Journal of Engineering and Applied Sciences 12 (17): 4349-4355, 2017
ISSN: 1816-949X

A Review on the Technical Performance Criteria of Post Occupancy Evaluation (POE) of Refurbished Heritage Museum Buildings

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Abstract: Heritage buildings in Malaysia are important in view of the fact that it reveals the history of the country besides acting as a landmark and also as tourism booster. Due to many important roles they play, conservation refurbishment is executed to conserve and preserve heritage buildings for future generation and some of them were adapted into new uses such as a museum. POE is executed to evaluate the building performance after they undergone a refurbishment process. Technical performance is one of the elements POE. Previous studies focus on limited technical performance criteria however this study will establish the technical part from a more holistic perspective focuses on a heritage museum building. Thus, this study focuses on reviewing the technical performance criteria of POE on refurbished heritage museum buildings from literature review and also from the semi-structured interview. This study adopts a comprehensive literature review from various sources such as journals, government documents, website documents, books and online books whereas, the semi-structured interview was conducted towards the experts from the museum department. Finding shows that the technical performance criteria for refurbished heritage museum buildings were temperature, relative humidity, lighting, acoustics, indoor air quality, MVAC, security, plumbing, sanitation, electrical services, fire safety, building finishes, structure, energy consumptions, water consumptions, pest control and lastly adaptability.

Key words: POE, technical performance, heritage, museum, refurbishment, MVAC

INTRODUCTION

A heritage building is a building that is built with unique architecture, scientific, culture and art perspective. In addition the material used and details of the buildings elements reflect Malaysia's cultural history (Syahru and Edwards, 2006). Due to the cultural uniqueness and high historical value these buildings embrace, tourists are likely to be attracted towards these heritage buildings thus making heritage buildings as one of the tourism booster in Malaysia. To ensure the longevity of the heritage buildings they were adapted into new use as one of the method of conservation. There quite a lot of museums and galleries that were adapted and listed under the Heritage List. The museums or galleries are National Textile Museums, Sultan Abdul Aziz Royal Gallery, The Stadthuys Malacca istana Jahar istana Kenangan and Seri Menanti Royal Museum to name a few. Refurbishment is a construction work to an existing building to change the original building which includes repair, conversion, renovation, restoration, conservation, retrofit and new build extension (Ismail, 2008). Nevertheless, refurbishment work is complex and uncertain (Ismail, 2008). Therefore, those refurbished buildings need to go under evaluation to ensure the buildings meet users requirement and performance standard. Post Occupancy Evaluation (POE) is a method of building evaluation which evaluates the performance of a building such as the technical and functional performance. Results from POE will provide a basis for a guideline to produce a better building in the future. POE has many elements of evaluation however; based on the literature review the most evaluated aspects of building performance were the technical and functional performance of a building.

Issue statement: There are many challenges in refurbishment works of heritage buildings which results in poor technical building performance. First thing first, the refurbishment work itself is a complex and uncertain (Ismail, 2008). It involves many works and involvement of many parties at one time. Other than that, the requirements for heritage buildings are stringent and also not uniform inconsistent and frequently change and this has made the refurbishment work become more

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complicated (Ali and Zakaria, 2012). On top of that, the availability and compatibility of materials also pose challenges in refurbishment of heritage buildings (Siti, 2014). Furthermore, the inadequate of design information pertaining to heritage buildings has forced the designers to produce a design based on their 'gut feeling' which will lead to major design failure due to wrong calculations (Siti, 2014). Besides that, a museum that was adapted from a building it must comply with the museum's mission which is to protect the cultural property (ICOM, 2009). However, when it comes to adapting a heritage building into a museum there could be a conflict between museum's mission and the restriction on refurbishment of heritage buildings (Brugman, 2011). Either the museum's mission is affected or the building historical value is jeopardized. Previous study focuses on limited technical criteria however this study will establish the technical part from a more holistic perspective.

