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# Validation and ranking of user requirement related building performance attributes and sub attributes for government residential buildings

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## Abstract

**Purpose** – Purpose of this study is to identify and validate user requirement related building performance attributes and sub attributes for performance evaluation of government residential buildings.

**Design/methodology/approach** – User requirements in a building were listed from ISO 6241-1984 (E). Seven building performance attributes were identified through literature review and linked with the user requirements. Three more attributes not directly related to building performance but that could influence user satisfaction were also identified. The attributes were grouped into physical, environmental and external factors to suit the intervention strategies proposed to be implemented by maintenance agencies to enhance user satisfaction. The need for amplifying the attributes for better comprehension by occupants was felt; hence, characteristics of each of these attributes were listed based on literature survey and review. In total, 42 such sub attributes were identified to amplify ten attributes. To validate the adequacy of these attributes, an online survey was launched to garner feedback on first adequacy of the attributes and secondly to confirm whether there is a necessity for amplification of attributes for better comprehension by occupants. In total, 200 responses were received through the online survey, and the data received were categorized as per gender, location, sector, profession and finally civilian/military.

**Findings** – The outcome of the survey revealed that 84% of the participants felt that the attributes were adequate enough to assess building performance and 75% of them agreed that amplification of attributes through sub attributes as essential for better comprehension and to avoid ambiguity in response. Also the seven identified attributes were ranked from 1 to 7 with 1 being the most important. Weights of each attribute in the scale of 1 were also arrived at based on the responses. Similar exercise was carried out for all sub attributes.

**Research limitations/implications** – Present research is confined to government residential buildings that are constructed and maintained through public funds and hence individual occupants are not constrained by economics. Other type of building infrastructure used for training, sports, storage, medical, etc., will have certain more specific performance parameters in addition to the ones identified in this paper for residential buildings. Economics also become a factor from users' perspective in case of private residential buildings which does not form part of the scope of this paper. However, as a future scope, the number of attributes can be escalated depending upon the type of building being surveyed, keeping the identified attributes as core attributes.

**Practical implications** – This paper links the end user satisfaction with building performance and the outcome of surveys will provide useful insights to the behaviour of buildings as well the efficiency and effectiveness of the existing maintenance management systems. Survey based on these attributes and sub attributes will enable the facility managers to ascertain the satisfaction level of occupants with respect to building performance, satisfaction with respect to external factors such as accessibility, amenities and societal issues other than building performance. It will enable the facility managers and decision makers to prioritize their maintenance according to importance, availability of funds, etc. It will also provide a data bank over the



years that can indicate the changing aspirations of occupants of government residential buildings. This will enable policymakers to review specifications, authorizations and scales.

**Originality/value** – This paper links user requirement with building performance. ISO 6241-1984(E) forms the basis for user requirement. Survey based on these user requirement related building performance attributes shall enable facility managers prioritize their maintenance efforts in management of facilities.

**Keywords** Surveys, Data analysis, User satisfaction, Maintenance management, Residential buildings, Building performance

**Paper type** Research paper

## Introduction

Military Engineer Services (MES) is one of the biggest government construction/maintenance agencies in India, responsible for construction and maintenance of infrastructure for its Armed Forces. Presently, there is no tool in place to gauge effectiveness of the maintenance management system in MES (Gopikrishnan and Paul, 2017). With outcome-based facility management gaining ground, any built facility is also required to be evaluated on its performance, post occupation. Actual outcome is dictated by performance of a facility in meeting users' needs and expectations (Gopikrishnan and Topkar, 2016). The most ideal way to gauge performance of a facility is to measure the degree of end user satisfaction (Gopikrishnan and Paul, 2017). Numerous lists of factors are presently available to gauge performance of a building with respect to physical functional and aesthetical aspects. User satisfaction should have been the primary concern instead of being one of the less important factors. There is a need to identify and standardize the requirements of a building user and categorize the building performance attributes (BPAs) according to these user requirements. In order to avoid arbitrariness in identifying user requirements, ISO 6241-1984 (E) was taken as a datum to specify user requirements. Out of the various types of infrastructure constructed and maintained, it is considered appropriate to gauge user satisfaction in residential buildings due to sleeping occupancy and related functions. Occupants are in interface with residential buildings during non-duty period in family life environment. Despite dealing with Armed Forces, study area is in the domain of civil life functions. This research paper lists user requirements, attributes and sub attributes related to building performance and establishes the linkages between user requirements and the attributes. Attributes not directly linked with building performance but that can influence user satisfaction are also identified. Validation and ranking of the attributes and sub attributes for quantifying user satisfaction are also carried out to device a scale for gauging effectiveness post implementation of intervention strategies.

