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Abstract
The purpose of a building is to provide shelter for activities that carried out by the building users. The question is, does the facilities in the building perform well and appropriate to its use? The needs of occupants are affected by the building performance and on occupants' evaluation of the buildings. Hence, Post Occupancy Evaluation (POE) is introduced to empower the occupants' opinion as the benchmark of building performance evaluation. POE comprises as one of the technique that is used to evaluate whether a building meets the user's requirement. The broad aim of this paper is to determine the correlation of public buildings and occupant's satisfaction; in order to seek possible opportunities for government involvement (as the building owner) and the public (as the user) to evaluate the performance criteria. By using a proposed framework of POE, the study has revealed that 74% of the aspects in building performance are in high correlation with the occupants' satisfaction. The study concludes that the application of POE is effective and beneficial to be used by the public sector in evaluating the performance of public buildings in Malaysia.

Keywords
Post occupancy evaluation, Public buildings, Building performance, Occupants' satisfaction, Correlation analysis

1. Introduction

A completed building must able to perform its functions in the manner that will ensure satisfaction to its occupants. Generally, regular maintenance programmes are conducted after the building has been occupied to ensure that the building is functioning well at all times. By execution of maintenance programmes, the occupants will be able to use and utilize the facilities as the provision of facilities supports the business operations by the building occupants. In short, the building facilities and services must be fit for the purpose of the users. Post Occupancy Evaluation (POE) is the evaluation of the performance of buildings after it is occupied. In addition, POE provides a mechanism to understand the mutual interaction process between buildings and the user needs and to recommend ways of improving the building performance and environment. Zimring and Reizenstein (1980) defined POE as an examination of the effectiveness of occupied design environments for human users. Vischer (2002) finds that POE is used not only to determine client's or user's satisfaction, but it is also used to fulfill other objectives. These objectives include determining building defects, supporting design and construction criteria, supporting performance measures for asset and facility management, lowering facility life cycle costs by identifying design errors and improve building performance. The approach implies a strong relationship between the development of a building project and the post occupancy stage. It serves as a

tool to account for building quality which is essential when organizations are required to demonstrate that building programmes are responsibly managed (Watson, 2003).

In relation to the title, the main purpose of this study is to determine the correlation between the building performance and occupants' satisfaction level for Malaysia's public buildings. The analysis of findings is determined based on the POE undertaken, which comprises of approaches and evaluation methodologies that address its effectiveness within the broader context of the problem in building procurement fragmentation.

2. Problem Identification

The federal government is the largest owner of public buildings and facilities in Malaysia. Despite the realization of the importance for the maintenance management of the public buildings, however it has not been emphasized clearly and systematically, which results in over budget costing for maintenance and remedial works (Zakaria and Hamzah, 2007). The reported cases of defects in public buildings are described in a chronology of events starting from year 2005 to 2007 (refer to Table 1).

Table 1: Chronology of Defective Public Building Cases in Malaysia (Source: Natasha *et al*., 2008)

DATE/YEAR	DESCRIPTION OF DEFECT OCCURENCE
April 2005	Collapsed ceiling at Parliament Building
Year 2006	Fungus infection on wall at Hospital Sultanah Aminah, Johor Bharu
Year 2007	Defects at Navy Recruit Training Centre (PULAREK), Johor
Year 2007	NKVE-Meru highway collapse
Year 2007	Floods from 7th floor down to 2nd floor at Immigration Department Putrajaya
Year 2007	Plaster ceiling collapse at Entrepreneurial Department Putrajaya
14 May 2007	Collapsed ceiling at the new court complex in Jalan Duta, Kuala Lumpur
17 May 2007	Collapsed ceiling at Parliament Building
21 May 2007	Leaking pipes caused flooding at the new court complex in Jalan Duta, Kuala Lumpur
28 May 2007	Collapsed ceiling at Hospital Sultan Abdul Halim, Sg. Petani, Kedah
November 2007	Fungus infection on wall at Hospital Umum Sarawak (HUS), Kuching
November 2007	Fungus and spores spotted on wall at Hospital Temerloh (HoSHAHS) Pahang