As stated in the issue statement above, the stringent conservation regulations and also the complex and uncertainty refurbishment have affected the final products of refurbishment work. On top of that, many argued on the adaptation of museums from historical buildings because museums require specific requirements that affect the stability and safety of the collections it kept. They argued that it is better for the purposely-built museum to keep those invaluable collections. Museums have the requirements for them to comply with the collection, research, exhibit and education functions (Hugony and Ramsay, 2011). Most collections entail a specific kind of preservation such as relative humidity and temperature which require very expensive equipment as well as high energy and maintenance cost (Hugony and Ramsay, 2011). Due to that, during the refurbishment process, attention should be given to the building parts that cannot be modified and also the building parts that can be modified as well as the contribution of heritage building towards the achievement of museum's mission (Hugony and Ramsay, 2011). Therefore, the heritage museum buildings need to be evaluated especially in the area of technical performance to ensure it is perform under the standard performance.

MATERIALS AND METHODS

Aim and scope of study: This study aims to review the technical performance criteria of POE focusing on the refurbished heritage museum buildings only. The criteria is based only on the literature review from numerous published sources such as journals, government documents, website documents, books and online books focusing on the technical performance of POE of refurbished heritage buildings. A semi-structured interview was also conducted to identify more criteria that were missing from the literature review.

Rational of study: This study will provide knowledge regarding the technical performance criteria of refurbished heritage museum buildings in particular which benefits the conservator, building manager, contractor and stakeholders finds useful to improve the heritage museum building performance in the area of technical performance. Besides that, this study also will help the students and researchers in the area of museum building performance predominantly to do a further and deeper research associated to the heritage museum performance.

Post Occupancy Evaluation (POE): POE is a method of providing feedback from users throughout the building's lifecycle which is used in the future on technical performance of the building (Blyth and Gilby, 2006). POE is different from other types of building performance since it is focusing on the user's comfort. POE as a process of evaluating buildings in a systematic and scrupulous manner by comparing the overall building performance with stated performance criteria after they have been built for some time focusing on users need and the functionality of the design (Hassanain and Mudhei, 2006; QG, 2015). The stated performance criteria can be the same or different from each of the museums. POE intended to provide the view of the design consequences so that the lesson learnt can help in improving a better building in the future (Hassanain and Mudhei, 2006; QG, 2015).

POE has offer great benefits towards the building owners, stakeholders and also the occupants. The benefits range from short term to long term. In the short term, POE helps to identify the problems and determine the best solutions for it (Blyth and Gilby, 2006; Hassanain and Mudhei, 2006; QG, 2015). Not that POE helps to find the solution but also POE seems to be a great instrument and also a connection between the facility management and user's from the user's feedback. This would improve the facility management response towards user's demand (Blyth and Gilby, 2006; Hassanain and Mudhei, 2006). Consequently, the decision maker can learn from the design mistake made during the design stage and thus gain a valuable lesson for the future design (Blyth and Gilby, 2006; Hassanain and Mudhei, 2006; QG, 2015). In the medium term, POE helps in adapting a building into new use (Blyth and Gilby, 2006; Hassanain and Mudhei, 2006). POE is very useful before a refurbishment work to identify the strength and weaknesses of the particular building. Other than that, POE also helps to reduce the cost required throughout the building life cycle