## Literature review

User requirement and building performance are the two major aspects being considered in this paper. For any building constructed, it is necessary to take care of the user requirements related to physical, functional and financial aspects (Gopikrishnan and Paul, 2016). Physical aspects relate to building fabric and properties, functional aspects to relationship of building with occupants and financial aspects to capital costs/life cycle costs of the building. All the three aspects discussed above are aimed at meeting users' needs, expectations and aspirations. A building can be deemed as performing if occupant is satisfied and vice versa. Loosemore and Hsin (2001) argue that it is extremely difficult to measure impact of a facility based on emotions, attitudes and behaviour of occupants/users. Kotler (1997) defines satisfaction as a person's feeling of pleasure or disappointment resulting from comparison of the product's perceived performance/outcome in relation to his/her expectations. Many

researchers consider satisfaction as overall measure, while others feel that satisfaction is described best by a combination of facets or attributes. For instance, Day (1977) sees no difficulty in measuring individual's satisfaction/dissatisfaction with overall outcome. Also, Czepiel and Rosenberg (1977) agree that consumer satisfaction can be thought of as a single overall evaluative response that represents summary of subjective responses to many different facets. Handy and Ptuff (1975) however disagree with overall satisfaction measurement, arguing that response to an overall satisfaction is only crudely measured. Zickmund (1994) corroborates Handy and Ptuff's views contending that measures of cognitive phenomena (such as satisfaction) are often composite indexes of a set of variables. This paper draws on views of Zickmund as well as Mbachui and Nkado (2007) with an approach of measuring user satisfaction with a set of attributes.

In case of government agencies which are responsible for construction and maintenance of assets through public funds, performance measurement is essential to ascertain outcome of constructing a facility and also establish accountability of service provider in ensuring end user satisfaction (Gopikrishnan and Paul, 2017). It is essential in private sector too, to remain competitive and cost effective in construction businesses. In both cases, performance measurement is essential, whereas indicators may vary depending on the goals for measuring the performance (Nik-Mat *et al.*, 2011).

### Usability

While evaluating performance of a building, usability becomes a very important factor. Understanding user needs and being able to use this as guidance is believed to make facilities more resource effective through matching against user needs (Lindahl *et al.*, 2011). This research also follows the same premise that the key issue in performance of buildings is usability. The theoretical potential of the facility to deliver a certain effect do not automatically make it usable in the real world. REBUS framework suggested by Lindahl *et al.* (2011) works on evaluation of usability and implementing knowledge of usability in construction of new projects and in improvement and management of existing buildings. However, Lindahl *et al.* (2011) did not list down the attributes for assessment of usability. Identification of attributes and sub attributes attempted in this research is also a step towards assessment of usability and its implementation in management of existing buildings.

Haron *et al.* (2013) suggest a five-stage evaluation process of hospital buildings on usability. Though the processes of evaluation are documented, what exactly should be evaluated or mapped, in the form of attributes related to usability is not mentioned, and it is the step of Mapping, this paper supplements.

Van der Voordt (2009) lists nine aspects required to be measured in order to understand usability. For example, Safety is an aspect required to be measured. However, for a user, Safety is a broad term and to know the satisfaction level of a building related to safety, there is a need to amplify safety, i.e. physical safety, electrical safety, fire safety so on and so forth. Amplification of these aspects or attributes in the form of sub attributes will lead to better comprehension of attributes by occupants enabling their feedback to be more precise and close to reality.

### User satisfaction

Jiboye (2012) mentions user satisfaction as one of the best means to evaluate outcome of any facility. Hasselar (2003) noted that an indicator is a sign that points to a condition to be measured, to evaluate specific qualities and performances. Criteria for measuring performance of buildings should be derived from parameters that have direct bearing on the

user satisfaction. Residential satisfaction is a reflection of the degree to which inhabitants feel that their housing is helping them achieve their goals. Existing studies carried out in Nigeria on public housing (Ukoha and Beamish, 1997; Olatubara and Fatoye, 2007; Fatoye and Odusami, 2009; Ibem *et al.*, 2012; Clement and Kayode, 2012) focus on general performance of public housing in meeting occupants' needs and expectations. In attempt to garner satisfaction of all categories of users on building performance, Kian *et al.* (2001) and Kim *et al.* (2005) suggested use of six BPIs, namely, spatial comfort, indoor air quality, visual comfort, thermal comfort, acoustic comfort and building integrity. Meir *et al.* (2009) approached BPE as a concept based on user experience and emphasized on inclusion of occupant's physiological and psychological comforts. From these studies, it is established that physical characteristics of residential buildings have significant influence on occupant's satisfaction with their residential environment. Ibem *et al.* (2013) attempted to examine physical characteristics of buildings in public housing and assess residents' satisfaction with physical, spatial, location, aesthetic and cost attributes of buildings.

### Building performance evaluation

Extensive research has been carried out on building performance evaluation in developed countries. In the past few decades, progress has been made in developing different evaluation tools and approaches (O'Sullivan *et al.*, 2004; Kim *et al.*, 2005; Khair *et al.*, 2012). Main categories of approaches presented in more detail by Khair *et al.* (2012) include functional suitability, quality assessment, serviceability, environmental performance, energy consumption, design, construction/services and post occupancy evaluation (POE) on technical, functional and behavioural aspects of buildings. Most of the research carried out in building performance is maintenance, energy, health and hygiene or purely technically oriented. Ho *et al.* (2004) identified eight key environmental qualities that contribute to occupant's health, namely, density, air, light, noise, thermal comfort, drinking water, waste disposal and cleanliness. These environmental qualities were then translated into a list of building specific attributes that can possibly be measured objectively. However, the assessment remains uni-directional, occupant's health, limiting the outcome only to enhance occupant's health. Moreover, out of the 14 user requirements listed in Table I of ISO 6241-1984 (E), research focuses only on hygiene.