POE is a systematic method that gather data collection and information on a particular building but unfortunately it has not yet undertaken for public buildings in Malaysia (Zakaria and Hamzah, 2007). POE can be seen as a multifaceted tool to be adopted in solving problems of building and facilities management as it evaluates the performance of buildings and facilities systematically. According to Preiser *et al*., (1988), hundreds of POE has been conducted on a variety of building types over the last 25 years. Some solutions includes the increasing involvement of the organisation being studied, better presentation of results, and better targeting of information to appropriate decision makers (Zimring, 1988). Preiser (1995) stated that historically, building performance was evaluated in an informal manner, and the lessons learned were applied in the next building cycle of a similar facility type. Building performance criteria are an expression and translation of client goals and objectives, functions and activities, and environmental conditions that are required. Therefore, the outcome of this study information about building in use and shows how well the concept of POE works for the building management in public sector. The process of POE is relative to the integration of people's requirement and its workplace. Hence, POE is described as the best application strategy that needs to be adopted in evaluating performance of public buildings in Malaysia.

3. Research Objectives

The introduction and the problem statement above led to the formulation of the research aim and objectives. The broad aim of this research is to determine the correlation between performance of public buildings and occupant's satisfaction level, by using POE approach and guideline. In accordance with the research aim, the entailing objectives of this study are i) to review and analyze the performance of public buildings using the proposed framework of POE, ii) to determine the satisfaction level of the building occupants in terms of building elements, services and environment, and iii) to obtain the correlation between the performance of public buildings and occupant's satisfaction level.

4. Literature Review

POE as defined by Watson (2003) is a systematic evaluation of opinion about buildings in use, from the perspective of the people who use them. It is generally intended to convey the parameters of buildings that work well and also focus on the mistakes that should not be repeated in future designs of buildings. A POE study conducted by Watson (2003) at a public building i.e. Marlborough School Technology Centre, New Zealand found that the centre successfully supports student learning, and it produced key recommendations for the future. The result helps to improve the building performance when similar buildings need to be developed and helps to identify a measurable link between building quality and educational outcomes, which is notoriously difficult to show. The Federal Facilities Council (2002) has compiled results from POE to various types of government and public buildings in the United States (US) into a technical report. The study was conducted by six federal agencies in the US and among the objectives of such implementation is to increase building quality and performance. The summary of the findings provides input to the ongoing performance measures programmes for the offices and public building and enhance design improvement. Only building performance evaluation has the ability to accomplish this and POE provides the process of the actual evaluation of a building performance once in use by the occupants.

Despite many research undertaken in the context of building performance, the aspects of evaluating its performance is still not widely emphasized in Malaysia. The term of POE is still new and many building practitioners are unfamiliar with this approach in evaluating building performance. Therefore, a framework of POE is developed as a guideline to conduct the evaluation in a systematic way.

5. Proposed Framework for Application of POE

The suggested framework (Figure 1) is derived from the analytical literature review of the study which consists of the concept, process, phases and also in-depth review of previous study conducted from previous research. This framework consists of a systematic sequence of six (6) steps involving identification of building parameters; evaluation of objectives; selection of planning approach; conducting of the POE inspection; application of findings and actions in response to feedbacks. The steps fall within three (3) phases namely, the initial phase; process phase, and recommendation phase. Each phase illustrates issues or activities that need to be addressed in the POE. This framework provides potential application of POE for public buildings in Malaysia.

6. Analysis and Findings

Based on the framework of POE, an inspection survey was conducted to eight (8) selected public buildings in Putrajaya, the administrative urban centre of the government where major of public buildings are located. The analysis of this research is divided into three (3) sections. The first section features comparative analysis on building performance review in the pursuit of determining the score performance either under poor, medium or good performance. The second section features the analysis on the survey findings pertaining to the satisfaction level of the surveyed building occupants in terms of building

