Received 18 October 2018
Revised 31 December 2018
28 March 2019
Accepted 21 May 2019

Sustainable built heritage: maintenance management appraisal approach

Brit Anak Kayan
Centre for Building, Construction, and Tropical Architecture (BucTA), Faculty of Built Environment, University of Malaya, Kuala Lumpur, Malaysia

Abstract

Purpose – Sustainability encapsulated economic, environmental and societal parameters. Without exception, these parameters also conforms the efficiency and increasingly importance of sustainable maintenance management for built heritage. However, there is less attention to the appraisal approach for maintenance management of built heritage, twinned with inconsistent and impractical assessment upon their maintenance strategies. With the aim to support sustainability, the purpose of this paper is to give an insight to the question on how the maintenance management appraisal approach practically determines and ultimately substantiates the decision-making process that promotes sustainable built heritage, based on current scenarios and practices in Malaysia.
Design/methodology/approach – Maintenance management appraisal for sampling of built heritage enables assessment of efficiency of maintenance and repair during maintenance phase based on survey (questionnaires) and statistical analysis.
Findings – It recognises the importance of maintenance management appraisal in achieving efficiency and underpinning rationale decision making for maintenance strategies and service quality (SERVQUAL).
Practical implications – It must be emphasised that maintenance management appraisal is not confined to built heritage, and can be applied to any types and forms of property. The decision made as a result of its utilisation is practically support sustainable repair.
Social implications – The implementation of this appraisal highlights the efficacy of maintenance strategies and SERVQUAL that may be adopted.
Originality/value – The paper is a rigorous appraisal of maintenance management of built heritage. This appraisal relays the "true" sustainable built heritage, contextualised within maintenance strategies and SERVQUAL that consequently allows rationale in achieving sustainable development.

Keywords Sustainability, Built heritage, Statistical analysis, Sustainable repair, Maintenance management, Appraisal approach

Paper type Research paper

1. Introduction

Sustainability encapsulates economic, environmental and societal parameters. Thus, an appraisal upon the efficiency of maintenance management for built heritage is no exception, to conform these broad parameters. Within the realm of sustainable development, maintenance management appraisal of built heritage is currently undergoing a paradigm shift (Hill, 2016). Gradually, sustainable built heritage is moving away from the conventional belief that it will be characterised entirely by state-of-the-art of maintenance intervention, by using relevant cutting-edge technologies and contemporary repair materials. Practically, maintenance intervention prolongs life cycle and safeguard cultural values of built heritage. It maintains their historic fabric (Brereton, 1995), becoming guiding principles for modern society (Sodangi *et al.*, 2014), explicitly involving good maintenance programmes to achieve effectiveness, continuous care, regular investigation and reports (Kayan, 2015). It is said that effective protection of historic fabric of built heritage through maintenance

The author would like to thank the contribution made by the Department of Development & Estate Maintenance, University of Malaya, Kuala Lumpur Malaysia, Department of National Heritage, Malaysia, and Mr Yang Rui for access to building maintenance and repair data.

Journal of Cultural Heritage Management and Sustainable Development
Vol. 9 No. 3, 2019
pp. 266-281

2044-1266
DOI 10.1108/JCHMSD-10-2018-0074

management is not only undertaken from a cultural perspective, but also from an economic viewpoint.

It must be emphasised that maintenance management of built heritage has regularly subjected to transformation during their whole life cycle because of the changes in economy. This is reflected in the fact that 50 per cent of Europe's national wealth is the sum up of its existing built environment (Balaras *et al.*, 2005; Forster and Kayan, 2009; Forster *et al.*, 2013). In the case of UK's gross domestic product, maintenance accounts for nearly half of its total expenditure on construction, mainly upon 450,000 listed and 10.6m pre-1944 buildings (Maintain Our Heritage, 2004; Balaras *et al.*, 2005). Remarkably, these buildings (also comprises of built heritage) had entailed an estimated of £30bn (in 1995 prices) in financial value of repair works, a figure that increased to £36bn in 2002 (at 2002 prices) (Department of Trade and Industry, 2002; Arup Research and Development, 2003). Notably, premature deterioration of these existing built environment assets is frequently associated with a lack of regular maintenance intervention and intrusive repair, which, in turn, can extensively decrease their significance values.

It is unquestionable that undertaken maintenance intervention of built heritage is not only crucial to protect their significant values, but also important for ensuring that the financial, economic and societal capital invested in the fabric is retained. Owing to this, maintenance management team can be more specific in outlining maintenance programme for built heritage by considering impact on their significant values, particularly on the benefits to the society, users and occupants (Worthing *et al.*, 2002). Meanwhile, Sodangi *et al.* (2014) suggested that in order to achieve a sustainable management of built heritage, it is of paramount importance that maintenance takes a leading role in conserving their significant values. Previous relevant studies highlighted that theoretical and knowledge development on sustainable maintenance programme and strategies of built heritage. These works promote the philosophy of effectiveness in maintenance management of built heritage including consideration upon key strategies such as active involvement (Dormaels, 2016), empowerment (Ferreira, 2018) and acknowledgement of culture and heritage of local community (Barghi *et al.*, 2017). Beneficially, this will provide mitigation to a sharp decrease in economic and ecological resources of built heritage, while their cost effectiveness helps to increase the preservation of authenticity and social development value.

On the other hand, impacts on significant value of built heritage by relevant challenges and building defects are commonly overlooked by maintenance management. Moreover, sustainable maintenance management appraisal approach of the built heritage remained to be not in the priority, which entail to inconsistent and impractical assessment on their maintenance efficiency. Subsequently, this leads to poor implementation of maintenance strategies, mainly due to consistent ignorance and absence of definite maintenance management principle, particularly in a repair process (Worthing *et al.*, 2002). Comparatively, a study within Malaysian context by Kamal *et al.* (2008) revealed that 40 per cent of local built heritage was in poor condition, and as highly as 80 per cent were severely damaged by building defects, mainly due to inappropriate repair undertaken by the maintenance management team. Meanwhile, the work by Zolkafli *et al.* (2019) established that the lack of maintenance is highly affecting strategies of maintenance for Malaysian built heritage. Quite similarly, in Western Europe, inappropriate repairs by the maintenance management team exacerbated defects problems, which, eventually, can have fatal consequences for built heritage property (Theodossopoulos, 2018). In line of this, there is need for adoption of knowledge framework in maintenance strategies in order to achieve sustainable repair on sociocultural significance value of built heritage (Akasah and Alias, 2009). Clearly, these previous works demonstrated that there is a relationship between sustainability and the effectiveness of maintenance management of built heritage, within the perspective of maintenance and repair.

