Journal of Building Engineering 9 (2017) 17–28

Contents lists available at ScienceDirect

Journal of Building Engineering

journal homepage: www.elsevier.com/locate/jobe

Key Performance Indicators for Building Condition Assessment

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ARTICLE INFO

Keywords:
Building Condition Assessment
Degradation
Asset management
Decision making

ABSTRACT

Purpose: The aim of this research is to give to construction industry stakeholders some Key Performance Indicators (KPIs) able to help them making the best decisions when acquiring, operating, maintaining and repairing a building. These KPIs are intended to be included inside a Building Condition Assessment procedure developed by the authors.
Approach: This work is mainly based on two types of KPIs: one, here called Technical index, to assess building degradation and maintenance, so to have a measure of how the asset is getting older; and another, here called Documents index, to measure the quality and quantity of available building documents and thus to know if the building fulfils its legal requirements.
Findings: The proposed KPIs give a picture of the asset current condition, a measure of how it is maintained, the list of its pathologies and also an indication of missing documents.
Research limitations: The KPIs developed are meant to help survey an asset with only visual inspections. In case one or more serious problem are detected, a specific analysis may be required, no matter the final value of the KPIs.
Practical implications: The knowledge about built assets given by these KPIs will help stakeholders in making the best decision when operating or deciding to buy an asset.
Originality: KPIs and Building Condition Assessment procedure are the outcome of an original research that had the purpose of developing instruments for a reliable but quick evaluation of assets condition, to be performed before acquiring them or making major decisions about their refurbishment.

1. Introduction

Operating, maintaining and, eventually, refurbishing constructed assets is every year harder because new performance requirements, as instance UK is now legally bound to reduce emissions by 80% on 1990 levels by 2050 [1], have to be fulfilled whilst assuring economic yield. The owners' requirement of having an economically-efficient asset must, nowadays, be satisfied with the same priority of having, for example, a low CO_2 impact building. As a consequence, decisions of asset managers are becoming more complicated and a deep knowledge of the asset condition is needed [2].

Typically, asset managers must make decisions about maintenance and renewal alternatives based on sparse data about the actual state of their own assets [3] and this often causes the waste of much money: one third of all maintenance costs are used inefficiently as the result of unnecessary or improper maintenance activities [4]. Moreover, researches highlight that most of the stakeholders in the construction industry – designers, contractors, suppliers and owners – are wasting a huge amount of money looking for, validating and/or recreating facilities information that should be readily available. For example, a NIST study [5] estimated that operations and maintenance personnel spent, during year 2002, US $4.8 billion verifying that documentation accurately represented existing conditions of capital facilities, and another US $613 million transferring these data into a useful format.

Assets owners are constantly in search of new solutions to these problems and the outsourcing of maintenance activities is one of the strategies used. In terms of maintenance outsourcing, a set of potential and attractive benefits can be reached such as to reduce maintenance costs, to improve environmental performances, to obtain specialist skills not available in house, to improve work quality, etc.. However, outsourcing also involves a set of drawbacks that must be taken into account, among these [6]:

- loss of control and loss of a learning source, because an internal activity is externalised;
- loss of knowledge of the building;
- possible dependencies on the supplier.

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http://dx.doi.org/10.1016/j.jobe.2016.11.004
Received 16 May 2016; Received in revised form 25 October 2016; Accepted 9 November 2016
Available online 15 November 2016

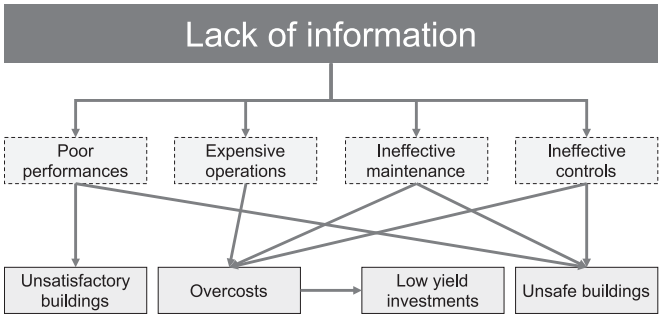

Fig. 1. Main issues due to lack of information on existing buildings.

Maintenance outsourcing is frequently associated to a global service contract: in brief, a company is demanded to manage and perform a set of defined maintenance operations scheduled over a period of time. Frequently happens that the client, to save additional money, does not ask for detailed feedbacks or statistics about components condition; this leads to the loss of important information about the asset. As a consequence of this loss, the client after some time is no more able to control the supplier, its work and asset condition. The Key Performance Indicators (KPIs) herein presented could be used as a valid instrument to monitor building condition over time, even better if the controls are planned periodically through the life cycle of the asset.

Problems related to lack of building knowledge arise also at building handover, when facility managers typically receive many "bankers' boxes" full of information about their facilities. Today those who use information provided must, at best, pay to have the data keyed into the relevant data systems. At worst, facility maintenance contractors are paid to survey the existing building to capture as-built conditions [7].

