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Original Paper

User Satisfaction Index: An Indicator on Building Performance

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Abstract

Infrastructure in rapidly developing countries like India is on an upswing and is equally flourishing in both private as well as public/government sectors. Public spending by government agencies lacks effective monitoring post construction especially on maintenance of assets. It makes the government agencies less accountable on their expenditure as also with the procedures/processes followed for maintenance of these assets. With tens of thousands of crore indian rupees being spent on maintenance of government residential accommodation, it is imperative to have a gauge to measure the effectiveness of these maintenance agencies. Presently, no such means exists to actually measure effectiveness of maintenance of government assets. Mere expenditure of allotted funds by the end of a financial year cannot be a viable indicator to vouch for the genuineness of spending. The most ideal route to measure its effectiveness is the most important stake holder, viz. the end user. This paper is a part of an ongoing research where the ultimate overarching goal is to develop a conceptual framework to implement an intervention strategy for gauging and enhancing user satisfaction based on user requirement related building performance attributes. This paper deals with development of an instrument necessary to garner feedback on user satisfaction. The content of the questionnaire is based on carefully selected attributes for user requirements that reflect building performance. An endeavor is made to convert the user feedback into quantifiable user satisfaction index to assess performance post implementation of intervention strategies by the FM agency.

Keywords: User satisfaction, Building Performance Evaluation, Attributes, Questionnaire, Validation, Survey, User Satisfaction Index.

1. Introduction

Maintenance management of infrastructure has gained enormous prominence in recent times and a lot of research is in progress to conceptualize and illustrate robust procedures and practices for enhancing the effectiveness of maintenance management. The main modus operandi of research is on listing of various factors that need to be assessed for evaluation. The researchers have named such factors as key performance indicators and grouped a number of such indicators and suggested various means to garner inputs on the same for assessment and deductions. Extensive literature is available to choose from in order to understand facets of facilities management. Ho et al (2004), Shohet (2006), Augenbroe and Park (2007), Myeda et al (2009), Lavy et al (2010), Illesanmi (2010), Zawawi et al (2011), Meng and Minougue (2011), Nik Mat et al (2011), Abdul Lateef et al (2011), Yewande et al (2011), Mohammad et al (2012), Ibem et al (2013), Aigavbova and Thawla (2012), and Valen and Lohne (2016) reveal that the listing and grouping of indicators varied

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from each other depending upon type of facility and purpose of evaluation. Air quality, energy, building envelope etc are certain purposes and residential buildings, hospitals, hostels and educational facilities are some of the types of facilities. However, what is common in all these facilities is the user and there is a scope to devise an assessment framework that can be commonly applied to different facilities and purposes [8,21,3,17,14,10,26,15,19,1,25,16,9,2,24].

Facilities and their maintenance management are still relatively a new concept in developing countries like India, more so in government sector. Though thousands of crores of indian rupees are spent on maintenance of government assets, there is no means available at present to check the effectiveness of the procedures/processes being implemented by the facilities management agencies. It will also be a tool that can be used to establish accountability of the FM agencies. Going by the concept of what can be measured only can be managed; this research is an endeavor to formulate a User Satisfaction Index (USI) that can be a key performance indicator in evaluation of performance of buildings.

2. Literature Review

Exhaustive literature is available to understand the concepts of building performance evaluation based on number of theories. While developing an assessment framework for health and hygiene performance of apartment buildings Ho et al (2004) developed a Building Health and Hygiene Index (BHHI) based on environmental qualities that contribute to occupants' health [8]. Ho et al (2004) link environmental qualities and building factors to derive an algorithm that will indicate BHHI [8]. Though it will indicate state of health and hygiene of buildings to developers, facility managers and occupants, utility with respect to post identification of BHHI and also the methods/tools that'd be adopted to obtain the necessary inputs seems lacking.

Augenbroe and Park (2005) developed a performance toolkit that offers an instrument for assessment of technical performance of buildings [3]. However, the elements of the toolkit primarily cover issues related to energy consumption like lighting and thermal comfort. Though an attempt has been made to address maintenance as a performance indicator, it reiterates the already existing PIs like Building Performance Indicators (BPIs); Maintenance Efficiency Indictor (MEI); Manpower Sources Diagram (MSD); Managerial Span of Control (MSC) of Business Availability and Manpower Utilization Index (MUI) of Chan et al (2001) and Preventive Maintenance Ratio (PMR) of Barber and Hilberg (1995) [5]. A mention has also been made of a performance indicator defined as a ratio of building's state and maintenance cost. For extensive and repeated use of a toolkit, the factors that are short listed for consideration should be easily obtainable and the follow up action for interventions and implementation also needs to be effective. Gathering of complicated data and arriving at inferences without having an effective implementation strategy for enhancement of value to the buildings will only add to the complexities of facility managers and policy makers.

Shohet (2006) developed an integrated maintenance management model proposed to be used for maintenance and management of public acute care hospital facilities in Israel [22]. Being an extension of already existing research of Shohet et al (2003), Shohet (2006) classifies Key Performance Indicators (KPIs) into four categories viz [21,22]. Asset Development; Organization and Management; Performance Management and Maintenance Efficiency. Under these four categories, the under mentioned KPIs are calculated.

Table 1. KPIs for integrated maintenance management model Shohet (2006) [22]

KPI	Meaning	Factors involved
Built floor area	Area of the facility	(a) Built area (b) Occupancy of the asset (c) Age of the facility
Organization & Management	Human and external resources used in execution of building's maintenance	(a) Number of employees (b) Scope of FM outsourcing (c) Managerial Span of Control (d) Maintenance Organizational Structure
Performance Management	Building performance	(a) Building Performance Indicator
Maintenance Efficiency	Maintenance linked with cost	(a) Annual maintenance Expenditure (b) Maintenance Efficiency Indicator (MEI) (c) Age co efficient (d) Occupancy co efficient

In this comprehensive evaluation of overall building performance and systems, unfortunately the user doesn't find a place. Moreover, the assessment is pitched at a level for a strategic decision making based on technical assessment rather than reinvestment on the building to improve assessed aspects.