In the context of built heritage, there are distinguished differences between maintenance and repair. ICOMOS (1999) suggested that "repair involves restoration or reconstruction"

(International Council on Monuments and Sites, 1999). While maintenance intervention, i.e. repair work on built heritage, is effective at "prolonging the life of the element", it will also, contribute to damages (Worthing *et al.*, 2002) and "unnecessary replacement" of historic fabric potentially reducing value as a source of historical information (Brereton, 1995). Feilden (2003) expounded that the minimum maintenance intervention principle, however, caused least harm to the historic fabric. Nevertheless, budgetary pressures can often conflict with this principle, with the motivation to spend budget allocation always resulting in unnecessary works being undertaken (Forster and Kayan, 2009). Moreover, the nature of annual budgetary bidding processes in most heritage organisations makes planned maintenance difficult to administer, resulting to uneconomical repair works (Mills, 1994; Smith, 2005). Evidently, in practice, repair works on built heritage posed philosophical questions and influencing maintenance decision, such as no matter how carefully the repair works are carried out, there is always the potential to seriously diminish their authenticity. Despite these problems, there is less attention to the maintenance management appraisal approach of the built heritage. Also, the assessment upon the efficiency of their maintenance strategies remained inconsistent and impractical. In addition, good maintenance practice still leaves a gap in effective management strategies (Isa *et al.*, 2011). For instance, in the context of Malaysia, Isa *et al.* (2011) expounded that the theory and practice of maintenance needs for built heritage are still not duly addressed. With regard to aforementioned issues, therefore, this paper aims to practically embrace the maintenance management appraisal approach, and reflects the growing importance of the meaningful determination of sustainable built heritage. It also gives insight on hypothesis of this research, i.e. appropriate appraisal of maintenance management practically determines and ultimately substantiates the decision-making process, which promotes sustainable repair for built heritage. Significantly, this paper attempts to evaluate the current scenarios and practices of the maintenance management approach in Malaysian built heritage, identify the main challenges and deficiencies of provided facilities service from a user's or occupant's perspective and propose the appropriate approach for optimisation. This was undertaken based on a survey (set of questionnaires), using statistical analysis and relevant evaluation parameters.

1.1 Main research question (RQ) and its objectives

It has been highlighted previously that sustainability integrates the economic, environmental and societal parameters. Moreover, these parameters also aligned with the efficacy and increasing significance of sustainable maintenance management for built heritage. Nevertheless, the appraisal approach for maintenance management of built heritage gained little attention. Also, this situation is worsened by inconsistent and impractical assessment upon their maintenance strategies. Therefore, the main RQ of this paper is:

> *RQ1.* How maintenance management appraisal approach practically determines and ultimately substantiates the decision-making process that promotes sustainable built heritage?

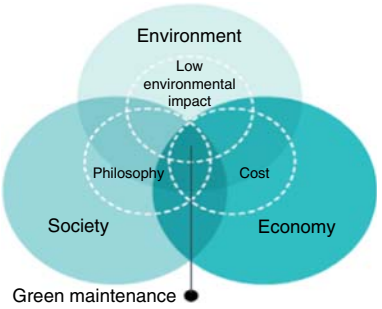
With the aims to supports sustainability, this paper gives an insight to the aforementioned *RQ1*. Based on current scenarios and practices in Malaysia, this research attempts to achieve the following specific research objectives (RO):

- RO1: to evaluate the current scenarios and practices of maintenance management approach in Malaysian built heritage;
- RO2: to identify the main challenges and deficiencies of provided facilities service from user's or occupant's perspective; and
- RO3: to propose the appropriate maintenance management approach for optimisation.

2. Sustainable built heritage repair: evaluation parameters

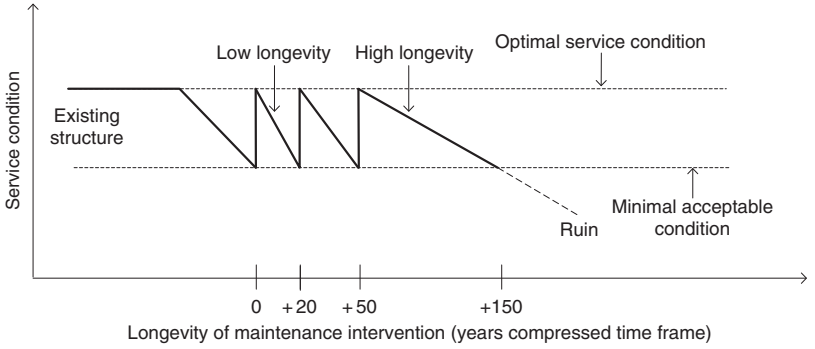
Philosophically, sustainable built heritage repair aims to better inform the evaluation of the long-term maintenance management requirements. It is appropriately directing decisions on their maintenance interventions in the form of the sustainable repair approach. Huq *et al.* (2017) suggested that the current condition of the built heritage commonly point out for appropriate maintenance interventions. This appropriate maintenance interventions are parallel with the conceptual model of "Green Maintenance". Figure 1 denotes the traditionally accepted conceptual "Green Maintenance" model within environmental, societal and economic parameters of sustainability. Moreover, the "Green Maintenance" model could be typified by a durable repair that suitably achieves the required broader set of building design and maintenance management requirement of built heritage. Notably, the model aims to better inform the evaluation of the long-term maintenance management requirements, appropriately directing decisions on sustainable maintenance interventions. Those maintenance interventions that intersect with all three parameters would potentially be considered as being the most sustainable in the context of built heritage repair.

Figure 2 shows how maintenance intervention implicates service condition of buildings (including built heritage) over time and their life cycle, with the downward sloping lines indicating a consistent deterioration process over the life of the repairs. Each maintenance intervention brings back existing structures to optimal service condition (which, in this case, is defined as when built heritage attained a good condition and able to fulfil its elemental functions). Subsequently, it then deteriorates through ruinous processes at a rate that



Source: Kayan (2015)

Figure 1.
Green Maintenance conceptual model



Source: Adopted from Forster *et al.* (2011)

Figure 2.
Impact of maintenance interventions on the optimal service condition over the whole life of buildings (including built heritage)

depends on the repair type. Maintenance intervention is assumed to occur when the minimum acceptable condition of built heritage is reached. Meanwhile, the saw tooth profile represents the results from successive interventions to extending built heritage lifespan, which has different durability and longevity of repair.

