DEVELOPING A TBPE SCORING FRAMEWORK FOR ASSESSING TOTAL BUILDING PERFORMANCE

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ABSTRACT

Building Performance Evaluation (BPE) has received an increasing attention over the past two decades among the researchers to provide a comfortable and stable internal environment to increase and provide a better human potential. To determining how well the facilities are performing in order to support the organisational goals and user requirement, it is vital to conduct regular building evaluations which provide the current status quo of the building. Aiming to this, there are various BPE approaches developed around the world, and as evidenced there are no in-depth studies on Building Performance Evaluation (BPE) in tropical countries to evaluate the building performance. However, adapting these approaches might not necessarily be applicable in the context of tropical countries due to geographical, climatic, cultural and other differences. This has been identified as the gap in this research and aimed to formulate a holistic Total Building Performance Evaluation (TBPE) scoring framework, for the assessment of performance of buildings. First, a comprehensive literature survey was carried out. This was followed by an expert survey to sieve out the most significant BP factors identified in the literature survey. With that detailed questioner survey was carried out proposing a TBPE scoring framework compromising total of two hundred and sixty five points to evaluate buildings with 7 criteria and 57 dimensions in which energy management, reachability to the building, occupational hygiene, thermal comfort, unit costs savings, load bearing capacity etc had higher contribution in evaluating building with relation to tropical context. Finally, this paper readdresses the need of evaluating the buildings and suggesting the paradigm to evaluate the buildings in an objective manner.

Keywords: *Building Performance; Building Performance Evaluation; Total Building Performance Evaluation.*

1. INTRODUCTION

People spend more than 90% of their time indoors and buildings are the facilitators of organisational performance in order to provide a comfortable and stable internal environment to increase and provide a better human potential (Amaratunga and Baldry, 1998). According to Barrett and Baldry (2003) for organisations to know how well their facilities are supporting organisational goals and user requirements, the organisations should introduce regular building evaluations. Where building evaluation is considered to be the first priority as it provides the current status quo of the building, before anyone can effectively predict future performance (Wong and Jan, 2003). Building Performance Evaluation (BPE) is, therefore, has become the key to determine the effectiveness of a built facilities performance in a comprehensive manner (Douglas, 1996; Lavy *et al*., 2010).

Steinke *et al*. (2010) indicated that the BPE becomes an integral part of all facility capital projects in a way that aligns facilities with larger organisational strategies and ultimately provides feedback for overall decision making. This was also stated by Pullen *et al*. (2000) the current state of the art indicates a need to develop integrated key performance indicators for facilities, seeking links between performance, maintenance, operations and energy expenditure and cost-effectiveness.

Thus, this research is focused to develop a TBPE scoring framework for the buildings in tropical countries. The discussion of paper begins with an introduction to the study followed by a critical literature review, brief of research methodology and proposing a Total Building Performance Evaluation (TBPE) scoring framework.

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2. LITERATURE REVIEW

The term Building Performance (BP) trace back from BC 1955 (Preiser and Vischer, 2005). The term formally originated from the introduction of Post Occupancy Evaluation (POE) in 1960 (Preiser and Vischer, 2005). In the past two decades, organisations have started to look at their buildings not just as a way to house people and activities, but also as a way to fulfil strategic objectives (Amaratunga *et al*., 2000; Brackertz, 2006; Steinke *et al*., 2010). Thus, Steinke *et al*. (2010) argued that the traditional POE does not provide the type of feedback needed to assess these strategic organisational outcomes.

Thus, the BPE has become an effective approach to assess the strategic organisational outcomes (Preiser and Vischer, 2005; Steinke *et al*., 2010). The BPE framework was developed in order to broaden the basis for POE feedback to include a wider range of stakeholders and decision-makers who influence on buildings (Preiser and Vischer, 2005). Preiser and Wang (2006) stated that BPE provides systematic "consumer feedback" on what works and what does not work in a building, thus helping to improve its performance. Furthermore, they argued that in building performance evaluation, the entire building delivery and life cycle is considered, ranging from early strategic planning, programming, design, and construction to occupancy, and eventually to the recycling or adaptive reuse of redundant facilities. As such, there are various techniques developed under different context. Among them checklist appraisal approach, architectural feasibility, matrix method, Orbit-2, Orbit-2.1, Building In Use (BIU), Building Quality Assessment (BQA) and Serviceability Tools and Methods (STM) could be named such.