In another exhaustive literature review on establishment of KPIs for facility performance evaluation, Lavy et al (2010) highlights functional indicators (13), physical indicators (08) and survey based indicators (04) [14]. Financial indicators cover facets like capital, operational, occupancy, maintenance and custodial costs; Physical indicators cover quantitative and qualitative building condition, resource consumption and property/real estate; Functional indicators encompass aspects like productivity, space utilization/adequacy and occupants' turnover rate; Survey based indicators cover customer satisfaction, community participation and suitability of the facility for intended functions. Though customer angle finds a mention, the in-depth review suggests broader applicability with scope of future research citing complex nature, limited applicability and non-existent/improper categorization of KPIs. Lavy et al (2010) clearly indicates need for more concise list of indicators that are not only representative of major aspects of performance measurement but also sufficient so decisions can be made based on them [14].

Myeda et al (2009) while establishing key factors in measuring maintenance management performance, categorize them into three factors. The list given by Myeda et al (2009) is given as under [17].

Table 2. Factors measuring maintenance management performance (Myeda et al, 2009) [17]

Aspect	Dimensions Measured	Focus Group	Performance Key Metrics
Functional Service Deliverance	Assurance Reliability Responsiveness Relevance Timeliness Validity	Maintenance Managers	Time/Use Quality
Technical Maintenance Services	Cleaning & Landscaping General Maintenance Lighting Air Conditioning	End Users	

	Lift & Escalators
	M & E
	Sanitary and washing
	Access, Signage, Parking
	Safety and Security
Image Building	Internal finishes
Image	External finishes

Myeda et al (2009) cover functional, technical and image aspects [17]. However certain important aspects like physical condition, environmental issues like air, water and noise quality, energy efficiency etc. It is also not clear whether safety and security cover physical, fire and electric safety and also security with respect to theft, burglary etc. Furniture is also not covered that can affect the functional efficiency of the building. Zawawi et al (2011) devised a tool known as Critical Success Factors (CSF) to measure performance in an organization to achieve their mission [26]. Researchers articulate in this paper to derive a generic process and procedure in maintenance management by investigating current practices of maintenance management in local authority organizations of Malaysia. However, Zawawi et al (2011) utilized the list of factors identified by Myeda et al (2009) and hence the inadequacies remain. The same set of indicators was also used by Nik-Mat et al (2011) while assessing the maintenance aspect of facilities management [19].

Abdul Lateef et al (2011) provides a maintenance performance matrix (MPM) covering eight aspects [1]. However all the eight factors discusses about the performance of FM agency only without any link to the effectiveness of the processes to enhance building performance. Value based maintenance management model (VBMM) as touted by Khamidi et al (2010) which is an extension of the same research bases its model on the management processes of Project Management Book of Knowledge (PMBoK) i.e. planning, organizing, directing, implementing and controlling [13]. VBMM also discusses only about the processes adopted by FM agencies. The research also falls short of suggesting a strategy for implementing efforts based on outcome of the processes.

Meng and Minogue (2011) carry out a comparative study of performance measurement models in facility management. In an interesting observation, Meng and Minogue (2011) prioritize Key Performance Indicator (KPI), Balance Score Card (BSC) and Business Excellence Model (BEM) models in the order of preference [15]. Capability Maturity Model (CMM) though briefly discussed, is deemed to be difficult to be applied in FM practice. While articulating the appropriateness of performance indicators, client satisfaction is listed as the topmost priority. However, among the ten indicators, cost effectiveness, responsiveness, service reliability, environmental compliance, staff commitment, client-service provider relationship and IT application cover aspects not directly related to building performance and focuses more on the FM agency. How comprehensively the client satisfaction is measured also is not clear.

Mohammad and Azim (2012) while assessing overall satisfaction with public housing, come out with 46 variables in four components listed as under in Table 3 [16]. The study infers that merely providing housing does not indicate success of housing development but meeting the actual housing needs and preferences of residents. Though the list covers spaces and services within the housing in detail however, falls short of some of the important characteristics like safety, physical condition, security, energy efficiency, furniture etc.

Table 3. Grouping of variables for overall satisfaction in public housing (Mohammad and Azim, 2012) [16]

Component	Variables	Purpose
Housing and physical features	11	Satisfaction with spaces within housing unit
Services provided within housing area	11	Satisfaction with services within housing area
Public facilities provided	20	Satisfaction with public facilities within/close to housing area
Social environment within housing area	04	Satisfaction with social environment within housing area

As part of post occupancy evaluation of hostel facilities, Yewande et al (2011) report on main functional and technical criteria of performance of a post graduate hostel [25]. Satisfaction level of occupants is obtained on 29 characteristics. However, physical condition, physical safety, water quality, furniture, sewage, drainage facilities, garbage disposal etc. were not covered.

Ilesanmi (2010), while carrying out post occupancy evaluation of public housing in Lagos, Nigeria, tried to analyze relationship between physical characteristics of a building and resident satisfaction [10]. Ten performance criteria were developed and used for conduct of survey and inferred that 62% of physical characteristics highly correlated with residents' satisfaction (r=0.62) which endorses the fact that physical characteristics can be linked with user satisfaction. The performance criteria listed by Ilesnami are as under.

Table 4. Performance criteria for POE of public housing in Nigeria (Illensanmi, 2010) [10]

Indicator	Meaning	Purpose
ViQ	External visual quality of building	Evidence and general state of external finishing such as renderings and painting
MiQ	Maintenance quality of building	Evidence and extent of renovations and improvement of buildings / apartments by the residents
StQ	Structural quality of building	Evidence of durability, stability and long-term integrity in terms of structure, fabrics and materials
DQ	Detailing quality of building	Detailing and performance of the operational elements, such as doors, windows, ceilings, roofi ng members and fascia boards.
QSv	Quality of building services	Availability and quality of amenities and conveniences, such as sanitary, water supply, refuse and sewage disposal.
Qrd	Quality of estate roads	Whether or not they were tarred, condition of surface, kerbs and drainage; and efficiency of vehicular circulation
QLs	Quality of landscaping	Evidence of designed landscape and their condition.
Qos	Quality of semi-public open spaces	Existence, condition, layout, and efficiency of open spaces between blocks of housing units for recreation and socialization; and indoor-outdoor spatial relationships.
Qen	Quality of environmental layout	Overall image of neatness, orderliness, layout efficiency, pedestrian circulation and street quality
QLc	Quality of location	Describes how the estate relates with the surrounding neighborhoods (Is it isolated, integrated or dominated).