Table 1: Summary of technical performance criteria of POE

Title	Researchers	Technical perfomance criteria
Technical performance criteria in general	Blyth and Gilby (2006)	Lighting, MVAC, acoustic, energy consumption, water consumption, energy consumption adaptability and durablity
	Hassanain and Mudhei (2006)	Ligthing, acoustics, fire safety, electrical services, sanitaion and structure
	Cooper *et al.* (1991)	MVAC, fire safety and health hazards
	Istvan	Lighting, MVAC, acoustic, energy consumption, water consumption, durability, fire safety, plumbing and envirnonmental impact
	Queensland Government	Lighting, acoustic, temprature and humidity
	Adewunmi *et al.* (2010)	Lighting, acoustic, temperature and indoor air quality
	Choi	Lighting, acoustic, fire safety and indoor air quality
	Hassanain and Mudhei (2006)	MVAC, fire safety, safety and security and plumbing
	Maclennan(1991)	MVAC, materials, building components and structure
	Preiser (1995)	Lighting, MVAC, acoustic, fire safety, electrical services, materials and building components
Technical performance criteria for refurbished heritage building	Atkins and Emmanuel (2014)	Lighting, MVAC, energy consumption, health hazards, temperature and indoor air quality
	Iyer-Raniga and Wong (2012)	Energy consumption and water consumption
	Shuang *et al.* (2014)	Lighting, MVAC, temperature, humidity and indoor air quality
Technical performance criteria for museum	Hyde and Davidson	Lighting, MVAC, energy consumption, water consumption, temperature and humidity
	Andreu and Oreszczyn (2004)	Lighting, MVAC, energy consumption, temperature, humidity and indoor air quality
	Bartsch *et al.* (2013)	MVAC, energy consumption, safety and security, temperature and humidity
	Leskard and Burden (2012)	Durability, safety and security, temperature and humidity
	Shuang *et al.* (2014)	Lighting, MVAC, indoor air quality, temperature and humidity

(Blyth and Gilby, 2006; Hassanain and Mudhei, 2006). POE seems to be one of the methods of preventive maintenance practice where the problems encountered in the earlier stage were eliminated immediately before it getting worse. Finally, in the long term benefit, POE will improve the design databases, standards, criteria and guidance literature (Blyth and Gilby, 2006; Hassanain and Mudhei, 2006). On top of that, POE can also develop the measurement of building performance through quantification (Blyth and Gilby, 2006; Hassanain and Mudhei, 2006).

There are three levels of investigations in POE namely indicative review, investigative review and diagnostic review. An indicative review is the simplest evaluation in POE. It is conducted to indicate the major failures and successes of the building's performance (Hassanain and Mudhei, 2006). The evaluation took only a short amount of time to identify the weaknesses and strength of the building to act as basis for further and deeper study. Most methods use were interviews, walk-through observation and also archival and document evaluation (Hassanain and Mudhei, 2006; Preiser, 1995). A more thorough investigation would be the investigative review that aims to investigate deeper into problems found during the indicative review using more rigorous technique (Blyth and Gilby, 2006; Hassanain and Mudhei, 2006; Preiser, 1995). Since, the evaluation is more profound, the methods use are more precise such as physical measurement backed up with questionnaire and interview that take week or more to complete (Blyth and Gilby, 2006; Hassanain and Mudhei, 2006; Preiser, 1995). A more holistic approach is the diagnostic review that analyse the physical performance data with occupant's responses (Hassanain and Mudhei, 2006). The physical performance data acquire from analysis of the building environmental systems were correlated with the occupant's perceptions to come out with the accurate predictions of the building performance.

Technical performance criteria on post occupancy evaluation: Technical elements are characterized as the background environment for carrying out activities in a building (Hassanain and Mudhei, 2006). This evaluation of technical performance is on the physical system's performance such as lighting, energy use, ventilation, acoustics, etc. (Blyth and Gilby, 2006). Technical elements require measurement using special instruments and require expert advice; therefore the procedure is way more complicated compared to other performance criteria such as the functional performance. The measurements of the technical elements are then compared to the actual stated performance criteria. As for example the temperature level inside a museum building is measured then compared to the standard temperature level for museum. In museum building, the technical performance is way more important compared to the other performance criteria because the background environment affects both collections and user's comfort inside the museum. Many writers have established the technical performance criteria of POE. Nevertheless, there has been little effort towards integrating the criteria. This study endeavours to provide a holistic perspective in establishing integrated technical performance criteria of POE of refurbished heritage museum buildings.