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, i.e. 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

**Table I.**  
User requirements  
listed in ISO  
6241-1984 (E)

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

Researchers have grouped various attributes together depending on purpose of evaluation. While measuring residential satisfaction in a housing colony, [Mohammad and Azim \(2012\)](#) grouped 46 attributes in four components, namely, housing and physical features, services within housing area, public facilities provided and social environment within housing area. [Gopikrishnan and Topkar \(2015\)](#) have grouped 13 attributes together which indicate user satisfaction more on functional aspects from facility maintenance perspective. While assessing maintenance aspects of high rise buildings, [Nik-Mat et al. \(2011\)](#) grouped 16 attributes in three heads, namely, functional, technical and image characteristics. [Ibem et al. \(2013\)](#) listed 27 attributes under five factors while carrying out performance evaluation of residential buildings. [Khalil et al. \(2010\)](#) identified 19 attributes for building performance during POE of public buildings. [Meng and Minouge \(2011\)](#) used 11 indicators, while measuring maintenance performance in buildings. [Hashim et al. \(2012\)](#) used ten attributes in four heads namely space, comfort, serviceability and safety. There are other case studies available too ([Olenrawaju et al., 2011](#); [Shohet et al., 2003](#)) wherein performance of buildings is assessed based on number of factors.

Literature review revealed that researchers identify and group attributes to evaluate performance of buildings for different purposes. Whatever be the purpose of evaluation, the underlying factor is that the occupant needs to be satisfied. There may be a case in point where the evaluation can indicate high performance, but occupant satisfaction remains low. As an example, a structurally and aesthetically appealing building built in an inaccessible area may be performing well as a building but may not satisfy the requirement of occupants. Hence, a requirement was felt to synchronize the BPAs according to user requirements and then evaluate those aspects from occupants' feedback which will truly reflect the building performance. This research paper is attempt in that direction and to standardize the list of user requirements, already available internationally accepted universal standard ISO 6241-1984 (E) has been taken as a reference point with respect to user requirements in a building.

It is feasible to link the user requirements/satisfaction to BPAs to formulate an effective intervention strategy with an overall aim to enhance user satisfaction ([Gopikrishnan and Paul, 2017](#)). It is possible for facility managers to identify and prioritize areas needing intervention, thereby accounting for his resources in terms of time, effort and money with user satisfaction being the scale.

### Methodology

This study applies a research method that included arriving at a list of BPAs and synchronizing them with user requirements. User requirements were identified from SO 6241-1984(E).

Based on literature review, seven BPAs were identified, namely, spaces, physical condition, safety, finishes, fittings and furniture, lighting, air, noise and water and waste disposal. The user requirements were then linked with the BPAs. Apart from the seven attributes that were directly related to physical and functional aspects of building, three

more attributes, namely, accessibility, amenities and societal, were identified as attributes that influence user satisfaction though not directly linked with building performance.

The ten attributes were grouped into three factors, i.e. physical (spaces, physical condition, safety and finishes, fittings and furniture), environmental (lighting, air, noise and water, waste disposal) and external (accessibility, amenities and societal). Grouping of attributes in the above three factors were carried out to facilitate the subsequent intervention strategies that will be implemented by maintenance agencies to improve user satisfaction. Out of the three, attributes grouped under physical and environmental factors will be taken care of by maintenance agency, whereas external factors are functions not related to building performance and cannot be influenced by the maintenance agency. The administrators are required to take care of the issues related to accessibility to buildings, amenities to be provided and to take care of the social needs of occupants.

The attributes were further amplified in form of sub attributes that could characterize each attribute for better comprehension by the occupant. Data analysis was carried out with 200 responses received from experts through an online survey. Based on the feedback of a carefully chosen expert group comprising of engineers, architects, consultants, facility managers and academia, validation of the attributes for its adequacy and necessity for amplification in the form of sub attributes were carried out. These user requirement related BPAs and their sub attributes were ranked according to order of importance and their weights obtained based on inter se importance.

Post identification of attributes and corresponding sub attributes, a need was felt to validate the same from domain experts prior to formulation of a survey instrument. Hence, an online survey was launched with a two pronged aim to ascertain the adequacy of attributes and whether there is a requirement at all to amplify the attributes in the form of sub attributes. It was also decided to obtain the ranking and weights of these attributes and sub attributes so that inter se weights can be arrived at that can facilitate formulation of overall satisfaction as an index. Though validation of all the ten attributes was carried out, ranking and weights were asked for the seven attributes and their corresponding sub attributes directly related to building performance were listed for obtaining ranks and weights. The questionnaire for this purpose was devised to garner these inputs as per gender (male and female), location (indians and foreigners), sector (public and private), profession (engineers, consultants, architects, academia, FM) and finally category (civilian and military personnel). The survey was launched in February 2017 and went on till May 2017. Out of the total responses received, 200 valid responses remained after necessary data cleaning.

These attributes and sub attributes will form the basis of a survey instrument in the form of a questionnaire. The feedback obtained through questionnaire surveys will be used to measure user satisfaction and in turn gauge performance of building. This quantification is essential to measure user satisfaction which can in turn reflect on performance of buildings, performance of maintenance agencies and effectiveness of the procedures followed. Validation and ranking will also enable facility managers gauge effect of interventions carried out in improving user satisfaction levels post implementation of intervention strategies.