Resident satisfaction for the above ten performance criteria were obtained under three heads viz. satisfaction with physical environment (PHYSAT), satisfaction with estate (ESTSAT) and satisfaction with apartment (UNITSAT). The researcher opines that the criteria cover socio-economic, functional and behavioral issues of housing. The questionnaire would have been an interesting reading to find out how many questions could the researcher have asked. It is always pertinent to word the questionnaire appropriately so that researcher can convey what he expects from the participant explicitly without any ambiguity. However, linkages of physical characteristics with relevant resident satisfaction were not established by the researcher in that which of the indicators of resident satisfaction affects which of the physical characteristics of the building.

While evaluating performance of residential buildings in public housing estates of Ogun State, Nigeria Ibem et al (2013) tries to identify user satisfaction attributes that contribute to building performance. The questionnaire designed by Ibem et al (2013) obtains information on building attributes separately and of user satisfaction level separately. Building attributes primarily consist of configurative details of building and user satisfaction is obtained from 27 attributes grouped under five factors reproduced as under in Table 5 [9].

Table 5. User Satisfaction Attributes for Building Performance(Ibem et al, 2013) [9]

Factor	Attributes covered
Type, Location and aesthetic appearance	No of bed rooms Building Type Design of toilet and bath facilities Type of material used in construction Location of building in the housing estate Aesthetic appearance of the building
Sizes of internal spaces	Sizes of living rooms Sizes of bed rooms Sizes of cooking and storage spaces
Illumination, thermal and visual comfort	Quality of natural lighting in bed rooms Natural lighting in kitchen Quality of air in bed rooms Natural lighting in bed rooms Quality of air in living/dining spaces Thermal comfort in the building Privacy in the building
Security and Protection	Protection against noise pollution Protection against dampness Protection against insects and animals Security measures in the building Fire safety measures in the building
Water and electric supply	Electric services in the building Water supply in the building

It is not clear why furniture which is one of the major requirements to enable a building perform its intended tasks does not find a mention with most of the researchers. Ibem et al (2013) do not cover important building attributes like energy efficiency, safety against fire and electricity, furniture and drainage/sewage disposal from the building [9].

Aigbavboa and Thwala (2012) grouped different characteristics under physical and social factors [2]. The types of attributes chosen to arrive at relative satisfaction indices (RSIs) laid more emphasis on building spaces. It does not include important requirements like safety, lighting, waste disposal, drainage, accessibility etc. Factors like amenities, neighborhood etc. does not find a mention in the grouping in order to arrive at user satisfaction. It leaves an area for improvement in research for in depth study of physical, functional, sociological and environmental aspects of buildings/occupants for holistic assessment and a true measure of user satisfaction.

Valen and Lohne (2016) examine assessment tools for strategic performance evaluation of buildings and Norwegian practice in light of international practice [24]. Authors found several interesting methods for assessment of building performance especially feed forward loop from Steinke, developed from BSC, soft landings framework and the Norwegian multi map method. Certain core concepts were defined for scrutiny viz. functionality and adaptability; (Worthington, 2008) that concern value adding and usability and viability that concern building functions. Authors articulate these properties as essential how building portfolios add value to user organizations and expresses its potential to give a productive facility that sustains and develops according to future needs and requirements. This research paper acknowledges and takes a cue from the viewpoint of Valen and Lohne (2016) that assessment of performance of a building portfolio require further methodological development and that there is a tremendous potential for such policy instruments in public sector [24].

3. Research Questions

Extensive literature review revealed that the attributes for building performance and user satisfaction vary depending upon the facility, purpose of evaluation and perception of researchers. Surprisingly, the most important stake holder i.e. the end user does not find prominence while assessing building performance. This leads to a number of research questions that emanates from the existing literature on maintenance management of facilities for which this research tries to find answers.

RQ 1: Is there a feasibility to standardize user requirements when it comes to building performance?
RQ 2: Can user satisfaction be measured?
RQ 3: Can a list of attributes be identified that can be applied across different types of facilities?
RQ 4: Will it be possible to establish linkages between user requirements and building performance attributes?
RQ 5: What is the tradeoff between complicated technical derivatives on building performance viz-a-viz simple attributes that facilitate effective implementation of interventions?
RQ 6: Is there a requirement of amplifying the attributes in a survey instrument for better comprehension of the respondent?

3.1 Objective

Objective of this paper is to develop a User Satisfaction Index (USI) as a key performance indicator for performance evaluation of buildings based on user requirement related building performance attributes. .

3.2 Methodology

Methodology is best explained through the under mentioned flow chart.

