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MAINTAINABILITY AND DESIGN ASPECT OF PUBLIC HOSPITAL

Mastura Jaafar*, Nur Liyana Othman

Department of Quantity Surveying, School of Housing, Building and Planning, Universiti Sains Malaysia, 11800, Penang, Malaysia

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*Corresponding author
masturaj@usm.my

Graphical abstract

Abstract

Maintainability is a pertinent aspect to be considered in building design and is a key approach associated with design and maintenance. Considering maintainability at design stage is important to reduce maintenance and operation costs and ensure that a building can efficiently perform its function. This paper assesses the design impact on maintainability of Hospital Sutanah Bahiyah in Alor Setar. This study analyzes the maintainability from three building aspects (i.e., accessibility, selection of type of material, and environment) based on a secondary report and a focus group interview. Findings support the need of a design team that considers maintainability to help the maintenance team perform maintenance work.

Keywords: Maintainability, design aspects and hospital building

Abstrak

Kebolehsenggaraan adalah aspek penting yang perlu dipertimbangkan semasa mereka bentuk bangunan, dan merupakan kunci yang berkait dengan reka bentuk dan penyelnggaraan. Pertimbangan aspek kebolehsenggaran di peringkat reka bentuk adalah sangat penting bagi mengurangkan kos penyelenggaraan dan operasi serta memastikan bangunan boleh berfungsi secara efisyen. Objektif kertas kajian ini adalah untuk menilai kesan reka bentuk terhadap kebolehsenggaraan Hospital Sultanah Bahiyah, Alor Setar Kajian ini menganalisa kebolehsenggaraan dari tiga aspek bangunan iaitu kebolehcapaian, pemilihan jenis bahan dan persekitaran) berdasarkan rekod hospital dan sesi temu bual berkumpulan. Hasil kajian menyokong keperluan pasukan reka bentuk untuk mengambil kira aspek kebolehsenggaraan bagi membantu pasukan penyelenggaraan dalam melaksanakan tugasan mereka.

Kata kunci: Kebolehsenggaraan, aspek reka bentuk dan bangunan hospital

1.0 INTRODUCTION

The term maintainability is identified as "the ability of an item, under conditions of use, to be retained in or restored to a state in which it can perform its required function, when maintenance is performed under stated conditions and using prescribed procedures and resources" [1]. Maintainability is a pertinent aspect to be considered when designing buildings and is a key approach associated with design and maintenance. Considering maintainability at design stage is important to reduce the maintenance and operation cost and to ensure that the building can efficiently perform its function. Maintainability has been labeled by many researchers as an important aspect in cost saving that improves the functionality of facilities or buildings [2].

Design is important because it determines the level of maintenance work needed. Defect in design often affects building performance and increases maintenance cost. Design is an important factor of defect in building [3]. Proposing changes at the early design stage is easy. However, any changes during the construction period require approval from an authorized party. Maintainability should work in tandem with design. Professionals should pay attention to building maintenance issues (i.e., building defects and how to rectify them), bring the issues forward into the design stage, and consider maintainability aspects [4]. The assessment on maintainability could be applied as a part of the design process [5]. A maintenance team rectifies building defects. A maintenance team's work effectiveness depends heavily on design aspect. Providing a safe workplace for the maintenance team to perform their task affects building performance, ensures safety, and eliminates unnecessary cost. Property managers reported that problems related to design inefficiency appear to be the most important challenge in building operation and maintenance [6].

Previous studies related building defects with faulty design (i.e., leakage, condensation, decayed, peeling paint, and staining) [7]. However, building defects can be eliminated and minimized with proper monitoring and action during the design stage because the appearance of defects is due to decisions and actions at design stage. Some design defects (e.g., defect with no proper access) are impracticable for the maintenance team to perform their task [8]. Thus, considering maintainability during design helps to diminish maintenance cost, reduce downtime, and improve safety [9].