### User requirement

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) are listed under in [Table I](#).



**Building performance attributes**

Based on the extensive literature review highlighted in preceding sections of this paper, finally seven factors were identified as BPAs essential to be measured to assess building performance (Gopikrishnan and Paul, 2017). These BPAs are listed as under in Table II.

**User requirements and linkage with building performance attributes**

Table III brings out the suggested linkage between user requirements listed in ISO 6241-1984 (E) given in Table I above and the BPAs obtained through rigorous literature review listed in Table II above.

**External factors**

Apart from the requirements/expectations from the building that a user occupies, there are certain other factors that influences user satisfaction, namely, the amenities that come along with the building and also societal pattern in the locality of residential complex. Location of the residential complex itself can be a factor to influence user satisfaction. Despite a high-quality construction, due to difficulty in access to the area, user satisfaction can get affected. Similarly, proximity to amenities such as shops, walkways, parks, play areas, access to public transport, availability of adequate parking, uninterrupted electric and water supply

**Table II.**  
Building performance attributes (BPAs)

S. no.	BPA
(a)	Spaces
(b)	Physical condition
(c)	Safety
(d)	Finishes, fittings and furniture
(e)	Lighting
(f)	Air, noise and water
(g)	Waste disposal

**Table III.**  
Linkages of BPAs with user requirements

S. no.	User requirement	BPA influencing user requirement						
		Spaces	Physical condition	Safety	Finishes, fittings and 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*

also need to be incorporated while obtaining user satisfaction. Though degree of congeniality and amenability of neighbourhood, community participation, etc., also influence user satisfaction, facility managers do not have any control over such factors. Care should be taken to ensure that feedback given by users do not get biased by societal requirements. Leaving out societal requirements may result in the effect of these factors getting distributed among other factors. Hence, it will be to garner the feedback on societal requirements too.

Another major factor that influences user satisfaction is the degree of expectation which will depend on the understanding of the users with respect to his/her entitlement based on current official standing in case of government employees. In case of a government employee, it would be safe to mention that user satisfaction should be measured against what is provided in comparison with entitlement. Despite being aware of entitlement and matching provisioning, if user satisfaction still remains low, it will provide an insight to policy makers regarding the growing aspirations of government employees.

### Reflection on external factors

The basic aim of this research is to identify user requirements and BPAs, link and group the user requirements and BPAs with an objective to provide a feedback to FM and administrative agencies with respect to areas needing attention on building performance in order to enhance user satisfaction. Out of the ten attributes that are grouped into three factors as brought out in Table IV, seven attributes grouped under physical and environmental factors take care of the standard user requirements listed in ISO 6241-1984 (E), and they are directly linked with the performance of buildings. However, the attributes, namely, accessibility, amenities and societal issues grouped under external factors are not directly linked with performance of building as such. But it is of paramount importance to garner the feedback of occupants on the external factor with an intention to wipe out the effect of bias of occupants while responding to the other attributes. If the occupants are

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

**Table IV.**  
Grouping of user  
requirement related  
BPAs



aware that separate feedback is required to be given on Accessibility, amenities and societal issues, likelihood of these attributes affecting feedback on other attributes directly linked with building performance gets reduced to a very large extent. However, such feedback will be of immense value to the administrative agencies of the locality to improve upon these aspects of the locality.

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### Grouping of attributes

Building performance evaluation over the years in the form of POE or otherwise reveals twofold purposes, namely, evaluation of construction and maintenance management. Such evaluation is also essential to implement knowledge of usability in construction of new projects and management of existing buildings (Lindahl *et al.*, 2011). In all these cases, attributes identified and linked with user requirements are relevant. For tangible utilization of user satisfaction surveys, there is a need to group these user requirement linked BPAs with intervention strategies that enable the FM to focus on areas deserving priority. Intervention strategies for enhancement of user satisfaction are generally in terms of physical, environmental and external factors. Moreover, the intervention strategy as well as grouping should facilitate both FM as well as administrative managers of the locality to target holistic enhancement of user satisfaction. Table IV presents grouping of the user requirement linked BPAs.

### Sub attributes

This section explains what and why sub attributes are essential. Satisfaction level will be garnered from occupants of buildings through questionnaire in the form of user satisfaction surveys. Without adequate description of the BPAs, it will be extremely difficult for a user to comprehend the actual meaning of these attributes and may ultimately end up giving an arbitrary response. Similarly, there is likelihood that the participant answering the question may not exactly be able to perceive what the researcher means by the attribute say spaces or physical condition and so on. Being a layman, unaware of technical considerations involved, there is a chance of participant's response not in sync with reality. Moreover, if an additional comment offered by the participant is contradictory with rating of a question, it may render user's behaviour inconsistent. Hence, there is a requirement to frame the survey instrument in a manner that the participant, irrespective of his background perceives the requirement of researcher and offer an objective feedback. Though the rating of users may vary depending on their social, economic, educational, financial background, researcher can ensure to convey what he exactly looks for in their reply, through adequate description of each BPA.