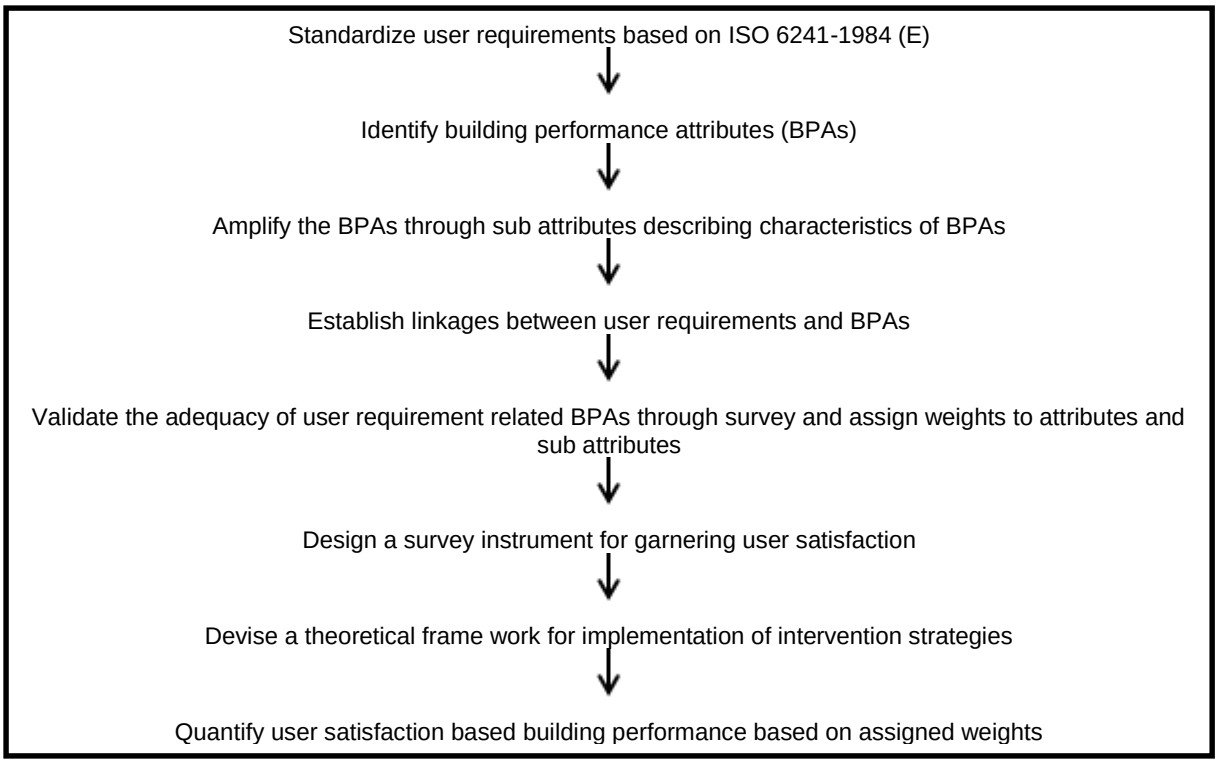

Figure 1. Methodology of Research

3.3 User requirements

Though many lists are available to describe user requirements, this paper has considered the internationally recognized universal standard ISO 6241-1984 (E) to arrive at the user requirements as datum. User requirements obtained from ISO 6241-1984 (E) is listed under in Table 6 (Gopikrishnan and Paul, 2016) [11,6].

Table 6. User requirements listed in ISO 6241-1984 (E) [11]

S No	User Requirement	Example
1	Suitability of space	Number, size, geometry etc
2	Durability	Retention of performance
3	Tactility	Surface properties, roughness etc
4	Dynamic requirement	Maneuverability, ease of movement etc
5	Tightness	Water proofing
6	Stability	Resistance to static and dynamic actions etc
7	Fire safety	Risks of outbreak of fire etc
8	Safety in use	During use of building ie movement, circulation etc
9	Visual	Natural and artificial lighting
10	Hygro thermal	Control of temperature
11	Air purity	Ventilation
12	Acoustical requirement	Intelligibility of sound, noise control etc
13	Hygiene requirement	Facilities for cleaning, waste water, materials etc
14	Economic requirement	Capital, running and demolition costs

3.4 Building Performance Attributes

Based on the extensive literature review highlighted in preceding sections of this paper, finally seven factors were identified as building performance attributes (BPAs) essential to be measured to assess building performance. (Gopikrishnan & Paul, 2016) Seven BPAs are grouped into built form and environmental factors directly related to building performance [6]. Three attributes though not directly related to building performance, has all likelihood of influencing user satisfaction. Hence they are grouped under external factors. BPAs grouped under physical, environmental and societal factors are listed as under in Table 7.

Table 7. Building Performance Attributes (BPAs)

S No	Factor	Attributes	User requirement
1	Built Form	1.1 Spaces 1.2 Finishes, Fittings & Furniture	Suitability for spaces for specific use
		1.3 Physical Condition	Durability requirements Tactile requirements Dynamic requirements Tightness requirements Stability requirements
		1.4 safety	Fire safety requirements Safety in use requirements
2	Environmental	2.1 Lighting	Visual requirements
		2.2 Air, Noise and Water	Hygrothermal requirements Air Purity requirements Acoustical requirements
		2.3 Waste Disposal	Hygiene requirements
3	External	3.1 Societal	Community participation Congeniality of neighborhood
		3.2 Accessibility	Accessibility to public transport Location of building Proximity to shops, walkways etc
		3.3 Amenities	Parking, shops, recreational facilities etc

3.5 User requirements and linkage with BPAs

Table 8 brings out the suggested linkage between user requirements listed in ISO 6241-1984 (E) given in Table 1 above and the BPAs obtained through rigorous literature review listed in Table 2 above.(Gopikrishnan and Paul, 2017)

Table 8. Linkages of BPAs with user requirements

S No	User Requirement	BPA influencing user requirement						
		Spaces	Physical Condition	Safety	Finishes, Fittings & Furniture	Lighting	Air, Noise and Water	Wastage Disposal
1	Suitability of spaces	*			*			
2	Durability		*		*			
3	Tactile		*					
4	Dynamic	*	*					
5	Tightness		*					
6	Stability	*	*	*				
7	Fire Safety			*	*			
8	Safety in use			*				
9	Visual	*	*		*	*		
10	Hygrothermal						*	
11	Air Purity						*	
12	Acoustical	*	*		*		*	
13	Hygiene		*				*	*
14	Economic	Not considered in case of govt residential accn from user angle						

3.6 Amplification of attributes

One of the important requirements in conduct of questionnaire surveys is that the participant should correctly comprehend the requirement of the researcher. What is perceived by the researcher and understood by the participant should match in order garner correct feedback. While asking for a feedback on attributes like Safety; Physical Condition; Spaces; Air, Noise and Water; Lighting; Finishes, Furniture, Fittings; and Waste disposal, these attributes need to be adequately amplified in the form of sub attributes, describing the characteristics of each attribute so that participants can provide a correctly comprehended feedback than guesswork. List of attributes and sub attributes are listed in Table 9 below. Building factors are the attributes that are directly related to building performance and external factors are those attributes not directly related to building performance but likely to have a bearing on user satisfaction (Gopikrishnan and Paul, 2017) [7]. On checking the necessity for amplification, 73% of an expert group comprising of facility managers, engineers, architects, academia, and consultants agreed to the fact that amplification will definitely facilitate the respondents to comprehend the questionnaire better and provide appropriate inputs on user satisfaction (Gopikrishnan and Paul, 2017) [7].