All stakeholders must pay attention on the maintainability aspect when designing a hospital to reduce operation and maintenance costs and eliminate superfluous cost owing to unnecessary building and design defects. Public hospitals provide hospital services free of charge to all eligible patients; such hospitals are important in in health care safety because they provide care for patients who may have limited access to care elsewhere [10], [11].

Hospital Sultanah Bahiyah, Alor Setar is located in northern part of Peninsular Malaysia. The hospital had been constructed and completed based on a design and build procurement system. The building was completed on February 2007 and cost MYR 560 million. The hospital began operation in September 2007 and is maintained by Faber Medi-Serve Sdn. Bhd. The issue on maintainability in this study focuses on design aspect (i.e., architectural), which incorporates building defects and maintenance problems. This paper assesses the design impact on the maintainability of Hospital Sutanah Bahiyah in Alor Setar. The scope of design aspect is only limited to architectural aspects.

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2.0 LITERATURE REVIEW

Maintainability as "the design characteristic which incorporates function, accessibility, reliability and ease of servicing and repair into all active and passive system components that maximises costs, and maximises benefits of the expected life cycle of a facility." [12]. maintainability as "easy to access and required only standard tools and techniques to maintain in." [13]. Therefore, the word of maintainability focuses on ease of maintenance to minimize cost, maximize function, and delay deterioration of a building throughout its life cycle.

Considering maintainability at design stage prolongs building life, lowers maintenance cost, and decreases downtime [14]. Therefore, the researchers have categorized design issue on maintainability aspect based on all the design factors, either on architectural or maintenance side. The categories are accessibility, materials selection, and environment.

2.1 Accessibility

Accessibility is very important for a maintenance team to perform its job. Some of the defective areas cannot be reached and thus affect building performance. Providing easy access especially to external wall, roof, basement, service, and windows through an access way, permanent and temporary access methods, and other access to the entire building) helps in the efficiency of maintenance work [15]. Maintenance practicality and adequacy where most designers ignore the availability of and access and space for maintenance equipment and its availability, as well as and design permanent fixation [16].

The issue of accessibility is the main problem for high-rise buildings. No proper access, especially to maintain the external façade, leads to difficulties for the maintenance team to perform their task [2]. Poor access increases maintenance cost and risks safety. Safety in accessing and conducting maintenance works is also a major problem [17] because it relates to people's lives. Moreover, the building shape causes difficulty in maintaining the building owing to blocked access [15] Maintenance teams usually face difficulties maintaining the façade of irregularly shaped high-rise buildings because some of them are not equipped with appropriate tools [18]. Thus, such buildings collect moisture, dust, or water [19].

2.2 Suitability of Materials

Maintainability of material selection process affects maintenance cost and work for future procedures that warrant the right choice at the design process [2]. Most of the common building defects arise owing to poor materials (i.e., inappropriate selection and use of joint materials) [20]. Building defects can be prevented if the designer uses appropriate materials and found that 53.08 percent of defects occur

because of poor material selection [7]. However, the root problems may not be caused by the materials but probably by poor design and workmanship if the materials have performed up to the standards but are still being exposed to higher impact [7].

Inappropriate material selection at the design stage and poor quality in application has caused many building defects [15]. Therefore, [2] suggest that designers should understand the functions of materials and components by accessing information, specification, and data on material performance before deciding what materials to use.

2.3 Environment

Building defects are caused by design aspects that did not consider weathering elements [7]. This factor is 52.76 percent, which shows that more than half of the building defects occur because of negligence of the environmental factors. The important part between materials selection and environment depends on the location of materials [21]. Designers have to design buildings by considering environments that help eliminate many building defects [7]. The durability of materials depend greatly on environment factors, such as weather or climate [21]. However, most designers do not realize the significance of environmental impact and the complex nature of their designs that needs design improvement [7].

Three types of climate: macro-, meso-, and micro-climate [22]. Macro-climate includes as arctic, extreme temperature, tropical, equatorial, and desert climate [23]. Meso-climate is the closest surroundings of buildings [24]. Micro-environment is determined by the degree of exposure to external climate, level and nature of the usage, orientation of the building, building shape complexity [15]. Macro-environment depends on temperature, pressure, humidity, rainfall, and building location and zones. Macro- and micro-environment have a great impact on maintainability owing to the high frequency of unnecessary maintenance work.