On identification of BPAs, characteristics representing these attributes were compiled. National Building Code (2005), issued by Bureau of Indian Standards, Government of India, was referred to compile the characteristics of BPAs. Tables V to XIV describe each attribute in the form of sub attributes and self-explanatory characteristic of each sub attribute (Gopikrishnan and Topkar, 2015). These attributes, sub attributes and description of

**Table V.**  
Characteristics of  
spaces for evaluating  
user satisfaction

S. no.	Characteristic	Description
1	Space adequacy	Should have adequate space to perform intended tasks
2	Height adequacy	Should have adequate height for ventilation and lighting
3	Accessibility	All spaces should be easily accessible with stairs, ramps, lifts, etc.
4	Grouping	Avoid infructuous movement, promote efficiency and administration
5	Redundancy	Space should not be redundant, unusable or more/less

characteristics of each sub attribute will form the basis of survey instrument that will be used for user satisfaction surveys:

- *Spaces*: The accommodation should have adequate space to perform intended tasks. The dimensions of rooms should be catering for air circulation and ventilation. All the spaces in the building should be easily accessible. The spaces shall be grouped in a manner to avoid infructuous movement. No space shall be redundant, unusable or more/less than requirement. Sub attributes and characteristics of spaces for evaluating user satisfaction are listed in [Table V](#).
- *Physical condition*: It pertains to building integrity with respect to cracks, leakages, seepage and dampness etc. The physical condition of the building should provide a sense of physical safety to the occupant. The building should be usable and durable. Sizes and grouping of rooms should be appropriate, effective and efficient to perform intended functions. Sub attributes and characteristics of physical condition for evaluating user satisfaction are listed in [Table VI](#).
- *Safety*: The building should provide safety against accidents due to falling, tripping etc. It should have provisions for fire safety, electrical safety and also protection against insects in the form of mosquito proofing, etc. Sub attributes and characteristics of safety for evaluating user satisfaction are listed in [Table VII](#).
- *Air, noise and water*: The building should be free of air, noise and water pollution. It should have proper ventilation and odour control. The building shall be acoustically comfortable with noise inside the rooms being intelligible. Sub attributes and characteristics of air, noise and water for evaluating user satisfaction are listed in [Table VIII](#).
- *Lighting*: Lighting in the building shall cater for artificial and natural lighting with required luminance to perform intended functions. Lighting should prevent glare, provide a safe decorative and pleasing environment conducive to the interest of occupant. Lighting provided in the building should cater for the visual requirements of the occupants. Sub attributes and characteristics of lighting for evaluating user satisfaction are listed in [Table IX](#).

S. no.	Characteristic	Description
1	Safety	That provides a feeling of safety
2	Performance	Provides comfort in performing intended tasks
3	Productivity	Indicates increase/decrease in productivity based on condition
4	Maintenance	Provision for maintenance of roofs, walls, ceiling
5	Psychological comfort	Impact of physical condition on the occupant

**Table VI.**  
Characteristics of  
physical condition  
for evaluating user  
satisfaction

S. no.	Characteristic	Description
1	Physical safety	Provides safety against accidents due to falling, tripping, etc.
2	Fire safety	Adequate fire extinguishers, water sprinklers, fire alarms, ventilation, etc.
3	Electric safety	Against electrical accidents due to loose fittings, wires, etc.
4	Disinsection	Protects from insects in the form of mosquito proofing, Fumigation, etc.

**Table VII.**  
Characteristics of  
safety for evaluating  
user satisfaction

- *Waste disposal:* The building should have provisions for proper drainage of water and sewage. It should have adequate garbage bins, incinerators etc. for waste disposal. There should be frequent cleaning services available to ensure garbage collection, maintain hygiene and sanitation. Sub attributes and characteristics of waste disposal for evaluating user satisfaction are listed in [Table X](#).
- *Finishes, fittings and furniture:* The internal and external finishes of the building should perform intended functions and provide an attractive appearance. The plumbing and wiring should be preferably concealed. The building should also have appropriate furniture both inbuilt as well movable shall be as per requirement of users. Fixtures in the rooms should serve their purpose and special fittings shall be provided for physically challenged people. Sub attributes and characteristics of finishes, fittings and furniture for evaluating user satisfaction are listed in [Table XI](#).
- *Accessibility:* Building should be easily accessible. The access should be wide enough for negotiation by vehicles and pedestrians. Location of the building should be in close proximity to shops, walkways, parks and other amenities. Sub attributes and characteristics of accessibility as an external factor for evaluating user satisfaction are listed in [Table XII](#).
- *Amenities:* Adequate open spaces should be available to the occupants in the area of buildings. The locality should have clearly marked parking with ingress and egress routes. The place should be secure against theft, burglary and other crimes. Traffic

**Table VIII.**  
Characteristics of air, noise and water for evaluating user satisfaction

S. no.	Characteristic	Description
1	Air	Not be replete with automobile exhaust, other hazardous gases
2	Noise	Control of external and internal noise with intelligibility of sound
3	Water	Clean enough for earmarked purpose like drinking, washing, etc.
4	Control	Has easily accessible control to both natural and forced ventilation
5	Ventilation type	Has provision for forced ventilation also in the form of air conditioning
6	Maintenance	Facilitates easy access for handling and maintenance