Table 9. Attributes amplified into sub attributes with description of characteristics

Sub Attribute	Description
Building Factors	
BF1 - Safety	
(a) Physical Safety	Provides safety against accidents due to falling, tripping etc
(b) Fire Safety	Adequate fire extinguishers, water sprinklers, fire alarms, ventilation etc

(c) Electrical Safety	Against electrical accidents due to loose fittings, wires etc
(d) Disinsection	Protects from insects in the form of mosquito proofing, Fumigation etc
BF2 – Physical Condition	
(a) Safety	That provides a feeling of safety
(b) Performance	Provides comfort in performing intended tasks
(c) Productivity	Indicates increase/decrease in productivity based on condition
(d) Psy Comfort	Provision for maintenance of roofs, walls, ceiling
(e) Maintenance	Impact of physical condition on the occupant
BF3 - Spaces	
(a) Space Adequacy	Should have adequate space to perform intended tasks
(b) Height Adequacy	Should have adequate height for ventilation and lighting
(c) Accessibility	All spaces should be easily accessible with stairs, ramps, lifts etc .
(d) Grouping	Avoid infructuous movement, promote efficiency and administration
(e) Redundancy	Space should not be redundant, unusable or more/less
BF4 - Lighting	
Uniformity	Uniformly lit to perform the tasks and improve performance
Control	Has easily accessible control to both natural and artificial lighting
Energy savings	Facilitates energy savings
Glare	Has proper shading devices to avoid glare
Maintenance	Facilitates easy access and handling for maintenance
BF5 – Air, Noise and Water	
(a) Air	Not be replete with automobile exhaust, other hazardous gases
(b) Noise	Control of external and internal noise with intelligibility of sound
(c) Water	Clean enough for earmarked purpose like drinking, washing etc
(d) Control	Has easily accessible control to both natural and forced ventilation
(e) Ventilation type	Has provision for forced ventilation also in the form of air conditioning
(f) Maintenance	Facilitates easy access for handling and maintenance
BF6 – Finishes, Furniture and Fittings	
(a) Finishes	The internal/external finishes should for an attractive appearance
(b) Concealment	The plumbing and wiring should preferably be concealed
(c) Furniture	Should have essential furniture to cater for intended purposes
(d) Fixtures	Fixtures in the rooms should serve their purpose
(e) Special fittings	For physically challenged people in toilets
BF7 – Waste Disposal	
(a) Adequacy	Should have adequate garbage bins, incinerators etc for disposal
(b) Cleanliness	Has a positive impact because of the hygiene and sanitation
(c) Drainage	Should be able to drain off water, avoid stagnation
(d) Sewage disposal	Efficiency in which sewage and sullage of building is disposed off
External Factors	
EF1 - Accessibility	
(a) Access	The facility should be easily accessible for the occupants/users
(b) Comfort	Should be wide enough and comfortable for vehicles/pedestrians
(c) Location	Proximity to shops, walkways, play areas, parks and other amenities
EF2 - Amenities	

(a) Open spaces	Adequate open spaces should be available for the users/occupants
(b) Parking	Adequate and clearly marked parking with ingress/egress
(c) Security	Against theft, burglary, crime rate in the area etc
(d) Traffic safety	In the form of barriers, speed breakers etc on the internal roads
(e) Connectivity	Telephone and internet connections should be available in the facility
EF3 – Societal Issues	
(a) Neighbourhood (b) Social Status (c) Education (d) Religious Spaces (e) Financial Status	Similar to the occupant

3.7 Ranking and weights to BPAs and sub attributes

The seven BPAs that were directly related to building performance were further analyzed for their inter se importance. Also the corresponding sub attributes were assigned weights depending on the order of priority. Measures were taken to ensure correct data analysis and necessary inferences were drawn. Without dwelling further into the process of data analysis, Rankings and weights obtained are tabulated as under in Table 10.

3.8 Questionnaire for performance evaluation

Based on the attributes and sub attributes identified, a questionnaire was formulated for conduct of user satisfaction survey in residential areas. A likert scale of 1 to 5 was uniformly adopted for the seven attributes directly related to building performance. Dichotomous questions were used for the external factors to understand the perception of occupants with respect to external factors i.e. Accessibility, Amenities and Societal issues. Questions have been appropriately worded in a manner the participant can clearly comprehend what the researcher is exactly asking and can convey the best possible unambiguous feedback. The ratings instead of being

Table 10. Ranking and Weights of BPAs directly related to building performance

BUILT FORM			
		1-Physical Safety	0.34
		2-Fire Safety	0.25
0.19	BF1-Safety	3-Electrical Safety	0.23
		4-Disinsection	0.18
		5-Safety	0.28
0.18	BF2-Physical Condition	6-Performance	0.21
		7-Productivity	0.17
		8-Psy Comfort	0.17
		9-Maintenance	0.17
		10-Space Adequacy	0.29
		11-Height Adequacy	0.21
0.17	BF3-Spaces	12-Accessibility	0.19

		13-Grouping	0.18
		14-Redundancy	0.13
		15-Finishes	0.24
		16-Concealment	0.21
0.09	BF4- Finishes, Fittings, Furniture	17-Furniture	0.19
		18-Fixtures	0.18
		19-Special Fittings	0.18
ENVIRONMENTAL		20-Air Quality	0.25
		21-Water Quality	0.18
0.14	BF5- Air, Noise, Water	22-Noise	0.16
		23-Control	0.15
		24-Maintenance	0.14
		25-Type	0.12
		26-Uniformity	0.26
		27-Control	0.22
0.13	BF6-Lighting	28-Energy Savings	0.19
		29-Glare	0.17
		30-Maintenance	0.16
		31-Sewage	0.27
0.10	BF7-Waste Disposal	32-Cleanliness	0.26
		33-Drainage	0.24
		34-Adequacy	0.23

numbered from 1 to 5, have been labeled specific to the nature of the opinion likely to endorsed by the respondent.