The lack of information, therefore, causes more or less directly a series of other problems (Fig. 1) that may lead to: (1) the use of unsafe buildings, e.g. buildings that do not comply to basic law requirements; (2) unsatisfactory buildings, e.g. buildings with poor performances; and (3) low yield investments.

To increase stakeholders' satisfaction, this lack of information must be filled and one possible way to improve the knowledge about assets is given by Building Condition Assessment (BCA), e.g. a technical inspection by a competent assessor to evaluate the physical state of building elements and services and to assess facility maintenance needs [8,9]. An asset evaluation achieved through a BCA can be included in the "performance evaluation and improvements" element, which is the basis of the asset management system outlined in the Annex B of the ISO 55000:2014 [10].

The surveys on buildings are the core of a BCA, their depth and outputs become critical when the analysis has to be performed on a building portfolio, because BCA has to help answering complex questions like: how to allocate maintenance budget on different buildings? How to choose the refurbishment alternative that best fits client's needs? Which is the best thermal insulation thickness to be used in a retrofit project? These questions are related to different asset scale, from single components to the entire portfolio, and can be answered using a rating system, consisting of BCA procedures and a set of KPIs, like the one herein proposed. This rating system enables stakeholders to make better choices about their assets; as instance, it is possible to find most damaged components in a building in order to give them a priority when scheduling maintenance operations. But also each building in a portfolio can be analysed, describing it with the proposed KPIs, so to compare it with others to allocate maintenance budget. Moreover, forecasts on the future value of the KPIs if no maintenance is undertaken can be done.

Technical due diligence (TDD) is part of the Facility Management process [12]; TDD consists in the observation of the general physical condition of an asset, looking for deficiencies, with an explanatory report as output. A survey [12] reported that buyers and sellers asked for TDD during handover, but also banks and FM providers use this methodology; the objective is to avoid unexpected costs both during handover and in the starting phase of a FM contract. Facility and asset managers, demanded to make complex decisions about their assets, need to periodically gather reliable and detailed information related to three main fields: physical, functional and financial [11]. Although BCA is mainly aimed at calculating of indicators related to facility's physical condition, it also provides a support for financial indicators computation. KPIs and BCA procedures developed by the authors can be considered a way to perform a TDD, and therefore integrated in the current practice.

Another example of the importance of physical condition indicators, together with financial ones, are given by Shohet and Nobili [13], which developed a performance-based contracting methodology for maintenance; the Building Performance Indicator (BPI) that they defined, related to physical state and fitness for use, is one of the KPIs used as the basis for contracting.

Facility managers are also demanded to make decisions about refurbishment needs of their assets; BCA can be considered a measure of the service quality and therefore fundamental for prioritising renewal [14].

2. Building Condition Assessment

BCA may be seen as a way to improve asset management knowledge and asset monitoring, as well as a method to enhance asset information management. BCA is thus part of the activities aimed to minimise financial and capital costs over the building life cycle while maximising asset value for every stakeholder. The importance of assets knowledge (and therefore of BCA) in a proper asset management programme is highlighted by Foltz and McKay [15] and by Ezovski [16], the latter focusing on commercial buildings. Reliable and objective knowledge of the physical state of their buildings will enable owners to develop appropriate strategies and actions for maintenance, repair, major replacements, refurbishments and investments [9]. All constructed assets should be assessed on an ongoing basis, so the assessment does not necessarily have to be performed all at once; the most effective asset management and reporting is often achieved through a planned condition assessment programme [17].

BCA techniques have been studied since the birth of the necessity of measuring assets performances during their service life [18–22], to consequently maintain them in the most effective way. Baird et al. [23] defined nine different types of evaluation techniques, from empirical to theoretical and from internal to external (Table 1).

Most of the assessment techniques found in literature fits in the categories shown in Table 1. For example, Shohet [24] described some methods, with different objectives and measuring parameters, based on qualitative evaluation criteria (e.g. the surveyor indicates the good/bad state of building components); Johnston et al. [25] defined other techniques, based on cost-driven KPIs and physical state rating, in combination with standards and regulatory compliance checking.

Assessment methods can vary also according to the building scale under analysis: from general (the whole building, if need be, split in macro groups) to particular (only one kind of component: e.g. windows). In the latter case, each component has a specific and detailed evaluation method, like for façades [26], for roofs [27], for rendering façades predictive maintenance [28], for ETICS [29] and for the entire envelope [30].

BCA, as part of the asset management system defined in the ISO 55000:2014 [10], should be conducted in combination with other important activities, like inspections and maintenance operations. Inspections often cause costs overrun if not efficiently organised and must be planned considering what is to be inspected [31]. Maintenance operations, in terms of both scheduling and costing, must be planned consequently to the building assessment to be the most effective as