Every repair type has differences in terms of durability (unpredictability of estimated service life) and longevity of repair. Therefore, it is not necessary for undertaking structural and elemental repair for the built heritage only when they are reach the same level of optimal service condition. Additionally, the time between interventions is influenced by many variables, including material durability, degree of exposure, detailing, and quality of repair and specification. For example, in the case of undertaking repair of masonry structures and elements of built heritage at frequent intervals, it will increase the risk of mechanical damage, such as scaffolding installation. Conversely, less regular repair of masonry structures and elements of built heritage can reduce the risk of damages. This aligns with the philosophical principle of least intervention, which is sustainable. To achieve sustainable repair, the maintenance management appraisal approach of built heritage need to adopt comprehensive evaluation methods on maintenance strategies and service quality (SERVQUAL). This way of appraisal is essentially important to achieve effective maintenance programme and repair strategies for built heritage. Methodologically, the appraisal commonly adopted comprehensive evaluation based on sampling (Knight and Ruddock, 2008), conceptual model (Collins, 2010), structured interviews and questionnaires (Agbor, 2011), critical observation on common building defects (Rui 2015; McGibbon *et al.*, 2018) and evaluation upon user's satisfaction level (Brida *et al.*, 2016). Also, the appraisal was regularly involved SERVQUAL instrument application based on the gap model and dimensions for the facility services evaluation, with the aim to measure and manage the quality of service (Parasuraman *et al.*, 1985; Zeithaml *et al.*, 1990), determining provided services' ability to satisfy the user's needs (Isa *et al.*, 2011), evaluating SERVQUAL offered by the management team in one or more fields (Bauch, 1999) and evaluation of maintenance work from the owners' perspective (Zolkafli *et al.*, 2019). Practically, the results of maintenance management appraisal are normally analysed using Microsoft Excel and Statistical Package for the Social Science (SPSS).

3. Research methodology: maintenance management appraisal approach

This section explained the background and rationale of selection of the sampling (in this case, built heritage) for this research, including elaboration on components for maintenance management appraisal approach, analytical site observation, structured interviews, SERVQUAL instrument application and results analysis of SPSS.

3.1 Sampling of built heritage

Selected sampling (in this case is built heritage) for this research was owned and managed by maintenance management teams of respective Dewan Tunku Canselor (DTC), University of Malaya and St Mary's Cathedral located both in Kuala Lumpur, Malaysia. The selection of the sampling is corresponded with RO1, i.e. to evaluate the current scenarios and practices of maintenance management approach in the context of Malaysian built heritage. Significantly, both buildings were published in the *Gazette* and declared as heritage site under the provision of Section 67(2) of National Heritage Act 2005 (Act 645) of Malaysia. Owing to different functional uses of educational and religious institution, respectively, they are having different construction techniques and materials used. Moreover, despite their similar locality, these built heritage buildings had a dissimilar rate of deterioration on their building elements and materials. Both buildings are consistently deteriorated due to weathering effects of typical hot and humid of tropical climate of Malaysia, with large areas of exposed structures and elements. This influenced the longevity of the repair techniques

undertaken on them. Theoretically, the faster the rate of deterioration caused by exposure to weathering effects, the more frequently repairs were required and the larger of exposed area repaired (Kayan, 2013). For the purpose of this research, the testing was undertaken by using a comprehensive evaluation upon sampling (built heritage) to identify main challenges and deficiencies of provided facilities service from a user's or occupant's perspective (in accordance with RO2. Subsequently, analysis was undertaken based on data gathered from identified respondents of building maintenance management team of the selected sampling (in this case, built heritage). Methodologically, the epistemological underpinning for this research is grounded in sampling that is typically associated with the use of multiple sources of evidence and a strong context (Knight and Ruddock, 2008). The documentation data provided by the respective maintenance management team were sufficiently to enable a wide-scale, meaningful analysis. Clearly, this is an important consideration in determining a suitable research method and, more specifically, a rigorous survey approach for this research. In addition, the number of samplings was sufficient and therefore enabled great validity in testing the research hypothesis (see Knight and Ruddock, 2008). In this research, determination of the suitability of the sampling was primarily assessed over the research period. The gathering of key variables of SERVQUAL dimension criteria for selected sampling was essential for research success. Meanwhile, the documents evaluated were retrieved from archival records within the sampling and were used to test the hypothesis established and the broader conceptual model (Collins, 2010). Note that only repair undertaken during the maintenance phase of the sampling are considered for the appraisal purposes of this paper. In order to achieve comparative data analysis for both sampling, the appraisal was undertaken on the basis of making effective sampling of participants (respondents) through survey. The survey processes are explained in the following section.

3.2 Sampling of participants for survey

Participants (samples of respondents) for this research were chosen from users of selected built heritage buildings (parallel with RO1 and RO2). Required sample size was determined based on the respective confidence level of 95%, the confidence interval (margin of error) of 13.5 per cent the standard deviation of 0.5, using the following equation:

$$\begin{aligned} Sample\ \ Size &= \frac{z^2 \times p(1-p)/e^2}{1+(z^2 \times P(1-p))/(e^2 N)} \\ &= \frac{1.96^2 \times 0.5(1-0.5)/0.135^2}{1+(1.96^2 \times 0.5(1-0.5))/(0.135^2 \times 915)} \approx 49.83, \end{aligned} \tag{1}$$

where population size = N; margin of error = e; z-score = z; standard deviation = p; and the z-score for the confidence level of 95% = 1.96.

Based on Equation (1), a sample size of 50 is needed for each sampling.

In this research, 150 respondents of DTC were selected for the survey, mainly selected among University of Malaya students, who were the common users of the building. Questionnaires were distributed in order to achieve effective sample of 50. Respectively, the returning rate of questionnaires from the survey is slightly lower, with 33.34 per cent or 50 completed questionnaires returned. In the case of St Mary's Cathedral, respondents are selected among ten members of the management team, who are responsible for operation of the building. They were comprises of 7 pastors/pastor's assistants and 3 administrative staff, plus, approximately, 800 church goers (building users). To gain the highest number of respondents, the questionnaires was distributed during Sunday Mass Services. This is mainly due to the highest average attendance of church goers (respondents), spread over

different masses services for the whole day. In the survey, a total number of 120 sets of questionnaires were distributed, with a returning rate of (44.17 per cent) or 53 questionnaires returned. Only selected 50 reverted questionnaires were used as the sample for further results analysis, to achieve a fair and effective analysis on the effectiveness of the maintenance management aspect for both samplings.

3.3 Critical observations

For this research, critical observations were undertaken to attain better comprehension of adopted maintenance strategies and provided facilities services quality in the sampling (associated with RO1). This is parallel to the relationship between sustainability and the effectiveness of maintenance management of built heritage, which includes enriching SERVQUAL (Agbor, 2011) and experiencing a high level of satisfaction among building occupants, users or visitors (Brida *et al.*, 2016). Primarily, critical observation was undertaken to investigate the general building's physical condition. First, a sample of photos of commonly found defects was recorded, mainly for identification and characterisation. Then, these most common defects were analysed based on their respective diagnosis and prognosis.