The questionnaire has been divided into four sections. Section I covers the personal details, Section II the ratings in a likert scale of 5 for seven attributes directly related to building performance. Section III lists the external factors with dichotomous questions and finally Section IV has a space for endorsement of additional comments in case the respondent likes to endorse. The format of questionnaire is enclosed as an annexure to this paper.

3.9 Pilot Survey

A pilot survey was undertaken to validate the questionnaire. One of the residential colonies of a military station was chosen for the pilot survey. The occupant profile was studied and sampling was carried out as per stratified random sampling technique. The questionnaire was administered to a sample size of 100 (n) among Officers, Junior Commissioned Officers and Other Ranks. The questionnaire was physically distributed to all participants. The content of the questionnaire was explained to the respondents by the survey team in english and local vernacular language as understood by the respondents. The exercise was carried over a period of 3 days. On collection and initial screening of data, 26 responses out of 100 were

found with minor errors which were rectified by revisiting the residential accommodation of the respondents.

4. Data Analysis

XLSTAT 2014 was used to analyze data. Preliminary checks were conducted to find blank pages, blank columns, and any specific pattern in responses. Errors in measurement for types I and II errors were checked and found appropriate. Once the data were prepared for analysis, the following analysis with respect to Section II of questionnaire was conducted to ensure translation, construct, and reliability validation of the questionnaire.

4.1 Translational Validity

Under Translational validity, content validity and face validity were checked. Content validity is examined to ascertain whether the content of the questionnaire is appropriate and relevant to the study. Content validity indicates that the content reflects a complete range of attributes under study and is usually verified by seven or more experts. In the present case, a list of these attributes was discussed with construction industry experts, including architects, engineers, consultants, and academicians and facility managers. 84% agreed that the attributes are adequate enough and 73% agreed that amplification of attributes in the form of sub attributes shall be useful.

The face validity was determined by examining the ease in which the respondents answered the questionnaire. Feasibility, readability, and word clarity were considered during the framing of the questionnaire. Instructions enabled the respondent to easily understand the contents of each section. The layout and style of the questionnaire provided comfort to the participant while answering the questions.

4.2 Construct Validity

Construct validity of the questionnaire was ascertained by conducting a confirmatory factor analysis of the collected data. XLSTAT 2014 was the software used to generate the output, based on which a conclusion could be made regarding the construct validity of the questionnaire. The results obtained on confirmatory factor analysis are listed below as Table 11.

Table 11. Results for construct validity

Test	Purpose	Range	Result
KMO correlation coefficient	Sample Adequacy	0.5-0.7 = Mediocre 0.7-0.8 = Good 0.8-0.9 = Great >0.9 = Superb	>= 0.7 for all attributes
Eigen Value	Factor Relevance	>1	>1 for all attributes
Factor Loadings	Correlation	>0.5	>0.5 for all attributes
Cronbach Alpha	Reliability	Minimum 0.7	>0.7 for all attributes

4.3 User Satisfaction Index

Aim of this whole exercise is to device a means to regularly evaluate building performance based on the user satisfaction obtained through the above designed questionnaire. The questionnaire comprises of questions garnering user satisfaction on various aspects that are directly related to building and also external factors that can influence user satisfaction. A need was felt to device a scale through which the satisfaction can be quantified. A user satisfaction index was conceptualized with simple mathematical calculations on MS excel format that can be easily handled by junior level employees of the FM agencies which do not require extraordinary technical or mathematical expertise to arrive at. The feedback obtained in the form of likert scale rating of the sub attributes was reduced in a scale of 0 to 1 using corresponding weights of sub attributes within each attribute. Subsequently, the derivatives of each attribute were reduced in a scale of 0 to 1 using corresponding weights of each attribute. The final figure obtained is termed as a User Satisfaction Index (USI).

5. Algorithm for User Satisfaction Index (USI)

Let n be the total number of respondents, k be the total division likert scale and t be the index for likert values. Let $\boldsymbol{c_{ijt}}$ be the total count of t value of likert scale for sub-attribute j of attribute i. Then average normalized scores SSA_{ij} of sub-attribute j for attribute i are calculated based on responses from user survey using formula below.

$$\mathrm{SSA_{ij}} = \frac{1}{\mathrm{n\times k}}\sum_{\mathrm{t=1}}^{\mathrm{k}} \mathrm{t} \times \mathrm{c_{ijt}} \quad (1)$$

Here i is index for attributes varies from 1 to 7 and the value of j varies for different attributes as per their number of sub-attributes. Thus SSA_{ij} , $i = 1 \ldots .7$ and $j = 1 \ldots .4$ or 5 or 6 ; are the average normalized score calculated from user satisfaction survey of sub-attribute j of attribute i. Let U_{ij} , $i = 1 \ldots .7$ and $j = 1 \ldots .4$ or 5 or 6 as the case may be, are the weight of sub-attribute j of attribute i obtained from expert opinion. The average normalized score of attributes 1 to 7 viz. $SA_1 \ldots \ldots SA_7$, whose value lies between 0 and 1, is calculated as under.