**Table IX.**  
Characteristics of lighting for evaluating user satisfaction

S. no.	Characteristic	Description
1	Uniformity	Uniformly lit to perform the tasks and improve performance
2	Control	Has easily accessible control to both natural and artificial lighting
3	Energy savings	Facilitates energy savings
4	Glare	Has proper shading devices to avoid glare
5	Maintenance	Facilitates easy access and handling for maintenance

**Table X.**  
Characteristics of waste disposal for evaluating user satisfaction

S. no.	Characteristic	Description
1	Adequacy	Should have adequate garbage bins, incinerators, etc., for disposal
2	Cleanliness	Has a positive impact because of the hygiene and sanitation
3	Drainage	Should be able to drain off water, avoid stagnation
4	Sewage disposal	Efficiency in which sewage and sillage of building is disposed off

safety should be ensured in the area. The locality should enjoy good connectivity with respect to telephone, mobile and internet. Sub attributes and characteristics of amenities as an external factor for evaluating user satisfaction are listed in [Table XIII](#).

- *Societal*: The neighbourhood shall ideally be amenable to the occupant. Religious spaces akin to the requirement of the occupant shall be available and easily accessible to the occupant. The social, educational and financial strata of the community in the locality shall be commensurate to the occupant to keep him comfortable. Sub attributes and characteristics of Societal Issues as an external factor for evaluating user satisfaction are listed in [Table XIV](#).

S. no.	Characteristic	Description
1	Finishes	The internal/external finishes should for an attractive appearance
2	Concealment	The plumbing and wiring should preferably be concealed
3	Furniture	Should have essential furniture to cater for intended purposes
4	Fixtures	Fixtures in the rooms should serve their purpose
5	Special fittings	For physically challenged people in toilets

**Table XI.**  
Characteristics of  
finishes, fittings and  
furniture for  
evaluating user  
satisfaction

S. no.	Characteristic	Description
1	Access	The facility should be easily accessible for the occupants/users
2	Comfort	Should be wide enough and comfortable for vehicles/pedestrians
3	Location	Proximity to shops, walkways, play areas, parks and other amenities

**Table XII.**  
Characteristics of  
accessibility for  
evaluating user  
satisfaction

S. no.	Characteristic	Description
1	Open spaces	Adequate open spaces should be available for the users/occupants
2	Parking	Adequate and clearly marked parking with ingress/egress
3	Security	Against theft, burglary, crime rate in the area, etc.
4	Traffic safety	In the form of barriers, speed breakers, etc., on the internal roads
5	Connectivity	Telephone and internet connections should be available in the facility

**Table XIII.**  
Characteristics of  
amenities for  
evaluating user  
satisfaction

S. no.	Characteristic	Description
1	Neighbourhood	Similar to the occupant
2	Social status	Similar to the occupant
3	Education	Similar to the occupant
4	Religious spaces	Similar to the occupant
5	Financial status	Similar to the occupant

**Table XIV.**  
Characteristics of  
societal issues for  
evaluating user  
satisfaction

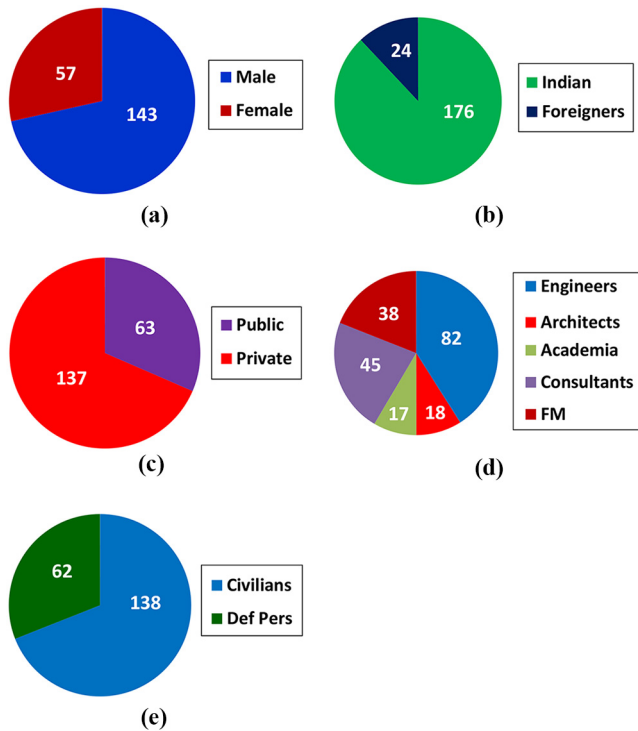
## Results and findings

### Responses

To have a basic understanding on the cross section of responses received, the responses were grouped as per gender, location, sector, profession and category. The charts depicted in Figure 1(a) to (e) give an idea on wherefrom these responses were received. These grouping enabled comparisons to check for consistencies of responses among various groups during data analysis.