Checklist appraisal approach is a common expert method while architectural feasibility approach is designed to determine whether a client organisation should remain in the building or to renovate it or to move to a different building (Becker, 1990). Matrix approach on the other hand is much in common with checklist appraisal approach which is evaluated by an expert using a checklist (Becker, 1990). Orbit-2.1 and Orbit-2 are two different approaches which differ in four ways where the original seventeen key issues were reduced to fourteen in Orbit-2.1. Further Becker, (1990) argues that Building-in-Use (BIU) approach is more systematic rather than an analytical approach of yielding information about people and buildings. Moreover, Building Quality Assessment (BQA) approach is essentially a tool for assessing what a building provides in terms of facilities. Serviceability Tools and Methods (STM) is another approach designed to bridge between functional programs written in user language on one side, and outline specifications and evaluations written in performance language on the other (Baird *et al*., 1996).

A well-conceived and well directed BPE approach can be extraordinarily effective in delivering real benefits to the building owners, managers and occupants (Baird *et al*., 1996). As illustrated by Baird *et al*. (1996) significant virtues of conducting a BPE are; better matching of demand and supply, improved productivity within the workplace, minimisation of occupancy costs, increased user satisfaction, certainty of management and design decision making, higher returns on investment in buildings and people, incentives for innovation and the development of alternatives. In the process of developing the BPE approaches there are some key general requirements should be considered (Jiun, 2005).

- Methodological transparency which means it should allow access and understanding of assumptions
- Focus on performance which describes that it should be as far as possible fully performance based and quantifiable
- Easily accessible measures which denotes that BPE's parameters should be easily measured and accessed
- Measures as a whole which means that the scope of assessment should not focus solely on one narrow aspect of building performance such as cost or energy efficiency
- Facilitate benchmarking describes the approach developed should able to facilitate the comparison of performance between different buildings for different organisations at different times

The characters mentioned above are some of the main requirements that should be adequately considered and addressed when developing a BPE approach. This led people to demand more from the buildings thus resulting in the heightened expectations of building performance as a whole (Steinke *et al*., 2010). In view of these requirements, BPE has been well established as a concept in recent years to facilitate and evaluate the buildings relating to the purpose it is indent for. But as for tropical countries the applicability of BPE concept and its approaches are still at the early stages. Financial measures such as annual maintenance costs per employee, cleaning costs per square metre, energy consumption per square metre, etc. are the most commonly used building performance criterions in tropical countries like Sri Lanka (Konara and Sandanayake, 2010). The most eligible motive for the concept of TBP and various BPE approaches have not become widespread among the tropical countries private or public sectors because of the unawareness of the building owners, facilitators and users regarding the merits of evaluating the performance of a building and at the same time reactive approaches of the building owners towards managing and maintaining the buildings they occupy.

Konara and Sandanayake (2010) further demonstrates that the TBP is not considered, rather the organisations in tropical countries such as Sri Lanka evaluate the performance of elements, components, materials and equipment of the building separately through annual maintenance assessments. TBP is not assessed in tropical countries and therefore as argued by Douglas (1996) that the predictability of TBP is relatively low. Thus building evaluations that continue in singular areas with recommendations for actions that will solve the performance problem are going to create more problems. Therefore, the process of evaluating building performance consumes a considerable amount of resources (such as time, money, labour) which has been contributed positively to the reactive nature of the building owners evaluating the TBP.

Hence, a building's performance can be judged on an almost infinite variety of criteria such as financial organisational issues, space use efficiency, performance or productivity, information technology etc. (Becker, 1990). In that sense, TBP studies can be seen as a whole building evaluation approach, which addresses the performance evaluation as a whole. Thus, seven criteria namely occupants comfort and health, sustainable, economic, process and growth, leadership and management, functional and technical, performances were encountered to develop the proposed TBPE scoring framework (Lützkendorf *et al*. 2005). The next section of this paper outlines the carried research methodology for this study.

3. RESEARCH METHODOLOGY

The survey research approach was selected for this research and three steps were adopted to develop the TBPE scoring framework as shown in the Figure 1.