(2)

$$SA_1 = U_{11} \times SSA_{11} + U_{12} \times SSA_{12} + U_{13} \times SSA_{13} + U_{14} \times SSA_{14}$$
$$SA_2 = U_{21} \times SSA_{21} + U_{22} \times SSA_{22} + U_{23} \times SSA_{23} + U_{24} \times SSA_{24} + U_{25} \times SSA_{25}$$
$$SA_3 = U_{31} \times SSA_{31} + U_{32} \times SSA_{32} + U_{33} \times SSA_{33} + U_{34} \times SSA_{34} + U_{35} \times SSA_{35}$$
$$SA_4 = U_{41} \times SSA_{41} + U_{42} \times SSA_{42} + U_{43} \times SSA_{43} + U_{44} \times SSA_{44} + U_{45} \times SSA_{45}$$
$$SA_5 = U_{51} \times SSA_{51} + U_{52} \times SSA_{52} + U_{53} \times SSA_{53} + U_{54} \times SSA_{54} + U_{55} \times SSA_{55} + U_{56} \times SSA_{56}$$
$$SA_6 = U_{61} \times SSA_{61} + U_{62} \times SSA_{62} + U_{63} \times SSA_{63} + U_{64} \times SSA_{64} + U_{65} \times SSA_{65}$$
$$SA_7 = U_{71} \times SSA_{71} + U_{72} \times SSA_{72} + U_{73} \times SSA_{73} + U_{74} \times SSA_{74}$$

User Satisfaction Index (USI) can be obtained from using the formula given below.

$$\mathrm{USI} = w_1 \times \mathrm{SA_1} + w_2 \times \mathrm{SA_2} + w_3 \times \mathrm{SA_3} + w_4 \times \mathrm{SA_4} + w_5 \times \mathrm{SA_5} + \mathrm{w_6} \times \mathrm{SA_6} + w_7 \times \mathrm{SA_7} \quad (3)$$

where $w_1 \ldots \ldots w_7$ are the weights of attributes 1 to 7 obtained from expert opinion.

As in our case, based on previous survey and calculation weights for attributes and sub-attributes are obtained using expert opinion. These values of w_i and U_{ij} are given in table 10.

Let us consider example of SSA_{11} to explain the calculations steps involved to find normalized score for sub-attributes. For a 5-point Likert scale therefore value of k is 5.Let the responses from 100 users obtained as summarized below.

1	2	3	4	5
15	20	10	40	15

Thus, the count for different sub-attributes is obtained from table above.
Then SSA_{11} is calculated as

$$SSA_{11} = \frac{1}{100\times5}\sum_{t=1}^{5} t \times c_{11t} = = \frac{1}{5} \times \frac{1}{100}(1 \times 15 + 2 \times 20 + 3 \times 10 + 4 \times 40 + 5 \times 15) = 0.64 \quad (4)$$

Similarly, other normalized score for sub-attributes can be calculated.

6. Conclusion

The main aim of arriving at USI is to make a comparison post implementation of interventions by the FM agency based on feedback obtained on various attributes. Increase/Decrease/No change in value of USI post implementation of interventions by FM agency will give a clear idea to the FM agency with respect to the efficacy of the processes and procedures followed by the FM agency. Increase in USI will vouch for the efforts of FM agency on the positive side improving its credibility. Thriving for increase in USI can be a huge motivating factor for the FM agencies which generally remain at the receiving end of dissatisfaction of occupants. The USI and the feedback on BPAs will also give a clear idea to the FM agency on prioritization of maintenance efforts in case of crunch in resources in terms of money and manpower. In case of decrease in USI, accountability of the FM agency will be at stake which will again keep the FM agency guarded against any inappropriate activities and may indicate additional efforts required to be made for enhancement in USI.

Factors like age of buildings, paucity of funds and non-availability of manpower will always affect the USI. However, these impediments will always remain, especially in government sector. USI, though not a perfect indicator, it will definitely act as an indicator towards the effectiveness of the processes and efficiency of the FM agency.

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APPENDIX

QUESTIONNAIRE FOR USER SATISFACTION

INSTRUCTIONS

(a) The questionnaire has four sections | **(b) Please fill details as asked for in Section I**

(c) Fill ratings by ticking the shaded boxes on the right hand side | **(d) Indicate Yes or No in Section III**

(e) Provide additional comments if any, in Section IV

SECTION I – PERSONAL DETAILS

Date:	**Loc:**	**House No:**
Rank:	**Name:**	**Unit:**

SECTION II - RATINGS

1-SAFETY – Provisions in the building other than structural safety

(a) Physical Safety – Safety against slipping, tripping, falling from windows and terraces

Highly Safe	Quite Safe	Barely Safe	Unsafe	Highly Unsafe

(b) Fire Safety – Adequacy of arrangements for safety against fire – Equipment, Water, Escape routes

Highly Adequate	Quite Adequate	Barely Adequate	Inadequate	Highly Inadequate

(c) Electrical Safety – Condition of switches, wiring and electrical fitments

Excellent	Very Good	Good	Bad	Very Bad

(d) Dis-insection – Provisions for mosquito proofing, fly proofing and protection against insects

Highly Adequate	Quite Adequate	Barely Adequate	Inadequate	Quite Inadequate

2-PHYSICAL CONDITION – Structural Condition of the building

(a) Safety – Structural safety based on appearance of the building

Highly Safe	Quite Safe	Barely Safe	Unsafe	Quite Unsafe

(b) Performance – Comfort level the building provides in performing designated tasks in various rooms

High Comfort	Sufficient Comfort	Bare Comfort	Discomfort	High Discomfort

(c) Productivity – Impact the condition of the building has on productivity

Highly Positive	Quite Positive	Barely Positive	Negative	Highly Negative

(d) Psychological Comfort – Psychological impact of the building condition on you

Highly Positive	Quite Positive	Barely Positive	Negative	Highly Negative

(e) Maintenance – Attention that the physical condition of the building needs now