### Queries on attributes and sub attributes

Two queries were asked to the experts. One was whether these attributes are adequate enough to represent the building performance reflecting user requirements. Second question was whether it was required to amplify the attributes in the form of sub attributes in the survey instrument to enable better comprehension of the attributes. For the query on adequacy of attributes, 168 participants, i.e. 84 per cent agreed that the attributes are adequate to represent user requirement related BPAs as shown in Figure 2(a) below. Out of the 13 responses who have not agreed on the adequacy of attributes, only four of them gave reasons for inadequacy. While one response suggested “Vaastu Sastra” be added as an attribute, one suggested adding “Architectural aspects” such as façade as an attribute. One of the respondents was of the opinion that age, sex, demographic factors were missing, though it was not the case. One respondent commented that importance of attributes can be



**Figure 1.**  
(a) As per gender;  
(b) as per location;  
(c) as per sector; (d) as  
per profession; (e) as  
per category

different for different scenarios. However, the 19 responses who could not respond did not have any specific answers for the same.

In response to the query on whether amplification of attributes in the form of sub attributes is required, 145 responses, i.e. 73 per cent of them agreed that there is a need for amplification as shown in Figure 2(b) above. Respondents, who negated nor refrained from commenting, did not specify any reasons for doing so. After considering the above, it was decided that the BPAs were adequate and there is a need to amplify them in the form of sub attributes for better understating by the occupants.

### Data analysis

The data collected through the online survey of domain experts were rank ordered ordinal data. Receipt of 200 valid responses through unambiguous rank ordered questions establishes the face and content validity. Reliability was in-built in the questionnaire as mutually exclusive responses were asked for. Sample size checked for adequacy. Conduct of normality test on SPSS software revealed the data to be non-normally distributed, non-parametric tests as applicable were carried out for data validation. Kruskal–Wallis test and Mann–Whitney U-tests conducted on the data as an alternative to ANOVA, and *t*-tests revealed that the distributions were similar across different categories.

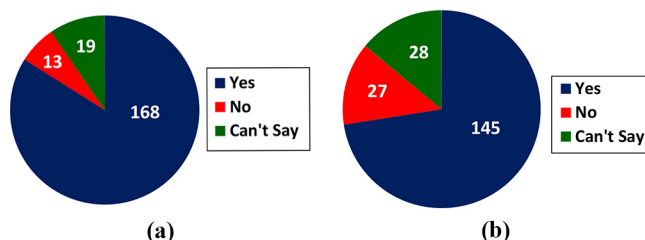
### Rankings and weights

Modes and sum values of the attributes and sub attributes were worked out. Mode gives the most occurring value for an attribute or sub attribute. In case of more than one attribute/sub attribute having the same value, higher will be the one having lesser sum value. Weights of attributes and sub attributes were then calculated based on check sum and weight sum values. In case of attributes, first preference is taken as 7 (among seven attributes) and next preference as 6, so on and so forth. Similarly for the sub attributes. Figure 3 depicts the ranking of all seven BPAs along with their weights mentioned against each.

Safety has been ranked as the most important BPA with a 0.19 weightage closely followed by physical condition and spaces with weights of 0.18 and 0.17, respectively. It goes along with common logic too for an occupant preferring safety, physical condition and spaces in that order. Environmental issues of air-noise-water, lighting and waste disposal follow suit with weights of 0.14, 0.13 and 0.1, respectively. Physical requirements are given a better priority than environmental factors which is understandable. Finishes-fittings-furniture is ranked seventh with weightage of 0.09 revealing the comparatively low ranking against other attributes.

Ascertaining ranks and weights of sub attributes was also carried out in similar fashion and the results are depicted from Figure 4(a) to (g).

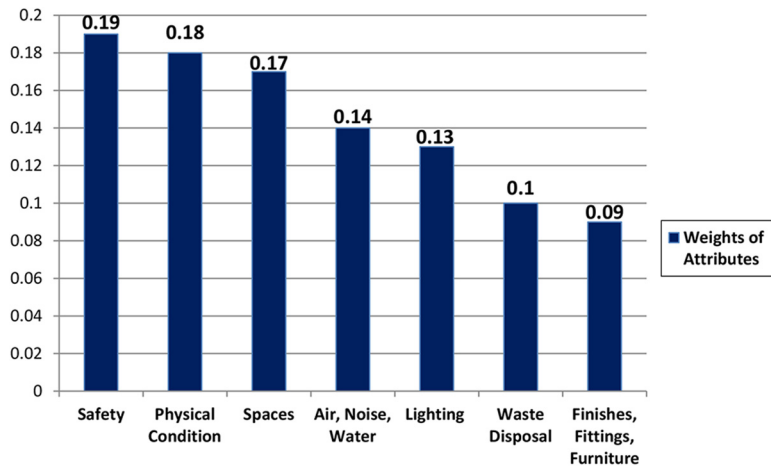
The main inference on the rankings and weights obtained on the sub attributes is that none of these characteristics are off target and are closely grouped. It will not be possible to



**Figure 2.**  
(a) Response on adequacy; (b) response on amplification



**Figure 3.**  
Ranking and weights  
of BPAs



leave out any of these sub attributes while framing the survey instrument which implies that the length of questionnaire will be governed by the 34 sub attributes.