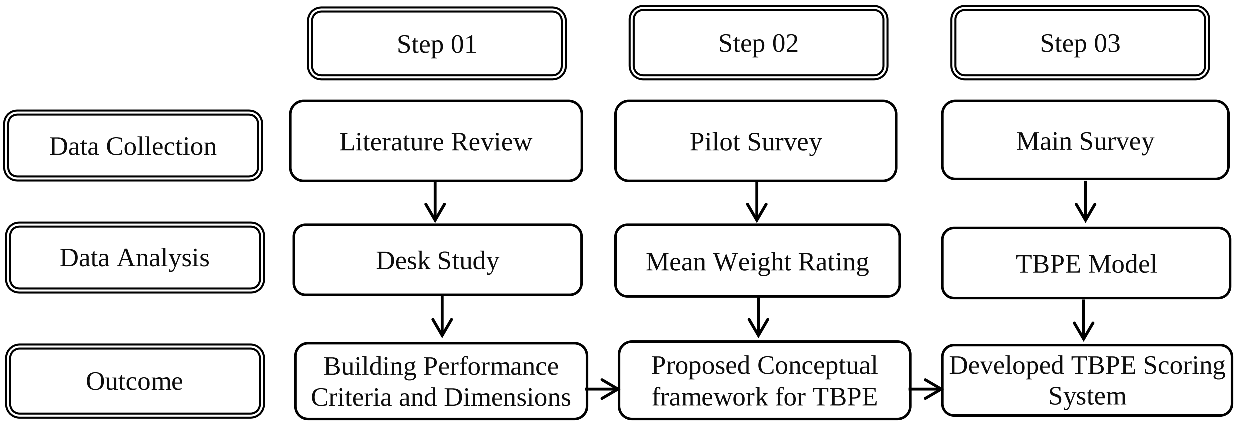

Figure 1: Steps in the Research Methodology

Step 1: A comprehensive literature review was conducted to explore the concept of BPE, BPE requirements, existing BPE approaches to identify the relevant BP criteria and dimensions through referring books, journal articles and unpublished dissertations.

Step 2: Pilot survey was carried out among five industry experts and analysed using Mean Weighted (Eq: 01) in order to sieve out the most significant and fundamental BP criterions and dimensions to derive with a conceptual framework for the development of TBPE scoring framework which are relevant to the tropical countries.

$$M = \frac{\sum (V_i x F_i)}{n} \qquad \text{(Eq: 01)}$$

Where, M = mean weighted rating, V_i = rating given by the respondent, F_i= frequency of responses, n = is total number of responses.

Step 3: The proposed conceptual TBPE framework consisting of seven performance criteria and its fifty seven dimensions (Table 1) were developed using the literature review and the pilot survey findings.

4. PROPOSED TBPE SCORING FRAMEWORK

The proposed values of TBPE framework were constructed using linear factorial approaches as follows (Eq: 02).

$$\text{P} = \sum_{i=1}^{7} C_i \qquad \text{(Eq: 02)}$$

Where P = TBP score of the building; C_i = (where i = 1, 2, 3….7.) denotes the criteria's total score and to deploy the (C_i) criteria's total score, it is derived through;

$$C_i = \sum_{i=1}^{n} D_i \times q \qquad \text{(Eq: 03)}$$

Where D_i = (where i = 1, 2, 3…, n) denotes the ith criteria's dimension's score, and q = {R / 0, 0.25, 0.5, 0.75, 1} denotes the parameters rated by decision maker for the dimensions performance level (adapted based on the model suggested by Hong, 2007) and where R = denotes the real number. Further, to determine the score for each dimensions (D_i) it is obtained through;

$$D_i = KW_i \qquad \text{(Eq: 04)}$$

Where W_i = rank reciprocal weight of the ith dimension, and K = a constant numerical value is determined based on assigning score 1 to the least important dimension (adapted based on the model suggested by Hong, 2007). Whereas W_i of each dimension is derived by using;

$$W_i = \frac{\frac{1}{R_i}}{\sum_{i=1}^{57} \frac{1}{R_i}} \qquad \text{(Eq: 05)}$$

Where R_i = (where i = 1, 2, 3 …., 57.) denotes the ith dimension's rank. Whereas the R_i rank for each dimension could be rank by deriving with an overall performance weightage (OPW) where the least OPW was provided with a least ranking and whereas the maximum value of OPW of the ith dimension was ranked first (adapted based on the model suggested by Kamarazaly, 2007). Thus, OPW can be deployed using;

$$X_{i,k} = I_i \times M_{i,k} \qquad \text{(Eq: 06)}$$

Where $X_{i,k}$= Overall Performance Weightage (OPW) of the kth dimension of the ith criteria, I_i = Relative Important Index (RII) of ith criteria, $M_{i,k}$ = mean weighted rating of kth dimension of ith criteria which can be formulated using the Equation 1.Whereas the RII of ith criteria is thus used to derive with;

$$I_i = \frac{\sum W}{AN} \qquad \text{(Eq: 07)}$$

Where; W = Weighting to each criteria by the respondent, A = highest weight, N = total number of samples (The relative importance index range from 0 to 1).