The most important factor to be considered by architects is building location [25], which includes shape and height that may influence the amount of wind and rain that affects building surface. Moreover, location and orientation of buildings are affected by other environmental factors. Architects may fail to consider or overlook environment elements when designing building. Architects do not consider local climate condition when designing the exterior shape and materials, resulting in significant building defects [16]. In Malaysia, "some of our overseas trained designers have different approaches and sometimes put too much of their overseas design into the local design products or blindly incorporate overseas design concept for the local usage" [18] page 30).

3.0 METHODOLOGY

This research has been conducted in two steps to identify the impact of the design defects on building maintenance. The first step involves document review. All documents are from hospitals and Faber Medi-Serve. The documents that we need to review to obtain the results include the following: 1) Condition appraisal: A report that provides a list of overall and major defects during defect liability period; 2) Technical report: A report that was produced in relation to the system (i.e., engineering-based); 3) Technical advice: A written advice based on end user request/complaint, which normally includes small defects; 4) Reimbursable work: Additional work outside the scope of Faber Medi-Serve terms of reference which include upgrading/repairing work; 5) Hospital building plan; 6) Contract document, standard, and specification.

The second step involves a focus group interview with the maintenance team of Faber Medi-serve Sdn. Bhd. and hospital engineers on 15th April 2014 to gather their experience hospital maintenance and their perception on maintainability aspects. The main objective of this focus group interview is to obtain the professional point of view and feedback regarding hospital problems. A set of questions have been prepared based on building defects obtained from the previous stage (i.e., secondary data).

The set of questions consists of three sections: accessibility, suitability of materials, and environment. The Likert scale for the accessibility, suitability materials, and functionality sections ranges from 1.00 (Very good) to 5.00 (Very poor). The Likert scale for the environment section ranges from 1.00 (Definitely) to 5.00 (Very probably not) to measure the environment's contribution to building defects.

Hospital Sultanah Bahiyah is located at KM6, Jalan Langgar, Alor Setar. The total area is 70 acres and has been divided into two main areas, which are Hospital Sultanah Bahiyah (65.2 acres) and Nursing Training Collage (4.8 acres). Construction work started in 2000 and was completed in February 2007. Hospital Sultanah Bahiyah includes single and multistory buildings with 660 beds and was commissioned in the same year. The hospital has been an important healthcare facility to the Kedah residents. The project cost was initially at MYR 500 million. However, the final project cost reached MYR 550 million after changes of standards and requirements from the Ministry of Health. The construction project started on 16 August 2000 and was supposedly completed in 2003. However, this project has been delayed, and the contractor has been extended five times extension in four years until its completion in 2007. Problems on the contractor rose especially with regard to changes of sub-contractors and the lack of skilled workers. Changes in designs, addition of new medical wards, and changes in latest equipment exacerbated the delay.

4.0 RESULTS AND DISCUSSION

4.1 Accessibility

Accessibility aspect has been assessed from three aspects.

1. Accessibility aspect on external building elements
2. Accessibility aspect on internal building elements
3. Accessibility aspect on fittings

The accessibility on maintenance work for external building elements (Table 1) is poor (mean: 3.50–4.49). The most affected building elements in terms of access provision is ceiling (3.83), which is followed by roof, window, and door (3.50) and wall (3.11). Roof has been ranked as first element that is poor in terms of safety access (4.33) compared with ceiling (4.17) and window and door elements (3.67). The building element that has the poorest type of access is roof (4.40), followed by ceiling (4.00) and window and door elements (3.67). The building shape hindered the maintenance work especially window and door elements (3.67), followed by roof and walls (3.50) and ceiling (3.20) elements.