Technical performance criteria of poe for refurbished heritage museum buildings: Table 1 shows the summary of technical performance criteria of POE in general for

refurbished heritage building and also for museum from various researcher. Not only there are no specific elements of POE but there are also no specific technical performance criteria of POE. Based on literature review, the difference of technical performance criteria were due to different types of buildings being evaluated. Different types of buildings have different types of technical performance. Therefore, there is a need to establish technical performance criteria of POE not only to support the occupants in carrying their daily routine in heritage buildings but also to ensure the longevity of heritage buildings for future generation.

Therefore, based on Table 1 the technical performance criteria of POE of refurbished heritage museum buildings based on the previous evaluations were temperature, relative humidity, lighting, acoustics, indoor air quality, MVAC, security, plumbing, sanitation, electrical services, fire safety, building finishes, structure, energy consumptions, water consumptions and lastly adaptability.

RESULTS AND DISCUSSION

Temperature: This criterion measures the level of temperature that affects the user's comfort at the exhibition area and office area and also the collection's condition at the exhibition area and storage area (Matthews, 1991; NPS, 2015; Yau *et al*., 2013). In museums, temperature is very important aspect that requires extra attention. The temperature must be at certain required level depending on the types of collections they exhibit. Temperature that is too hot will accelerate the ageing process while too cold will make the material easily fracture (Yau *et al*., 2013).

Relative Humidity (RH): This criterion measures the level of RH that affects the user's comfort at the exhibition area and office area and also the collection's condition at the exhibition area and storage area (Yau *et al*., 2013). RH related closely with temperature. The level of RH is important to ensure the collections are not deteriorated besides providing an appropriate environment for visitors comfort and health.

Lighting: This criterion measures the level of lighting that affects the user's comfort at the exhibition area and office area and also the collection's condition at the exhibition area and storage area (Matthews, 1991; Sulaiman *et al*., 2011; Tetreault, 2015). Lighting is not only affecting the human's comfort but also can cause damage such colour fading and deterioration towards the collections (Karim *et al*., 2012). Therefore, the lighting is also one of the crucial elements in museum building performance.

Acoustic: This criterion measures the level of acoustic that affect the user's comfort at the exhibition area and office area and also the collection's condition at the exhibition area and storage area (Matthews, 1991). Noise can also affects the visitors comfort during their visits. It can disrupt the communication process between visitors and exhibitions. On top of that according to respondents from the semi-structure interview session for certain museum collections such as the fabric material, noise can also affecting the materials condition. The vibration from the noise can loosen the bond between the thread of the fabric.

Indoor Air Quality (IAQ): This criterion measures the chemical contaminants in the surrounding air that can affect occupant's health and comfort inside a particular building (Prihatmanti and Bahauddin, 2014). An indoor environment requires a good IAQ level so that the health of the occupants is in good condition. Besides that, according to respondents from the semi-structure interview, chemical contaminants also can affect the collections physically and chemically.

MVAC: This criterion emphasizes on the air conditioning performance and functionality (Matthews, 1991; Karim *et al*., 2012; Neuhaus, 2012). A museum must have a sufficient circulation of clean air not only for the occupant's health but also for the collections (Matthews, 1991). Hence, a museum needs to have a good MVAC system. Besides that, MVAC will help to keep the temperature and relative humidity levels are at the required levels.

Security: This criterion emphasizes on the of security features inside and outside the museum building (Matthews, 1991). Security is also an important aspect in museum. Due to the very valuable collections therefore, they are prone to theft. There are various types of security features that the museums can incorporate. A museum building that is adapted from other heritage building which requires special attention in incorporating a security system so that it will not affecting the building authenticity.

Plumbing: This criterion emphasizes on the water supply adequacy and defects of the plumbing system (Hassanain and Mudhei, 2006; KSHS, 2016; HE, 2016). This criterion is a common aspect in building evaluation that to ensure the occupants are comfortable with the water services provided. On top of that, old buildings have quite an issue with the hidden plumbing system that sealed inside the walls, ceiling and also underground.