3.4 Interviews

Structured interview was conducted upon the selected sampling (with management team members of built heritage). In this research, building manager of each sampling was selected as the sample of the respondents for the structured interviews (total sample of two respondents). Selected building managers were known actively involved in maintenance management of the sampling, both at a strategic and operational level. The interviews were undertaken mainly to establish their understanding on the current building's service condition. It also attempts to identify relevant issues of sustainability, problems and challenges faced by maintenance management team, led by these building managers (parallel to RO2). It involved an evaluation on their responses and feedbacks upon building maintenance and repair, including remedial action on building defects. Moreover, this was adopted to determine on how the team were to get in touch with the building's user concerns with regard to the building's service condition.

3.5 Questionnaires

Questionnaires were distributed among respondents comprises of the building's users and occupants. The selected respondents include members of maintenance management teams of different departments, who are using different space of the building during their working hours. Objectively, questionnaires of this research attempts to evaluate the respondent's perceptions upon the building's deficiency in terms maintenance management, i.e. an evaluation of impact in the context of efficient maintenance programme and strategies, as discussed previously in introductory background (see ICOMOS, 1999; Isa *et al.*, 2011; Sodangi *et al.*, 2014; Kayan 2015; Dormaels, 2016; Barghi *et al.*, 2017; Ferreira, 2018). This has been outlined in accordance to RO2. Eventually, this was undertaken to find the gap between the respondent's expectation and perception upon the facilities service provided in the sampling. The questionnaires act as a survey tool to gather useful data able to generate results analysis, specifically on deficiencies of provided facilities services in the sampling, from the respondent's perspective. It also gives insight on the latter's experiences while using building services and facilities of the former, using SERVQUAL application.

The SERVQUAL questionnaire in this research was administered in the form of two sets. The main set consists of 22 statements, seeking for perceptions of the respondents on actual SERVQUAL of the selected sampling. These statements were outlined to determine perception of the former upon the current SERVQUAL of the latter. Each statement

represents an aspect of one of the five dimensions of SERVQUAL, namely, tangible (question 1–4), reliability (question 5–9), responsive (question 10–13), assurance (question 14–17) and empathy (question 18–22) (Aziz and Sapri, 2013). It requires respondents to indicate their perceptions over the given statements (based on seven-point rating scale, with 1 = representing "strongly disagree" and 7 = representing "strongly agree"). Meanwhile, the second set of questionnaires, also comprising 22 statements, was purposely outlined to gather the respondent's expectations upon the provided building's facilities services. Identically, the respondents were asked to indicate their expectation using the similar rating scale.

As highlighted previously, each corresponding statement of the questionnaires was set to represent respective SERVQUAL's dimension: tangible, reliability, responsive, assurance and empathy (Rui, 2015). The first set of questionnaires collecting ratings for 22 statements mainly comprises the respondent's perceptions upon SERVQUAL of the selected sampling. Meanwhile, the second set 22 statements gathers ratings on the respondent's expectation upon the same parameters. In this research, the score gap was determined for each questionnaires, i.e. score gap = perception score – expectation score. Note that whenever the perception score is higher than the expectation score, the service rendered in the sampling is deemed to be above the user's and occupant's expectation. On the other hand, whenever the score gap is zero, the SERVQUAL meets the latter's satisfaction (Parasuraman *et al.*, 1985; Zeithaml *et al.*, 1990).

3.6 Service quality (SERVQUAL)

Gap model. In practice, the quality of service is difficult to measure, thus dissimilar to quality of a product, different in terms of the ability for quantification. Comparatively, the latter has measurement parameters such as length, depth, width, weight, whereby the former has various invisible characteristics, making it intangible and not measureable. Besides that, customer expectations upon the former vary. This is mainly due to the user's and occupant's previous experience and personal needs, which, in turn, is practically not easy to be identified. However, this issue can be resolved by SERVQUAL, which can provide the methodology to measure and manage the quality of service (Parasuraman *et al.*, 1985; Zeithaml *et al.*, 1990).

Based on the gap model of the SERVQUAL, the user's experiences in using provided services of the sampling were evaluated. Objectively, this evaluation mainly to determine the quality of provided services, which, theoretically, is purely from the user's point of view. In addition, SERVQUAL also enables the quantification of the user's experiences in using buildings services. The quantification is based on a comparison between expectations and perceptions of the users upon building's service performance. Theoretically, the user's collective perceptions of actual service performance is commonly exceeded their expectations. In terms of building performance optimisation philosophy, this is achieved whenever building management teams were able to provide services that able to satisfy the needs of users (see Isa *et al.*, 2011). This is connected with RO3. Conversely, if the perceptions of actual service performance of the building do not meet the expectations of users, the SERVQUAL offered by the management team is lacking in one or more fields (see Bauch, 1999).

Dimensions for the facility services evaluation. Operationally, facility services need to be supplied by the facilities management teams of buildings. On the other hand, however, every user and occupant of buildings has various standards for their respective expectation, perception and satisfaction upon these supplied facilities services. In this research, SERVQUAL instrument is utilised to find the gap between the expectation and perception of the latter. This is undertaken to determine the appropriate approach for optimisation (as per RO3). It evaluates

relevant SERVQUAL of buildings provided by the former, with an appraisal on the capability of provided services to meet standards set by the latter (see similarity of work by Zolkafli *et al.*, 2019) on the evaluation of maintenance work for heritage buildings in Malaysia from owners' perspectives). Table I shows the SERVQUAL dimensions used for the evaluation of facility services in the built heritage property (sampling) selected for this research.

4. Results

Research results analysis for both sampling was explained in the following section.

4.1 Observation diagnosis and prognosis of most common defects

Most common defects diagnosis and prognosis on both sampling (built heritage) is shown in Table II. These results are also associated with the respective RO1 and RO2.

4.2 Findings from interviews with facilities management team

Interviews with personnel from strategic level of facilities maintenance management team of Department of Development & Estate Maintenance, University of Malaya (JPPHB), revealed that they had prepared a long-term maintenance policy, by adopting regular maintenance for DTC. Frequently, repair works are commonly undertaken by the team prior to relevant ceremonies or official events, held at this building. The team indicated that the corrective maintenance intervention is normally carried out by them whenever building defects were identified during regular building inspection. Meanwhile, the team claimed that the main source for maintenance and repair budget (in the form of endowment) is mainly received from the Federal Government of Malaysia. In addition, there is an establishment of awareness and appreciation upon the importance of regular maintenance and care for DTC by the latter. However, it has been highlighted by the former that the financial support received from the latter to attain sustainable development and repair for DTC remained insufficient. These findings reflect the current scenarios and practices of maintenance management approach in Malaysian built heritage (as outlined in RO1. Notably, the critical success factors for maintaining built heritage including the creation of sufficient funding, effective management systems, competent personnel, continuous care, shared building's significant values, training and development of maintenance management team (Akasah, *et al.*, 2011). Comparatively, this is quite similar to findings from the work of Zolkafli *et al.* (2019), which discovered that a lack of maintenance of built heritage is commonly due to limited financial support.