Table 1: Proposed TBPE Factors

Functional Performance	**OC and Health Performance**	**Process and Growth Performance**	**Technical Performance**	**Economic Performance**	**L and M Performance**	**Sustainable Performance**
▪ Space suitability and usability	▪ Level of cleanliness	▪ Failure response rate	▪ Ease of maintenance	▪ Preference on WLC costs	▪ Number of training on BP	▪ Energy management
▪ Space clarity	▪ Thermal comfort level	▪ Fire safety plan	▪ Load bearing capacity	▪ Unit costs savings	▪ Making right decisions	▪ Environmental loading
▪ Service life	▪ Availability of PPA equipment	▪ Maintenance of past data	▪ Thermal protection of envelope	▪ Additional income stream	▪ Managing and controlling resources	▪ E-Procurement policy
▪ Signage, way finding performance	▪ Occupational hygiene	▪ Security plan	▪ Technology efficiency	▪ CSR expenditures	▪ Interest and ethical behavior of staff	▪ Selection of environmental friendly materials
▪ Site amenities	▪ Level of olfactory comfort	▪ Maintenance of hazardous materials	▪ Structural stability	▪ Return on Investment (ROI)	▪ Level of accountability of the service provided	▪ Waste management
▪ Level of expression for values of service	▪ Internal and external communication	▪ Sustainable design process in planning and renovation process	▪ Durability of elements		▪ Determine the type of care andservices	
▪ Site sustainability	▪ Room acoustics	▪ Benchmarking	▪ Availability of occupancy sensors		▪ No. of awareness programs conducted	
▪ Level of flexibility	▪ Noise isolation	▪ Management of building service				
▪ Cultural, recreational value of site	▪ Ventilation effectiveness	▪ Monitoring of technical systems				
▪ Aesthetics, appearance of building	▪ Glare control					
▪ Provision for disabled in building						
▪ Reachability to the building						
▪ Occupancy density						
▪ Design efficiency						

The quantitative values for BP factors in TBPE framework were established through the equation which is presented in Table 2 (where, R = ranking of factors, W_i = rank reciprocal weight of factors and D_i = scores for each factors).

Table 2: TBPE Scoring Framework

	Total Building Performance Factors	R_i	W_i	D_i
	Functional Performance			**62**
FP-1	Space suitability and usability	10	0.0215	6
FP-2	Space clarity	33	0.0065	2
FP-3	Service life	7	0.0307	8
FP-4	Signage, way finding performance	21	0.0102	3
FP-5	Site amenities	31	0.0069	2
FP-6	Level of expression for values of service	21	0.0102	3
FP-7	Site sustainability	36	0.0060	2
FP-8	Level of flexibility	28	0.0077	2
FP-9	Cultural, recreational value of site	47	0.0046	1
FP-10	Aesthetics, appearance of building	43	0.0050	1
FP-11	Provision for disabled in building	53	0.0041	1
FP-12	Reachability to the building	2	0.1075	29
FP-13	Occupancy density	53	0.0041	1
FP-14	Design efficiency	21	0.0102	3
	Occupants Comfort and Health Performance			**54**
OH-1	Level of cleanliness	20	0.0107	3
OH-2	Thermal comfort level	4	0.0537	14
OH-3	Availability of PPA equipment	51	0.0042	1
OH-4	Occupational hygiene	3	0.0717	19
OH-5	Level of olfactory comfort	24	0.0090	2
OH-6	Internal and external communication	24	0.0090	2
OH-7	Room acoustics	37	0.0058	2
OH-8	Noise isolation	34	0.0063	2
OH-9	Ventilation effectiveness	11	0.0195	5
OH-10	Glare control	17	0.0126	3
	Technical Performance			**27**
TP-1	Ease of maintenance	14	0.0154	4
TP-2	Load bearing capacity	6	0.0358	10
TP-3	Thermal protection of envelope	14	0.0154	4
TP-4	Technology efficiency	19	0.0113	3
TP-5	Structural stability	56	0.0038	1
TP-6	Durability of elements	57	0.0038	1
TP-7	Availability of occupancy sensors	14	0.0154	4
	Process and Growth Performance			**18**
PP-1	Failure response rate	18	0.0119	3
PP-2	Fire safety plan	38	0.0057	2
PP-3	Maintenance of past data	13	0.0165	4
PP-4	Security plan	27	0.0080	2
PP-5	Maintenance of hazardous materials	44	0.0049	1
PP-6	Sustainable design process in planning and renovation process	55	0.0039	1
PP-7	Benchmarking	48	0.0045	1
PP-8	Management of building service	32	0.0067	2
PP-9	Monitoring of technical systems	50	0.0043	1
	Sustainable Performance			**64**
SP-1	Energy management	1	0.2150	57
SP-2	Environmental loading	49	0.0044	1
SP-3	E-Procurement policy	29	0.0074	2
SP-4	Selection of environmental friendly materials	26	0.0083	2
SP-5	Waste management	39	0.0055	1
	Economic Performance			**26**
EP-1	Preference on WLC costs	45	0.0048	1
EP-2	Unit costs savings	5	0.0430	11
EP-3	Additional income stream	12	0.0179	5