The maintenance team has claimed to have no proper access for the maintenance work (i.e., *"no fixed ladder to enter the roof area"*), and the team just uses temporary access to maintain the roof. Moreover, one of the respondents mentioned that *"the flat roof access is not maintenance friendly"* because they have to use the building window to enter the flat roof area. They also mentioned that *"bringing equipment or machinery to the defective place is difficult."*

Scaffolding and cranes are used as temporary access because of the unavailability of a permanent access at the hospital. Using temporary access can damage the landscape and affect daily traffic and image of the hospital. This issue is supported by the following statement: *"no space for crane, which is blocked by the landscape"* and *"the building is too high to use scaffolding and it will damage the landscape of hospital."* A large space is needed to balance the scaffolding to reach above three floor levels.

Table 1 Accessibility Aspect on External Building Elements

Category	Building Elements	Accessibility			
		Provision for access	Safety Access	Types of Access	Building shape
External Building Elements	Floor	1.83	1.83	1.80	2.83
	Roof	3.50	4.33	4.40	3.50
	Ceiling	3.83	4.17	4.00	3.20
	Wall	3.11	3.11	3.33	3.50
	Window & Door	3.50	3.67	3.67	3.67

Mean: Less than 1.49: Very Good ; 1.50-2.49: Good ; 2.50-3.49: Barely Acceptable ; 3.50-4.49: Poor ; 4.50-5.00: Very Poor

Accessibility for internal building elements (Table 2) is considered good because it does not require large equipment and has easy to reach defects areas for maintenance work. The provision for access especially for ceiling element (2.54) is barely acceptable compared with floor and wall (2.00) and window and door (1.83), which are considered good. Safety access issues include reaching the ceiling (2.96), floor, window and door (2.00), and wall elements (1.83). Ceiling is the highest (2.75) in terms of types of access compared with floor, window, and door (2.00) and wall (1.83). Building shape affects maintenance work at floor element (2.67), followed by ceiling and wall (2.17) and window and door elements (2.00).

However, the ceiling accessibility level is a main problem because of the unavailability of an access door to enter the ceiling area. The statement was supported by the maintenance team members who stated that *"no access door at ceiling is available for the maintenance worker to do maintenance work"* and *"no area for maintenance access."* They added that *" accessing the plaster ceiling area is difficult because of the lack of access door, as well as the need to cut down the plaster ceiling for maintenance"* and that *"no safety mechanisms are present at all in the operation theatre."* The numbers of access door at the ceiling depends on the mechanical and electrical system above the ceiling area and the function of the room. Selecting ceiling finishes is important because it can determine the types and regularity of maintenance work. The plaster ceiling usually do not have a lot of system above the ceiling. However, an access door is still needed to allow maintenance workers to enter the ceiling in case of problems.

Table 2 Accessibility Aspect on Internal Building Elements

Category	Building Elements	Accessibility			
		Provision for access	Safety Access	Types of Access	Building shape
Internal Building Elements	Floor	2.00	2.00	2.00	2.67
	Ceiling	2.54	2.96	2.75	2.17
	Wall	2.00	1.83	1.83	2.17
	Window & Door	1.83	2.00	2.00	2.00

Mean: Less than 1.49: Very Good ; 1.50-2.49: Good ; 2.50-3.49: Barely Acceptable ; 3.50-4.49: Poor ; 4.50-5.00: Very Poor

Table 3 shows that accessibility to the fittings is barely acceptable. Provision for access is barely acceptable for roof gutter (3.13), followed by built-in cabinets (2.83) and sanitary fittings (2.40). Roof is has barely acceptable safety access with a mean score of 3.33 compared with built-in cabinets (2.17) and sanitary fittings (1.75). Roof (gutter) is difficult to access with a mean score of 3.33 compared with built-in cabinets (1.83) and sanitary fittings (1.75). The last factor that obstructs access to maintenance work is building shape. This factor has affected roof

(gutter) maintenance work with a mean score of 3.00, followed by built-in cabinets and sanitary fittings (2.00).

Gutter is one of the roof fittings that always have major defects. The maintenance team stated that "*no proper access is available for the gutter maintenance*" and that they "*need to walk on the center of roof without safety route.*" Hence, they suggest having a proper route for the maintenance team to do maintenance work. They do not have a problem accessing built-in cabinets and sanitary fittings.