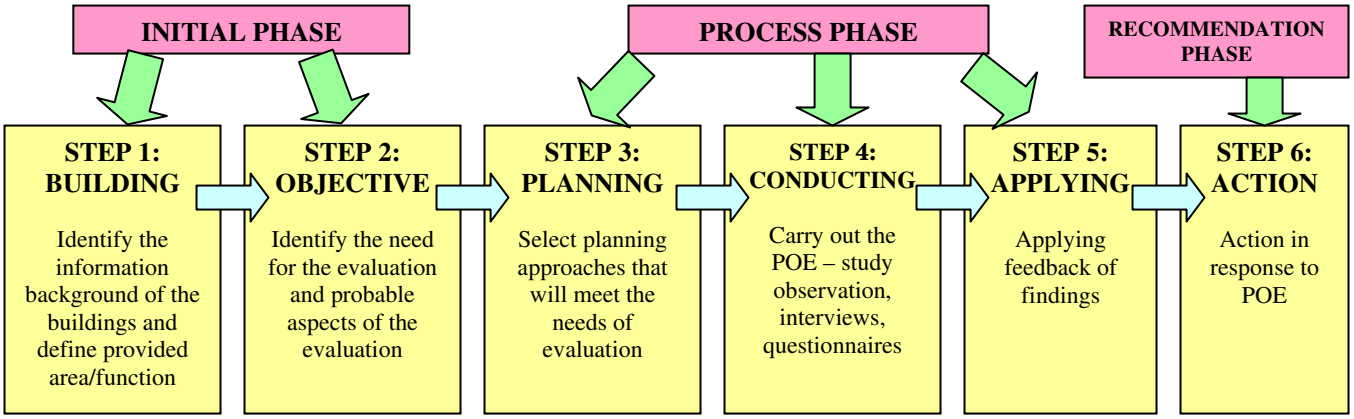

Figure 1: Suggested Framework for Application of POE

elements, services and environment (building parameters). The findings were derived from 133 replied survey questionnaires out of 160 survey questionnaire sets that have been distributed and the respondents consists of the building occupants of the government and public buildings in Putrajaya. The final section features the correlation analysis between building performance scores and the building occupants' satisfaction score.

6.1 Section 1 – Building Performance Review

The performance of building parameters is measured using a numerical Scale Category from 1 to 10 in a form of checklist which is based on the quality of building elements, services and environment which is based on the following formula:

$$PS = \frac{\text{Scale Category}}{\text{Full Score}}$$

where, PS : Performance Score
Full Score : 10

It denotes that the building performance score (PS) is poor if the scale category is below 0.4, medium if scale is 0.5 and good if the scale category is between 0.6 to 0.9. Table 2 presents the summary of results of the building performance score based on the 19 parameters of building elements, services and environment. The results from Table 2 show that generally the building performance is good; however, there are several buildings are rated in medium and poor performance. This evaluation is however conducted based on one time study visit and observation. Hence, the score needs to be compared with the occupants' satisfaction score as they had sufficient time to experience the performance of the buildings and therefore able to identify any chronic problems.

6.2 Section 2 – Occupants' Satisfaction Level

The survey was designed to determine the satisfaction level of the building occupants on the 19 parameters as stated earlier in Table 2 based on a Likert scale from 1 to 5; "1" - Very Unsatisfied, "2" - Unsatisfied, "3" - Medium Satisfied, "4" - Satisfied and "5" - Very Satisfied. Table 3 presents the result of occupants' satisfaction score by using the following formula to calculate the satisfaction score (SS):

$$SS = \frac{RS\,[N^5 + N^4 + N^3 + N^2 + N^1]}{FS\,[\text{Total } N^5]}$$

where, SS - Satisfaction Score
RS - Relative Score
FS - Full Score
N - No. of respondents
N^5, N^4, N^3, N^2, N^1 - (No. of respondents answered for Likert Scale) x (Likert Scale)