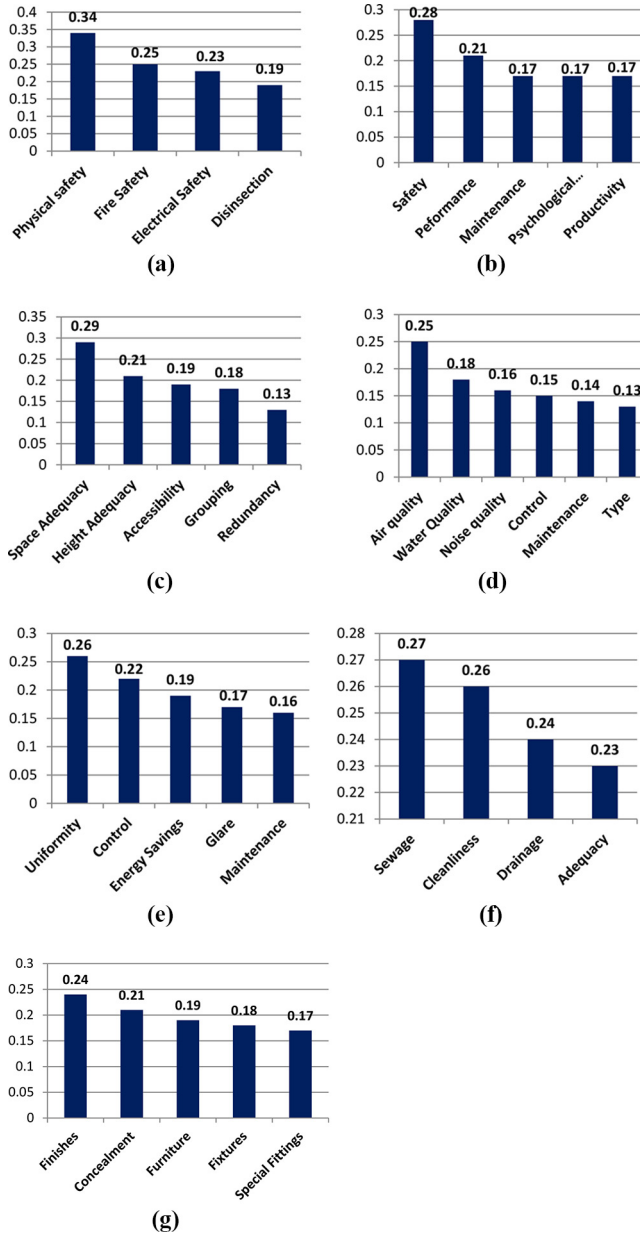
### Implications/limitations of the research

The biggest implication of this research is the tool being made available to measure building performance in relation to user requirement. This research will form the basis for formulation of an Index that will reflect on the effectiveness of procedures and processes followed by the FM in maintaining the residential facilities. Moreover, in the existing maintenance management system of government agencies, there is no accountability with respect to expenditure of humungous amounts of public funds in maintenance of residential assets. Such a measuring tool will establish accountability of implementing agencies with respect to the expenditure incurred on maintenance of facilities. Another major implication is that the feedback through these attributes/sub attributes can be available as a repository of data to the decision makers and policy framers to understand the growing aspirations of government employees.

Present research is confined to government residential buildings that are constructed and maintained through public funds and hence individual occupants are not constrained by economics. Other type of building infrastructure used for training, sports, storage, medical, etc., will have more performance parameters in addition to the ones identified in this paper. Economics also become a factor from users' perspective in case of private residential buildings which does not form part of the scope of this paper. However, as a future scope, the number of attributes can be escalated depending upon the type of building being surveyed, keeping the identified attributes as core attributes.

### Conclusion

Building performance can be gauged and measured based on user satisfaction. This paper had validated the attributes and sub attributes that were required to evaluate building performance through BPAs based on user requirements. Three attributes not directly linked with building performance but can influence user satisfaction have also been identified under External Factor. In total, 84 per cent of the expert group of 200 architects, consultants, facility managers, engineers and academia agree that the



**Figure 4.** (a) Weights related to Safety; (b) weights related to physical condition; (c) weights related to spaces; (d) weights related to air, noise, water; (e) weights related to lighting; (f) weights related to waste disposal; (g) weights related to finishes, fittings, furniture

attributes are adequate and 73 per cent of them agree to the fact that amplification is essential for better comprehension of attributes by occupants. Ranking of attributes as per the degree of importance reflect the inter se significance of attributes and sub attributes.

Survey based on these attributes and sub attributes will enable the facility managers to ascertain the satisfaction level of occupants with respect to building performance, satisfaction with respect to external factors like accessibility, amenities and societal issues other than building performance. It will enable the facility managers and decision makers to prioritize their maintenance according to importance, availability of funds, etc. It will also provide a data bank over the years that can indicate the changing aspirations of occupants of government residential buildings. This will enable policymakers to review specifications, authorizations and scales.

Grouping of the attributes in three categories will enable effective implementation of intervention strategies by the FM and administrative agencies. The weights obtained on the attributes and sub attributes will pave way for formulating an index, enabling quantification of user satisfaction which has never been done before. As anything that can be measured can only be managed, this quantification will help comparisons before and post implementation of intervention strategies that can provide valuable insights to the FM and administrators on the way ahead in management of facilities. As a future scope, applicability of these attributes to other type of buildings can be explored as the attributes are likely to remain the same with addition of some more based on type of buildings.

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