Comparatively, facilities management team of St Mary's Cathedral indicated that their building is maintained by the National Heritage Department (JWN). On a mandatory basis, repair works for this building were executed based on maintenance policies outlined by the latter. It is found that the team raised their concern that regular maintenance of this building is mainly restricted to certain building elements only, such as external walls. Moreover, due to its national heritage status, the maintenance of this building is essentially under jurisdiction of JWN's conservation guidelines. Meanwhile, building repairs (including works

Dimension	Quality element
Reliability	All the facilities supplied should always be in good condition and can be used at any time
Tangible	Appearance of facilities supplied should be clean and attractive
Responsive	When damage or malfunction occurs, repair of facilities can be done timely and the repair time should be short
Assurance	Supplied equipment and facilities should always safe to be use without worries
Empathy	The facilities supplied should consider the user's specific needs and convenience

Source: Adopted from Aziz and Sapri (2013) and Rui (2015)

Table I.
SERVQUAL dimensions for facility services evaluation

Diagnosis and prognosis of most common defects	
Dewan Tunku Canselor (DTC)	St Mary's Cathedral
(a) Fungal stain and harmful growth Rapidly occur with the presence of water, high moisture and humidity due to a lack of ventilation in building materials such as masonry, bricks and concrete Creepers and ivy plants grow on either stone or brick walls with presence of the nutrients provided by water. Roots go deep into the existing holes of the wall or building elements causing cracks and water penetration Stains and deterioration caused by the roof leakage; rainwater discharge, continuous dripping and splashing on wall surface with moderate risk. The affected wall area needs to be monitored and inspected regularly to control the spread of the defect Installation of shades along the corridor of the building might reduce the further damage, which gives shelter to the wall rainwater leakage from the roof Repair needs to be done regularly to avoid high future cost	*(a) Peeling of paints* Usually occurs on exterior including building facades, plastered walls, columns, ground floor and areas that excessively exposed to rain and dampness, splashing from rainwater and direct sunlight Structural integrity of the wall largely not affected. Only a defaced wall surfaces, which requires regular repainting to maintain and preserve the historic fabric Regular inspection and maintenance of roof structures and covering materials, including remedial action on defective rainwater good
(b) Poor workmanship Poor installation of artificial ventilation equipment such as air-conditioning systems: shrinkage of building materials due to cooler and drier air, water dripping followed by condensation on building elements surface or building fabric, causing build-up of mold or fungal and stains, and affecting appearance and aesthetic Damage by exposed and corroded iron nails on the surface of the wall	*(b) Defective Rainwater Goods* Sagging or missing eaves gutters, corroded and rusty bracket of air-conditioning unit and broken galvanized iron down pipes or leaking rainwater heads Undersized gutters or down pipes and improper installation of water discharge at ground level which caused overflow, particularly during heavy rain Low quality of protection layer of painting on metal component of rainwater good causing corrosion and fracture Poor workmanship in projecting lead ears or lugs fixing to the wall, causing instability to the down pipes Regular repairs to conform Department of National Heritage relevant guidelines
(c) Cracks Either vertical or diagonal on walls as common symptoms of structural instability due to unstable foundations, presence of dampness, shrinkable clay soil, incompatible materials such as cement to patch cracks on existing walls, weak joints and thermal movement between wall and floor. Caused by the weathering effects, continuous exposure to rainwater, direct sunlight and wind, including shrinkage and sagging on frames of timber windows Physical uplifting by root of the trees close to the building causing cracks to the substructures such as foundations and walls The weight of the roof structures and elements components were forced to be received by the walls causing cracks due to overloaded	*(c) Dampness penetration* Water penetration through capillary actions; seeping through cracks between mortar joints and masonry materials, which subsequently trapped as moisture inside the building structures and elements Cracks and stains on the surface of building structures and elements; affects building appearance, mainly occurred on the pillar (particularly those located in the backyard with a lack of ventilation) Leaking gutters or down pipes, defective drains, burst plumbing and condensation due to inadequate air ventilation, causing mold on roof surface and moss on covering materials (roof tiles) due to high humidity and continuous sources of rainwater Rising damp caused by water penetration on building structures/elements through cracks or damaged mortar joints in the foundation and walls

Source: Adopted from Rui (2015) and McGibbon *et al.* (2018)

Table II.
Diagnosis and prognosis of most common defects on sampling (built heritage)

for improvement of appearance) were commonly undertaken by JWN on periodic basis (in this case, every ten years). In order to achieve sustainable repair, the team suggested that there is a need to provide viable budget allocation and regular maintenance interventions. Also, the team opined that the interior of the building is still in a good condition. This is mainly because they have been allowed regularly by JWN to take necessary repair works

within sectional interior area of the building, based on an in-house basis. It must be emphasised, however, that the execution of these repairs is highly depended upon budget allocation received from JWN. Notably, due to consistent budget constraints faced by JWN, which, in turn, leads to a lack of regular maintenance and repair, exterior wall defects of this building have been frequently aggravated. Looking ahead, in order to maintain and protect St Mary's Cathedral in more sustainable ways, the management team has set to resolve insufficient budget allocation for repair issues as their main priority.

4.3 Quantitative analysis

Dewan Tunku Canselor. Figure 3 shows that the overall score of facilities SERVQUAL for DTC is less than zero. This indicates that there is a significant gap between perception and expectation among its occupants and users. Notably, negative SERVQUAL gap values signify that none of the items in the quality of facilities service in DTC meets its occupant's or user's expectation (as per RO2). Subsequently, there are obvious dissimilarities between the numerical values of perception and expectation, which result in negative outcomes for all five evaluated dimensions. Despite having capability to attain its intended function, however, according to current occupants and users who are participated in the survey, the performance of DTC in terms of its specific facilities service remained at unsatisfactory level.