Table 2: Result of Building Performance Score

NO.	BUILDING ELEMENT, SERVICES & ENVIRONMENT	PERFORMANCE SCORE (PS)							
		"Poor" if 0.10≤PS≥0.40, "Good" if 0.60≤PS≥0.9				*"Medium" if PS=0.50, "Excellent" if PS=1.0*			
		BLDG #1	BLDG #2	BLDG #3	BLDG #4	BLDG #5	BLDG #6	BLDG #7	BLDG #8
1.	Floor Finishes	0.60	0.70	0.80	0.80	0.80	0.70	0.80	0.60
2.	Wall Finishes	0.60	0.70	0.80	0.80	0.8	0.90	0.80	0.80
3.	Ceiling Finishes	0.70	0.70	0.70	0.80	0.90	0.70	0.80	0.90
4.	Door	0.70	0.70	0.70	0.90	0.80	0.80	0.70	0.80
5.	Window	0.60	0.70	0.70	0.90	0.90	0.70	0.80	0.70
6.	Staircase	0.60	0.80	0.70	0.90	0.90	0.70	0.80	0.80
7.	Roof	0.70	0.60	0.80	0.70	0.80	0.60	0.80	0.70
8.	Quality of Finishes	0.60	0.60	0.80	0.80	0.80	0.70	0.70	0.70
9.	Quality of Structure	0.80	0.60	0.70	0.90	0.80	0.80	0.70	0.70
10.	Physical Maintenance	0.50	0.60	0.50	0.60	0.60	0.50	0.70	0.60
11.	Safety & Security	0.80	0.80	0.90	0.80	0.90	0.80	0.80	0.90
12.	Level of Cleanliness	0.80	0.70	0.90	0.80	0.80	0.90	0.80	0.80
13.	Quality of Lightings	0.60	0.70	0.60	0.70	0.80	0.50	0.70	0.60
14.	Air-Conditioning	0.80	0.70	0.50	0.90	0.80	0.40	0.80	0.70
15.	Landscaping	0.70	0.80	0.80	0.80	0.80	0.70	0.80	0.80
16.	Lift/Escalators	0.60	0.70	0.60	0.80	0.90	0.60	0.80	0.70
17.	Electrical & Mechanical	0.60	0.70	0.50	0.60	0.80	0.70	0.70	0.60
18.	Water & Plumbing Services	0.60	0.60	0.60	0.70	0.80	0.60	0.70	0.70
19.	Noise Pollution or Vibration	0.60	0.60	0.80	0.80	0.90	0.50	0.80	0.80

Table 3: Result of Occupants' Satisfaction Score

QUESTIONS	OCCUPANTS' SATISFACTION SCORE (SS) *"Discomfort" if 0.10≤SS≥0.49 "Neutral" if 0.50≤SS≥0.59 "Comfort" if 0.60≤SS≥1.0*							
	BLDG #1	BLDG #2	BLDG #3	BLDG #4	BLDG #5	BLDG #6	BLDG #7	BLDG #8
Q1- How satisfied are you with the finishes of the floor (its aesthetics, durability, suitability)?	0.58	0.65	0.73	0.77	0.73	0.66	0.62	0.60
Q2- How satisfied are you with the finishes of the wall (its aesthetics, durability, suitability)?	0.52	0.69	0.71	0.85	0.81	0.63	0.67	0.65
Q3- How satisfied are you with the finishes of the ceiling (its aesthetics, durability, suitability)?	0.57	0.64	0.61	0.77	0.81	0.66	0.65	0.71
Q4- How satisfied are you with the provision of door (its aesthetics, durability, suitability)?	0.55	0.67	0.67	0.84	0.82	0.63	0.63	0.71
Q5- How satisfied are you with the provision of window (its aesthetics, durability, suitability)?	0.40	0.64	0.55	0.87	0.83	0.58	0.71	0.70
Q6- How satisfied are you with the provision of staircase (its aesthetics, suitability)?	0.58	0.64	0.61	0.85	0.82	0.65	0.79	0.72

Table 3: Result of Occupants' Satisfaction Score (contd..)

