With the incorporation of design factors in the BSCI assessment scheme, developers will pay closer attention to their products and services. This is because higher grades obtained for their housing products or managed buildings can be a powerful marketing tool, especially when concerns over the quality of our living environment continue to surge.

More importantly, the BSCI offers information on good maintenance and management practices. Maintenance services providers can cross-check their practices with the criteria set for the scheme, and follow the practices to improve their services. Although the use of the BSCI for inter-building comparison of the maintenance performance is limited by the incorporation of design factors in the assessment scheme, the BSCI itself does serve as a useful performance evaluation tool for the maintenance managers. The continual maintenance performance can be evaluated by tracking the BSCI of the relevant buildings periodically. Furthermore, the BSCI can be used as a key performance indicator for maintenance services providers.

**Better Allocation of Resources for Maintenance**

It is not uncommon for building maintenance budgets to hardly meet the ever-increasing maintenance needs of their buildings (Shen and Spedding, 1998). Hence, it is essential to ensure that the best solution in terms of 'value for money' is achieved in a planned maintenance programme. The BSCI can be used as a priority setting tool for budget planning, providing a basis for allocating and directing funding to specific building problems. The value of the BSCI becomes more apparent when owners have a large portfolio of investment assets, and fiscal resources for maintenance are limited and must be spread out over extended periods. Needless to say, this priority setting function of the BSCI can help the government efficiently allocate resources to the areas where action is most needed.

**CONCLUDING REMARKS**

The problems associated with building hygiene and safety do not only affect property occupants or users. The problematic results and their costs are spread across the society. Undoubtedly, these problems should be properly addressed without further delay. Instead of resorting to the problems of intolerable incremental remedies, a long-term view should be taken. The implementation of the BSCI is beneficial to all parties. For building occupants and users, the assessment scheme provides a useful tool for building performance evaluation. For developers, building owners, and maintenance and management services providers, the information provided by the assessment scheme encourages better construction and maintenance of their buildings. The BSCI can be used to evaluate maintenance performance and help set priorities. For the government, the results of the BSCI can be used as a policy tool. As a result, the BSCI assessment scheme will serve to foster a culture of constructing and maintaining good quality buildings.

**REFERENCES:**