Figure 4 revealed that the expectation of DTC's occupants and users upon facilities services quality dimension are considerably low. Meanwhile, the perception values of the SERVQUAL are generally lesser than the expectation value. Moreover, there is a gap between the expectation and perception score, as per negative values for all five dimensions were evaluated. Significantly, the results also meant that the facilities' SERVQUAL of DTC is unable to fully meet the expectation of its occupants or users. Notably, empathy dimension among its current occupants and users has the widest gap of −1.772, as compared to the narrowest gap of −1.475 for assurance dimension. The gap values are all negative, indicating that the facilities provided did not meet the specific needs of current users and the occupants. Emergently, this signified that facilities' service of DTC needs to be urgently improved (as defined by RO3. Also, the occupant's and user's expectation is considerably high, with the highest score of 5.192 for SERVQUAL, under the empathy dimension. This was anticipated by the slightly lower score of 5.185 for the tangible dimension, followed by 5.125, 4.920 and 4.912 for responsiveness, assurance and reliability, respectively. In general, the results in Figure 4 show that facilities' service of DTC is still at an unsatisfactory level.

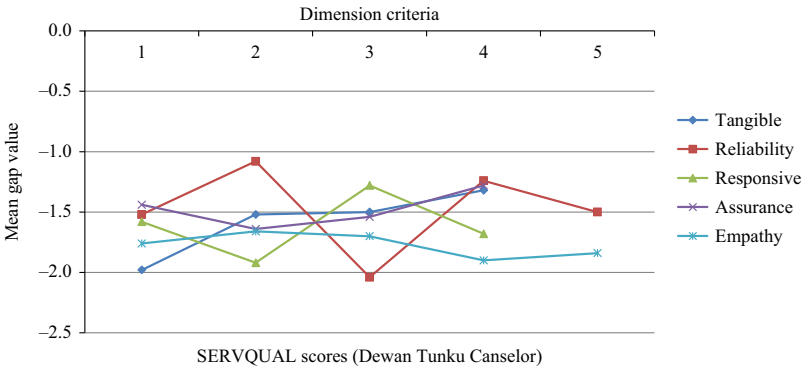
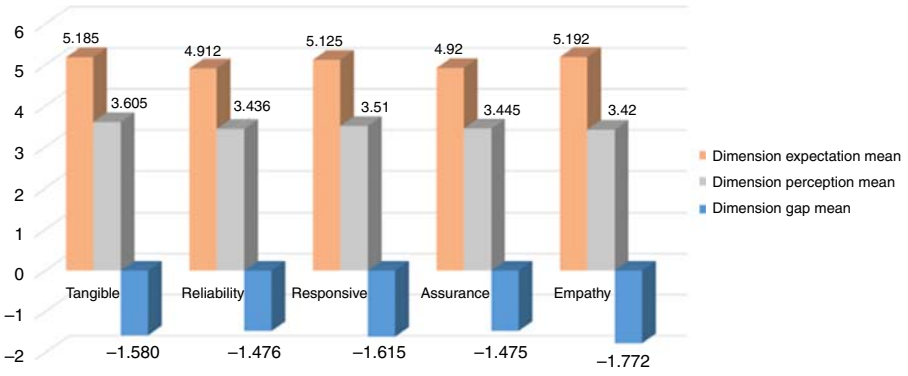


Figure 3.
Level of service quality (SERVQUAL) dimension criteria for Dewan Tunku Canselor

Source: Adopted from Rui (2015)

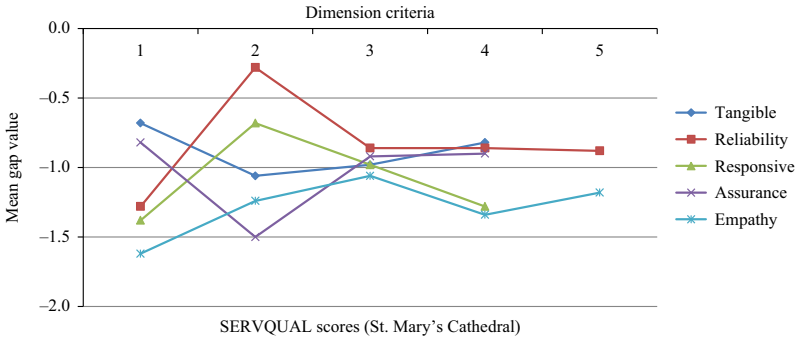


Source: Adopted from Rui (2015)

Figure 4.
Summary service quality gap for the five dimensions (DTC)

St Mary's Cathedral. In Figure 5, the overall score for all standards of facilities SERVQUAL of St Mary's Cathedral is zero. This indicates that there is substantial gap between perception and expectation values among its occupants and users (respondents participated in the survey). Moreover, all items in the quality of facilities service provided in this building are generally did not meet the occupant's or user's expectation, as showed by the negative SERVQUAL gap values (as outlined by RO2. Despite its ability to attain its intended function as a religious institution, however, according to its current occupants and users, the performance of this building in terms of specific facilities service is regrettably only at a substandard level.

Meanwhile, Figure 6 shows the expectation of current users and occupants of St Mary's Cathedral on the entire provided facilities service. In terms of its quality dimension of facilities service, the level of expectation of this building is considerably low, within the ranges of 4.910–5.056. Moreover, the perception on the facilities SERVQUAL among its users and occupants is relatively low at the range 3.768–4.092, with the gap of −0.885 to −1.288 for tangible and empathy, respectively. This also means that the facilities SERVQUAL of this building is undesirably unable to meet the expectation of its current users and occupants (as per RO2). Though the reliability of the building is considerably good, however, there is a concern of current users and occupants upon its provided services quality. As these provided services are prone to aging (wear and tear), the main concern of current users and occupants is safety and risk issues, which need an improvement (to attain optimisation, as outlined in RO3).



Source: Adopted from Rui (2015)

Figure 5.
Level of service quality (SERVQUAL) dimension criteria for St Mary's Cathedral

5. Discussion

In this research, a similar pattern of results was found for both sampling (built heritage), particularly based on the survey of overall perception among users and occupants upon provided facilities' service. The mean for overall perception for both sampling is commonly lower than the overall expectation, which signifies a deficiency in their provided facilities' services. It is also found from the survey that the expectation value is commonly higher than the perception value for facilities' service, thus indicating that service provided for remained inefficient. As per the respondent's responses from the survey, provided facilities services for both sampling are unable to fully satisfy their specific needs. It also discovered that the most common building defects are appeared to be the main challenges and issues for both sampling properties, which influenced the rate of deterioration. Also, it is discovered that the rate of a building's deterioration is highly dependent upon their maintenance strategies and repair approaches undertaken by maintenance management team. Notably, the implementation of good maintenance strategies for both sampling is consistently problematic, with the common setback of insufficient budget allocation. It must be emphasised that, in order to rigorously evaluate impact of maintenance management appraisal of built heritage within different interval years of maintenance, there is a need to consider difficulties in controlling relevant influencing parameters, such as budgetary restraints and philosophical frameworks of heritage conservation. It should be noted that the applicability of traditional philosophical tenets for maintenance management impact appraisal commonly underpins the suitability of the built heritage's facilities SERVQUAL. Philosophically, these parameters could be extended to more specifically encapsulate sustainability domain. Theoretically, complex parameters and critical success factors influenced sustainability of built heritage. Practically, in the case of this paper, the most effective maintenance strategies in terms of sustainability of built heritage are those that most suitably accommodate all parameters and sustainable solutions for maintenance and repair.