Least	Little	Regular	Urgent	Most Urgent

3- SPACES – Spaciousness and grouping of the rooms in the building

(a) Space Adequacy – To perform intended tasks and moving space

Highly Adequate	Quite Adequate	Barely Adequate	Inadequate	Highly Inadequate

(b) Height Adequacy – Sufficient for air circulation, easy movement and preventing echo

Highly Adequate	Quite Adequate	Barely Adequate	Inadequate	Highly Inadequate

(c) Accessibility – Good Layout and easy access to all spaces in the building

Very Easy	Quite Easy	Barely easy	Difficult	Very Difficult

(d) Grouping – Provision for privacy and minimize infructuous movement

Excellent	Very Good	Good	Bad	Very Bad

(e) Redundancy – Any part of the building unusable/waste of space

No Redundancy	Little	Very Little	High	Very High

4-FINISHES, FIITINGS & FURNITURE - Effectiveness of finishes, fittings and furniture

(a) Finishes – Internal and External appearance of the building

Excellent	Very Good	Good	Bad	Very Bad

(b) Concealment – Concealment of internal plumbing and electric wiring and other conduits

Highly Adequate	Quite Adequate	Barely Adequate	Inadequate	Highly Inadequate

(c) Furniture – Adequacy of built in and movable furniture for performance of intended tasks of spaces

Highly Adequate	Quite Adequate	Barely Adequate	Inadequate	Highly Inadequate

(d) Fixtures – Adequacy, Elegance and Effectiveness of fittings and fixtures

Highly Adequate	Quite Adequate	Barely Adequate	Inadequate	Highly Inadequate

(e) Special Fittings – That caters for specially abled occupants in the building

Highly Adequate	Quite Adequate	Barely Adequate	Inadequate	Highly Inadequate

5-Air, Noise, Water – Quality of Air, Noise and Water in the building

(a) Air Quality – Sufficiency of air in quantity and quality for respiration, thermal comfort and freshness

Highly Sufficient	Quite Sufficient	Barely Sufficient	Insufficient	Highly Insufficient

(b) Water Quality – Sufficiency of water quality for consumption

Highly Sufficient	Quite Sufficient	Barely Sufficient	Insufficient	Highly Insufficient

(c) Noise - Comfort level of noise in the interiors of the building

High Comfort	Sufficient Comfort	Bare Comfort	Discomfort	High Discomfort

(d) Control – Easy access of controls for ventilation

Very Easy	Quite Easy	Barely easy	Difficult	Very Difficult

(e) Maintenance – Degree of ease for access and handling for maintenance

Very Easy	Quite Easy	Barely easy	Difficult	Very Difficult

(f) **Type** – Adequacy of provision for both types of ventilation – Natural and Forced

Highly Adequate	Quite Adequate	Barely Adequate	Inadequate	Highly Inadequate

6-LIGHTING – Illumination provided in various areas of the building									
(a) Uniformity – uniformity of illumination in all spaces of the building									
Highly Uniform		Quite Uniform		Barely Uniform		Un Uniform		Highly Un uniform	
(b) Control – Accessibility of controls to lighting									
Highly Accessible		Quite Accessible		Barely Accessible		Inaccessible		Highly Inaccessible	
(c) Energy Savings – Efficiency of the provisions with respect to energy savings									
Highly Efficient		Quite Efficient		Barely Efficient		Inefficient		Highly Inefficient	
(d) Glare – Effect of glaring of illumination on eyes									
No Glaring		Barely Glaring		Little Glaring		Glaring		Highly Glaring	
(e) Maintenance – Degree of ease of handling for maintenance									
Very Easy		Quite Easy		Barely easy		Difficult		Very Difficult	
7-Waste Disposal – State of Sewage and Drainage									
(a) Sewage – Adequacy of sewage arrangement to drain off sewage from the building									
Highly Adequate		Quite Adequate		Barely Adequate		Inadequate		Highly Inadequate	
(b) Cleanliness – Efforts to keep the sewage and drainage lines clean									
Highly Adequate		Quite Adequate		Barely Adequate		Inadequate		Highly Inadequate	
(c) Drainage – Adequacy of drainage to drain off rain water and avoid stagnation									
Highly Adequate		Quite Adequate		Barely Adequate		Inadequate		Highly Inadequate	
(d) Adequacy – Provision of garbage bins, Dust Bins and Incinerators for disposal of waste from building									
Highly Adequate		Quite Adequate		Barely Adequate		Inadequate		Highly Inadequate	

SECTION III – EXTERNAL FACTORS				
8-ACCESSIBILITY				
(a) Access - Easy access to the building premises to the occupants	Yes		No	
(b) Comfort - Access comfortable enough to allow for vehicles and pedestrians	Yes		No	
(c) Staircases - Adequate and comfortable stairs to allow access to all floors	Yes		No	
(d) Location - Stairs/Lifts ideally located to avoid infructuous movement	Yes		No	
(e) Ramps - Provision of ramps for easy access of special people	Yes		No	
(f) Access - Easy access to the building premises to the occupants	Yes		No	
(g) Maintenance - Easy all round access to the building premises to the occupants	Yes		No	
9-AMENITIES				
(a) Open Spaces - Adequate open spaces in the vicinity of the building	Yes		No	
(b) Parking - Sufficient parking spaces for two/four wheelers	Yes		No	
(c) Security – The locality is free of theft, burglary and related crimes	Yes		No	
(d) Traffic Safety - Adequate road signs and related appurtenances for road safety	Yes		No	
(e) Connectivity – Good Telephone and Internet connectivity	Yes		No	
10-SOCIETAL ISSUES				
(a) Neighborhood - Congenial neighborhood	Yes		No	
(b) Social Status - Compatible social status amongst the occupants	Yes		No	
(c) Education - Comfortable education level facilitating pleasant interaction	Yes		No	
(d) Religious Spaces - Caters to the all types of religious requirements of occupants	Yes		No	
(e) Financial Status- Compatible financial status enabling comfortable co-existence	Yes		No	

SECTION IV – ADDITIONAL COMMENTS IF ANY	
Signature:	**Contact No:**