	Total Building Performance Factors	R_i	W_i	D_i
EP-4	CSR expenditures	52	0.0041	1
EP-5	Return on Investment (ROI)	8	0.0269	7
	Leadership and Managerial Performance			**15**
LP-1	Number of training conducted on BP	30	0.0072	2
LP-2	Making right decisions	9	0.0239	6
LP-3	Managing and controlling resources	35	0.0061	2
LP-4	Level of awareness programs conducted	41	0.0052	1
LP-5	Level of accountability of the service provided	40	0.0054	1
LP-6	Determining the type of care and services	46	0.0047	1
LP-7	Interest and ethical behavior of staff	41	0.0052	1

When analysing each dimensions under each criteria, six dimensions (energy management, reachability to the building, occupational hygiene, thermal comfort, unit costs savings and load bearing capacity) account for 140 points which is more than 50% of available points, while some important dimensions are rated with only one point such as structural stability, preference on WLC costs, waste management, maintenance of hazardous materials, etc. This explains the fact that the developed TBPE scoring framework to assess building performance is based on the local building professionals and building practitioners' opinions towards the importance of identified TBPE criteria and dimensions. Thus, the scoring framework (point distribution) solely based upon the building professionals' priority of these criteria at the time the survey is conducted.

Further, it is important to note that attempting the other credit requirements is also possible in the local context if desired by the building owner and the construction project team in order to achieve a good performance in building. It will increase the total number of points resulting in more environmentally sustainable buildings with prestigious TBPE scoring framework. Table 2 represents the maximum allowable scores of 64, 62, 54, 27, 26, 18 and 15 out of 265 to be distributed among sustainable, functional, occupant comfort and health, technical, economic, process and growth and leadership and managerial performance respectively. With the identified score Table 3 provides the parameters established for the purpose of distributing the score among the building performances which is provided to the building evaluator to assess in a five point Likert scale basis. Thus the TBPE can be modelled using Eq: 03 to rate the performance of the building with respect to the five point Likert scale 1 to 5 provided to the evaluator which assigned with the weights of 0, 0.25, 0.5, 0.75, and 1, which distributes the maximum allowable scores of 64, 62, 54, 27, 26, 18 and 15 out of 265 to be distributed to an allowable scores based upon the current building performance of building among sustainable, functional, occupant comfort and health, technical, economic, process and growth and leadership and managerial performance up to an acceptable level.

Table 3: Weights and Description of the Parameters

Scale	Rating for Dimension	Description	Weights Assigned %
1	NA	No such dimensions' performance is incorporated in to the building. Example; no thermal comfort followed.	0
2	P	Poorly following the dimension performance Example; no standards, technology used or followed	25
3	M	Moderately following such dimensions specified Example; standards are maintained while no new technology are incorporated	50
4	H	Highly adopting such dimensions in to the building. Example; standards are well maintained with improved technology	75
5	E	Excellently incorporated in to the building and maintained. Example; standards are excellently maintained and innovated technology are used to maintain such performance (usage of BMS to control thermal comfort)	100

5. CONCLUSIONS

A conceptual TBP framework was proposed compromising of seven criteria and fifty seven dimensions to assess building performance of tropical buildings. With the proposed conceptual TBPE scoring framework a mathematical TBPE model was derived to analysis and appropriate weights were assigned and derived with a TBPE scoring framework which was solely based upon the building professionals' priority at the time the survey was conducted.

Development of the TBPE scoring framework concluded of having a maximum allowable scores of 64, 62, 54, 27, 26, 18 and 15 out of 265 to be distributed among sustainable, functional, occupant comfort and health, technical, economic, process and growth and leadership and management performance respectively whereas it pin pointed the fact that, energy management, reachability to the building, occupational hygiene, thermal comfort, unit costs savings, load bearing capacity etc are having higher contribution on BPE with relation to Sri Lankan context.

The developed TBPE scoring framework can be further developed by identifying measurement units and parameters for each and every performance dimensions to tropical context in order to distribute the scoring, instead of asking the respondents to rate each dimension. After identifying the unit of measurements and parameters, a benchmark can be established for each and every performance dimension to standardise the scoring framework and to evaluate buildings according to the benchmarks.

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