To attain a better picture of maintenance management of built heritage, a wider scale of research sample is fundamentally required. It is also recommended that the qualitative research methods also can be applied to get a more comprehensive result of future research, with an inclusion of a validation process by the involvement of relevant experts in the field of built heritage. With broader and further in-depth appraisal approach, with a longer duration of research, a holistic analysis on the relationship between maintenance strategies and facilities SERVQUAL can be achieved.

6. Conclusions

The results of this research revealed that the maintenance management appraisal approach is able to provide the best options of maintenance strategies and facilities SERVQUAL of built heritage. This is aligned respectively with the aim and *RQ1* of this paper, which

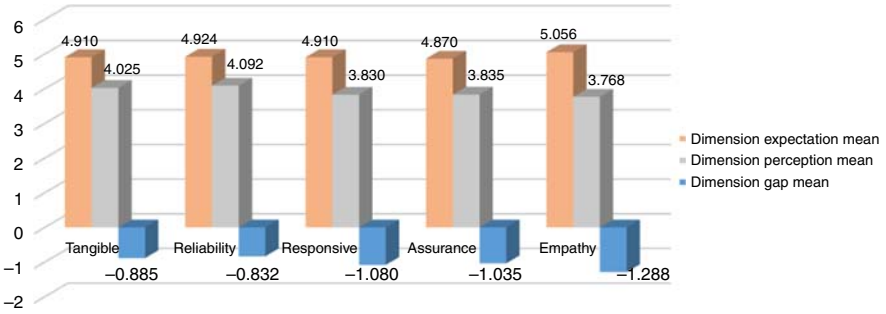


Figure 6.
Summary service quality gap for five dimensions (St Mary's Cathedral)

Source: Adopted from Rui (2015)

supports sustainability as well as gives an insight on how the maintenance management appraisal approach is practically able to determine and ultimately substantiate the decision-making process that promotes sustainable built heritage, based on current scenarios and practices in a Malaysian context. With the highest gap mean score, descriptive analysis based on data from the undertaken survey (using questionnaires) suggest that the most important aspect for improvement on maintenance management aspect is the dimension of empathy, with the highest gap mean scores of −1.772 and −1.288, respectively, for DTC and St Mary's Cathedral. From the survey, it can be concluded that empathy is the most significant dimension influencing facility services evaluation of both sampling. Philosophically, in heritage building conservation, this is essential to attain sustainable repair over their lifespan, particularly during maintenance phase. Substantially, this research had established and tangibly proof that this appraisal is also vital in achieving more rigorous analysis of maintenance strategies. Undertaken appraisal allows the rationale of different repair techniques and scenarios and ultimately makes maintenance decisions easier to defend. Ideally, to attain building performance optimisation, proactive action for facilities service improvement is paramount important. This had achieved RO1, an evaluation on current scenarios and practices of maintenance management approach in Malaysian built heritage. Obviously, to attain regular maintenance by competent and highly skilled maintenance team is highly recommended to improve the overall performance of built heritage. Built heritage performance optimisation is essentially required to have sufficient financial support and good maintenance plan and strategies, which should correspond well with their structural and elemental condition. These were associated with identified main challenges and deficiencies of provided facilities of the selected sampling from the user's or occupant's perspective as outlined in RO2. Moreover, it should be noted that the identification of main challenges and deficiencies of provided facilities is paramount important to achieve sustainable maintenance management approach for built heritage. Philosophically, this is not only sympathetically satisfying the specific needs of users and occupants of built heritage, but also beneficial to the society and local community, in the form of inheritance of maintained and protected significant values of historic fabric. Practically, this promotes adoption of a sustainable repair approach for built heritage through good understanding on the association between the maintenance strategies and facilities SERVQUAL. To achieve optimisation, this will provide guidance for proposal of appropriate maintenance approach for the built heritage (as specified in RO3). Consequently, it could be of value to those making and support sustainable repair for built heritage-focused decisions. Significantly, this work also can be expandable and replicable to both old and new build structures of different type and forms. Clearly, this will shift the current paradigm of conventional frameworks for maintenance management and enable improvement in its relevant area, particularly in achieving sustainable development.

References

Agbor, J.M. (2011), "The relationship between customer satisfaction and service quality: study of three service sectors in Umeå", master's thesis, Umeå School of Business, Umeå.

Akasah, Z.A. and Alias, M. (2009), "Application of the generic process modelling in the preservation of heritage school building", *Structural Studies, Repairs and Maintenance of Heritage Architecture XI: WIT Transaction on the Built Environment*, Vol. 109, doi: 10.2495/STR090291.

Akasah, Z.A., Abdul, R.M.A. and Zuraidi, S.N.F. (2011), "Maintenance management success factors for heritage building: a framework", *WIT Transactions on the Built Environment*, Vol. 118, pp. 653-658.

Arup Research and Development (2003), *Maintaining Value-Module 5: Demand and Supply, Building the Business Case for Planned Maintenance*, Arup Research and Development, London, (on behalf of Maintain our Heritage).

Aziz, Z.B.A. and Sapri, M. (2013), "An assessment of facility service quality performance for Malaysian public building: SERVQUAL approach", *Proceedings of the 4th International Conference on Business and Economic Research (4th ICBER), Bandung*, pp. 620-632.

Balaras, C.A., Droutsa, K., Dascalaki, E. and Kontoyiannidis, S. (2005), "Deterioration of European apartment buildings", *Energy and Buildings*, Vol. 37, pp. 515-527.

Barghi, R., Zakaria, Z., Jaafar, M. and Hamzah, A. (2017), "Students' awareness and attitudes toward archaeological conservation: Bujang Valley", *Journal of Cultural Heritage Management and Sustainable Development*, Vol. 7 No. 1, pp. 48-56.

Bauch, J.R. (1999), "Measuring service quality in recreational programs with SERVQUAL", *ICORE '98: Proceedings from the International Conference on Outdoor Recreation and Education, Fort Walton Beach, FL, 20–24 October*, pp. 45-50.

Brereton, C. (1995), *The Repair of Historic Buildings: Advice on Principles and Methods*, English Heritage, London.

Brida, J.G., Meleddu, M. and Pulina, M. (2016), "Understanding museum visitors' experience: a comparative study", *Journal of Cultural Heritage Management and Sustainable Development*, Vol. 6 No. 1, pp. 47-71.

Collins, H. (2010), *Creative Research: The Theory and Practice of Research for the Creative Industries*, AVA Publishing SA, Lausanne.