QUESTIONS	OCCUPANTS' SATISFACTION SCORE (SS) *"Discomfort" if 0.10≤SS≥0.49 "Neutral" if 0.50≤SS≥0.59 "Comfort" if 0.60≤SS≥1.0*							
	BLDG #1	**BLDG #2**	**BLDG #3**	**BLDG #4**	**BLDG #5**	**BLDG #6**	**BLDG #7**	**BLDG #8**
Q7- How satisfied are you with the finishes of the roof (its aesthetics, suitability)?	0.57	0.68	0.61	0.83	0.81	0.63	0.75	0.67
Q8- How satisfied are you with the overall quality of finishes in this building?	0.57	0.56	0.65	0.81	0.73	0.60	0.69	0.65
Q9- How satisfied are you with the overall quality of structure in this building?	0.57	0.60	0.65	0.80	0.82	0.65	0.71	0.67
Q10- How satisfied are you with the physical maintenance in this building?	0.49	0.52	0.35	0.59	0.54	0.46	0.56	0.53
Q11- How satisfied are you with the safety and security in this building?	0.62	0.71	0.78	0.68	0.78	0.58	0.74	0.65
Q12- How satisfied are you with the level of cleanliness in this building?	0.68	0.64	0.78	0.79	0.80	0.68	0.74	0.71
Q13- How satisfied are you with the quality of lightings (natural & artificial) in this building?	0.58	0.61	0.54	0.75	0.76	0.41	0.66	0.59
Q14- How satisfied are you with the cooling system (air-conditioning) in this building?	0.52	0.68	0.39	0.84	0.78	0.39	0.72	0.56
Q15- How satisfied are you with indoor and outdoor landscape in this building?	0.46	0.51	0.81	0.73	0.80	0.53	0.66	0.66
Q16- How satisfied are you with the lift/escalators system?	0.54	0.68	0.56	0.81	0.84	0.55	0.72	0.65
Q17- How satisfied are you with quality of electrical and mechanical fittings in this building?	0.46	0.61	0.38	0.53	0.84	0.53	0.52	0.59
Q18- How satisfied are you with the water and plumbing services in this building?	0.55	0.59	0.54	0.80	0.72	0.59	0.69	0.66
Q19- How satisfied are you with the noise pollution or vibration? (eg. traffic, mechanical systems)	0.57	0.51	0.68	0.80	0.81	0.54	0.75	0.68

6.3 Section 3 – Correlation of Building Performance and Occupants' Satisfaction

The final section of the analysis involves the analysis of correlation of the occupants' satisfaction in relation to the building performance. The correlation analysis was undertaken using Kendall's tau correlation using the statistical software program SPSS (Statistical Packages for the Social Sciences, version 12.00). The analysis was undertaken to see whether the building performance correlates with the satisfaction level of building occupants' based on the 19 parameters stipulated in the questionnaires. Table 4 shows the result of correlations and it denotes that if the correlation is high (correlation score above 0.5), the application of POE is beneficial to be used to evaluate the performance of public buildings in Malaysia. The region of correlations is presented in Figure 2.

a) Region A – high correlations (top):

The correlation between building performance scores and the building occupants' satisfaction scores are positively high based on 14 out of 19 parameters; quality of window, staircase, lightings, lifts, floor finishes, ceiling finishes, door, overall finishes, maintenance, air-conditioning, landscape, M&E fittings, water services and noise control.

Table 4: Correlation Score between Building Performance and Occupants' Satisfaction

VARIABLES FOR BUILDING PERFORMANCE	Floor finishes	Wall finishes	Ceiling finishes	Door	Window	Staircase	Roof	Finishes	Structure	Maintenance
CORRELATION SCORE	**0.689***	**0.089**	**0.676***	**0.630***	**0.866****	**0.828****	**0.124**	**0.756***	**0.287**	**0.737***
VARIABLES FOR OCCUPANT'S SATISFACTION	Floor finishes	Wall finishes	Ceiling finishes	Door	Window	Staircase	Roof	Finishes	Structure	Maintenance

VARIABLES FOR BUILDING PERFORMANCE	Safety	Cleanliness	Lightings	Air conditioning	Landscape	Lift	M&E	Water	Noise Control
CORRELATION SCORE	**0.447**	**0.187**	**0.866****	**0.746***	**0.556**	**0.906****	**0.615***	**0.751***	**0.798***
VARIABLES FOR OCCUPANT'S SATISFACTION	Safety	Cleanliness	Lightings	Air conditioning	Landscape	Lift	M&E	Water	Noise Control

b) Region B – low correlations (bottom):

The correlation between building performance scores and the building occupants are positively low based on 5 out of 19 parameters; quality of wall finishes, roof, structure, safety and cleanliness. Nevertheless, despite having low correlations, they do not constitute a negative correlation. The possible explanation for these low correlations is the difference perception raised by the occupants.