Sanitation: This criterion emphasizes on the cleanliness of toilet, functionality or damage of each feature and also the adequacy of the service provided. This criterion is also important to promote the health of the occupants. Besides that occupants comfort also related with the toilet hygiene.

Electrical service: This criterion emphasizes on the performance of electrical system inside the building such as on the adequacy of electric supply, operation of all exterior outlets and switches and frequency of fuses or circuit breakers trip (Hassanain and Mudhei, 2006; Adewunmi *et al*., 2010; KSHS, 2016). The performance of electrical services is vital to ensure the MVAC systems are running smoothly and therefore the temperature and relative humidity levels can be maintain. Other than that, it is important to the officers to do their daily work.

Fire safety: This criterion emphasizes on the performance of fire safety features such as the structural fire plan, fire detection system and also the fire suppression system (NPS, 2015). Fire safety provision is very important in a museum building not only to protect the precious collections but also the important documents stored in the office and also the occupants itself. Fire is the greatest threat to the heritage building and it is very susceptible to fire due to several factors such as the large scale buildings, flammable priceless contents, large numbers of visitors and weak resistance towards fire. Some of the heritage museums were built from timber which is very susceptible to fire.

Building finishes: This criterion emphasizes on the appearance of the wall, floor and ceiling finishes such as the defects or any other issues (Matthews, 1991; KSHS, 2016). Building finishes have a high impact towards the building architectural appearance. Besides that, the appearance of the finishes also has an impact towards the communication process between visitors and exhibits (Matthews, 1991). Visitors might distracted by the paint that is too bright which cause glare.

Structure: This criterion emphasizes on the performance of each structure such as the column, wall, window, door, floor, stair and roof (KSHS, 2016). Each of the structural elements is evaluated on the defects and its performance. Structural elements inside building are very crucial to ensure the stability of the buildings. Moreover, a heritage building is an old building that is prone to structural failure.

Energy consumption: This criterion emphasizes on the energy usage in building such as from the lighting usage and air conditioner usage. Some of the heritage buildings were upgraded to more advanced services system that fitted according to functionality and aesthetically which has high-energy consumption to suit the modern needs (Syahrul and Edwards, 2006). Eventually, the energy usage in the heritage buildings are higher compared to new built building. Nevertheless, respondents mentioned that energy consumption is not a major concern in most government building including museum that is owned by the government.

Water consumption: This criterion emphasizes on the water usage in a museum building (Blyth and Gilby, 2006). Museums do not require as much water as other types of building. Therefore, the water consumption is lesser than other types of building. Nevertheless, same as energy consumption, water consumption is not a major concern in most government building.

Pest control: According to the responses from the semi-structure interview, some of them did highlight about the pest control. Some of the collections were made from the materials that attracting the pest which results in damaged collections. Therefore, pest control management is very crucial in order to keep the collections safe from pest attack.

Adaptability: This criterion emphasizes on the flexibility, convertibility and expandability of the building. A good adaptable building should flexible towards any changes, easily convert to new use and can be expanded. However, heritage buildings are ruled by tight legislations that do not allow for changes that can affect the original appearance. Therefore, for heritage building an adaptable building is building that allow for changes in building regardless the changes but does not require a demolition to the whole building. Nevertheless, the key to determine the adaptability is to identify whether the new uses of building is perform well.

CONCLUSION

As a conclusion, there are 17 technical performance criteria of POE of refurbished heritage museum buildings. However, these criteria were based on literature review and semi-structured interview that need a deeper study to establish the more holistic strategic technical performance criteria of POE of refurbished heritage museum buildings.

ACKNOWLEDGEMENTS

The researchers would like to acknowledge and extend heartfelt gratitude to the Government of Malaysia,

the Ministry of Higher Education (MOHE), Universiti Teknologi MARA (UiTM) and Research Management Institute (RMI) for the financial support to embark the study through Lestari Grant.

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