Department of Trade and Industry (2002), *Annual Construction Statistic*, Office of National Statistics, Newport, CA.

Dormaels, M. (2016), "Participatory management of an urban world heritage site: the table de concertation du Vieux-Québec", *Journal of Cultural Heritage Management and Sustainable Development*, Vol. 6 No. 1, pp. 14-33.

Feilden, B.M. (2003), *Conservation of Historic Buildings*, 3rd ed., Architectural Press, Oxford, pp. 235-250.

Ferreira, T.C. (2018), "Bridging planned conservation and community empowerment: Portuguese case studies", *Journal of Cultural Heritage Management and Sustainable Development*, Vol. 8 No. 2, pp. 179-193, available at: https://doi.org/10.1108/JCHMSD-05-2017-0029

Forster, A.M. and Kayan, B. (2009), "Maintenance for historic buildings: a current perspective", *Structural Survey: Journal of Building Pathology and Refurbishment*, Vol. 27 No. 3, pp. 210-229.

Forster, A.M., Carter, K. and Kayan, B. (2013), "Greening maintenance", *RICS Building Conservation Journal*, December 2013/January 2014, pp. 32-33.

Forster, A.M., Carter, K., Banfill, P.F.G. and Kayan, B. (2011), "Green maintenance for historic masonry buildings: an emerging concept", *Building Research & Information*, Vol. 39 No. 6, pp. 654-664.

Hill, S. (2016), "Constructive conservation – a model for developing heritage assets", *Journal of Cultural Heritage Management and Sustainable Development*, Vol. 6 No. 1, pp. 34-46.

Huq, F.F., Akter, R., Hafiz, R., Al Mamun, A. and Rahman, M. (2017), "Conservation planning of built heritages of old Dhaka, Bangladesh", *Journal of Cultural Heritage Collaboration Management and Sustainable Development*, Vol. 7 No. 3, pp. 244-271.

International Council on Monuments and Sites (1999), *The Burra Charter*, International Council on Monuments and Sites, Paris.

Isa, M.A.F., Abidin, Z.Z. and Hashim, A.E. (2011), "Built heritage maintenance: a Malaysian perspectives", *Procedia Engineering*, No. 20, pp. 213-221.

Kamal, K.S., Ab Wahab, L. and Ahmad, A.G. (2008), "Pilot survey on the conservation of historical buildings in Malaysia", *Proceedings of the 2nd International Conference on Built Environment in Developing Countries (ICBEDC 2008), Penang, 3–4 December*, pp. 104-115.

Kayan, B.A. (2013), "Green maintenance for historic masonry buildings: a life cycle assessment approach", PhD thesis, Heriot-Watt University, Edinburgh.

Kayan, B.A. (2015), "Conservation plan and 'green maintenance' from sustainable repair perspectives", *Smart and Sustainable Built Environment*, Vol. 4 No. 1, pp. 25-44.

Knight, A. and Ruddock, L. (2008), *Advanced Research Methods in the Built Environment*, Wiley-Blackwell, West Sussex.

McGibbon, S., Abdel-Wahab, M. and Sun, M. (2018), "Towards a digitised process-wheel for historic building repair and maintenance projects in Scotland", *Journal of Cultural Heritage Management and Sustainable Development*, Vol. 8 No. 4, pp. 465-480, available at: https://doi.org/10.1108/JCHMSD-08-2017-0053

Maintain our Heritage (2004), *Putting it Off: How Lack of Maintenance Fails our Heritage*, Maintain our Heritage, Bath.

Mills, E.D. (1994), "Design and building maintenance", in Mills, E.D. (Ed.), *Building Maintenance & Preservation: A Guide to Design and Management*, 2nd ed., Butterworth-Heinemann, Oxford, pp. 1-15.

Parasuraman, A., Zeithaml, V.A. and Berry, L.L. (1985), "A conceptual model of service quality and its implications for future research", *Journal of Marketing*, Vol. 49 No. 4, pp. 41-50.

Rui, Y. (2015), "The development of built heritage maintenance in Kuala Lumpur", master thesis, University of Malaya, Kuala Lumpur.

Smith, J. (2005), "Cost budgeting in conservation management plans for heritage buildings", *Structural Survey*, Vol. 23 No. 2, pp. 101-110.

Sodangi, M., Khamidi, M.F., Idrus, A., Hammad, D.B. and Ahmedumar, A. (2014), "Best practice criteria for sustainable maintenance management of Heritage buildings in Malaysia", *Procedia Engineering*, Vol. 77, pp. 11-19, available at: https://doi.org/10.1016/j.proeng.2014.07.017

Theodossopoulos, D. (2018), "Nineteenth-century housing preventive conservation in Edinburgh and its Western European context", *Journal of Cultural Heritage Management and Sustainable Development*, Vol. 8 No. 2, pp. 95-110, available at: https://doi.org/10.1108/JCHMSD-06-2017-0041

Worthing, D., Dann, N. and Bond, S. (2002), "Issues in conservation management", *Proceedings of the CIB W070 2002 Global Symposium: Applying and Extending the Global Knowledge Base, Glasgow, 18–20 September*, pp. 292-302.

Zeithaml, V.A., Parasuraman, A. and Berry, L.L. (1990), *Delivering Quality Service: Balancing Customer Perceptions and Expectations*, The Free Press, New York, NY.

Zolkafli, U.K., Zakaria, N., Mazlan, A.M. and Ali, A.S. (2019), "Maintenance work for heritage buildings in Malaysia: owners' perspectives", *International Journal of Building Pathology and Adaptation*, Vol. 31 No. 1, pp. 186-195, available at: https://doi.org/10.1108/IJBPA-07-2018-0062

About the author

Brit Anak Kayan is Senior Lecturer at Department of Building Surveying, Faculty of Built Environment, University of Malaya, Kuala Lumpur, Malaysia, and has graduated with Bachelor of Science (Building Surveying) (Hons) in 1999 and received Master of Science (Building) in 2003, both from University of Malaya, and Doctor of Philosophy (PhD) (Construction Management) from Heriot-Watt University, Edinburgh, Scotland, UK, in 2013. Brit has over 19 years of experience as academician and two years in industrial practice, latterly specialising in sustainable materials and repair in the context of "Green Maintenance" modelling, life cycle assessment (LCA) approaches, environmental maintenance impact (EMI) and low carbon building materials, both in new built construction and heritage buildings conservation. Professionally, Brit is Full Member of the Royal Institution of Surveyors, Malaysia (MRISM) and Registered Conservator of Department of National Heritage, Ministry of Tourism and Culture (MOTAC), Malaysia. Brit Anak Kayan can be contacted at: brit284@um.edu.my