Based on Figure 2, the correlations show that 74% of the parameters are in the region of high correlations between building performance scores and the occupants' satisfaction scores. Since majority of the parameters are in high correlations, therefore it can be concluded that POE is effective to be applied for evaluating performance of public buildings in Malaysia.

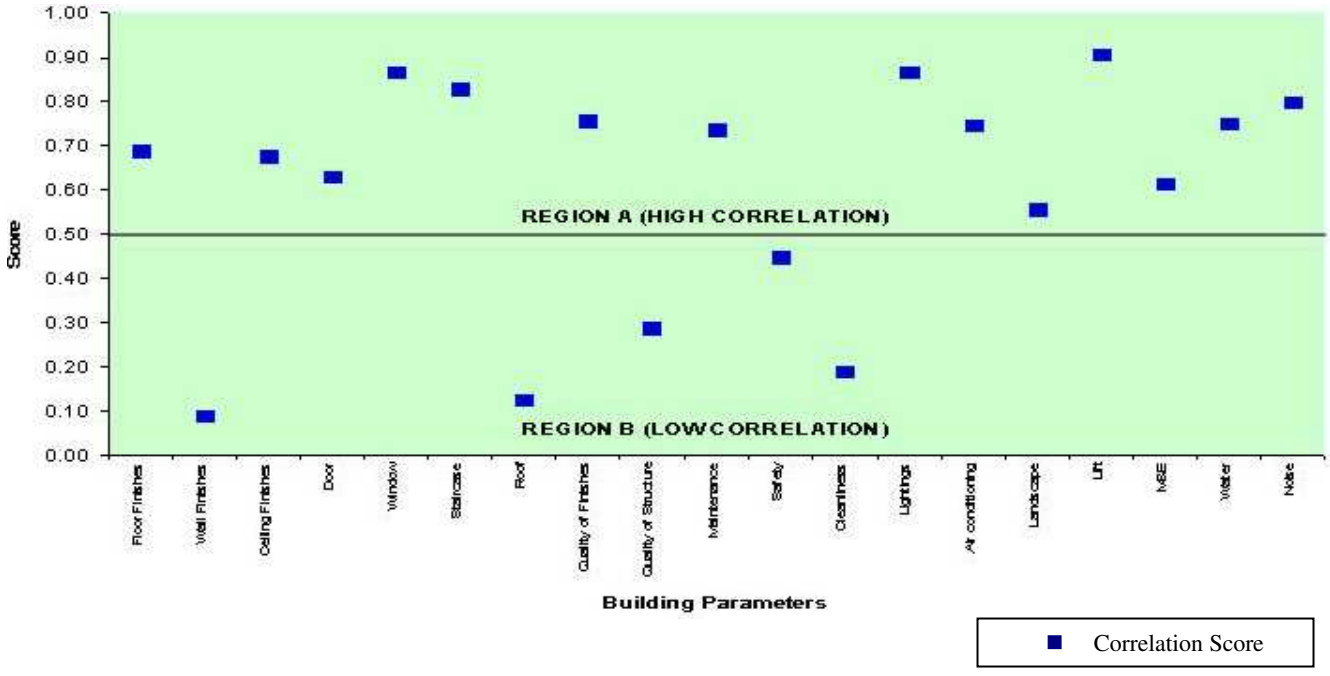

Figure 2: Region of Correlation between Building Performance and Occupants' Satisfaction

7. Conclusion

POE provides a valuable approach in analyzing the performance of government and public buildings in Malaysia. The approach has a great potential in analyzing building performance as it uses a strategic approach to achieve the best quality in building services, whereby the assessment integrates the building occupants' behaviour, perception and opinion as the building users. Inevitably, POE is a useful tool for building asset and facilities management; as long as the approach employed to collect feedback from users is effectively integrated towards performance quality of public buildings. The research also noted that much ideas and solution are developed to achieve buildings' sustainability and this can create an opportunity for wider application of POE, especially to public sector. The findings have also outlined the important considerations and recommendations towards improving the performance of the government and public buildings.

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