Table 3 Accessibility Aspect on Fittings

Category	Building Elements	Accessibility			
		Provision for access	Safety Access	Types of Access	Building shape
Fittings	Roof	3.13	3.33	3.33	3.00
	Built-in Cabinet	2.83	2.17	1.83	2.00
	Sanitary Fittings	2.40	1.75	1.75	2.00

Mean: Less than 1.49: Very Good ; 1.50-2.49: Good ; 2.50-3.49: Barely Acceptable ; 3.50-4.49: Poor ; 4.50-5.00: Very Poor

4.2 Suitability of Materials

The suitability of ceiling materials in Hospital Sultanah Bahiyah is good (mean: 1.50–2.49). Floor has good durability of materials (1.94), followed by ceiling (2.00) and wall (2.30). Floor is considered good in terms of availability of materials (1.94), followed by ceiling and wall (1.96 and 2.20, respectively). Floor obtained a mean score of 1.94 in terms of the suitability of materials for weather condition, whereas ceiling and wall obtained mean scores of 2.00 and 2.20, respectively. Ceiling obtained the lowest mean in terms of suitable materials for traffic usage (2.00), which is good, followed by floor (2.06) and wall (2.13). Floor obtained a mean score of 2.06 in terms of frequency of cleaning or maintenance, followed by wall and ceiling (2.17 and 2.20, respectively). The mean values for inspection of wall, floor, and ceiling are 1.93, 1.94, and 2.13, respectively. Minimal inspection between wall and floor has no big difference. The full details of materials and specification for ceiling (4.29) is considered poor, followed by wall and floor (3.96 and 3.67, respectively).

Weather condition is a problem because the humidity level is high and causes molds and fungus. Moreover, no details of materials (i.e., civil) have been given to the hospital and Faber team, thus affecting maintenance work. This statement is supported by the maintenance team, "*no details of materials, especially civil, are given to hospital*" and that "*no details on standard installation*" are provided. Moreover, they also stated that "*Hospital and Faber need full details of materials specification used as reference, especially on material usage. In addition, some materials in document contract are not same as those on site.*" Furthermore, they detailed that "*normally, ceiling materials is not a main problem. However, the defects occur because of the lack of insulation layer at the M&E system or the lack of PU foam or thermal barrier at ceiling or floor. Therefore, the ceiling sweats due to heat transfer or from M&E systems, creating a condensation and moisture problem.*" Furthermore, the problem of condensation affects wallpaper finishes because they peel off from humidity and moisture problems. The maintenance team mentioned that "*humidity can cause mold.*" They also indicated the "*need to apply thermal wall to avoid heat transfer that causes condensation issues.*"

A floor problem is traffic usage. That is, a certain area need heavy duty flooring finishes because people, food trolleys, wheel chairs, and stretchers use the same route. This statement is supported by the maintenance team who indicate that "*in the route of heavy trolleys such as those for food and linen, tiles must be heavy duty because current floor tile always cracks or breaks. Sometimes they crack because of wrong installation.*" The method of cleaning also needs to be considered because every type of finish have different methods and equipment of cleaning. Vinyl floors have different cleaning methods compared with carpet finishes. However, the maintenance team does not agree to use carpet as floor finish at the hospital because carpets are not suitable for hygienic environment and can collect dust.

Table 4 Suitability of Materials

Building Elements	Suitability of Materials						
	Durability of materials	Availability of materials	Suitable materials for weather condition	Suitable materials for traffic usage	Frequency of cleaning / maintenance	Inspection with minimal inspection	Full details of material specification
Ceiling	2.00	1.96	2.00	2.00	2.20	2.13	4.29
Floor	1.94	1.94	1.94	2.06	2.06	1.94	3.67
Wall	2.30	2.20	2.20	2.13	2.17	1.93	3.96

Mean: Less than 1.49: Very Good ; 1.50-2.49: Good ; 2.50-3.49: Barely Acceptable ; 3.50-4.49: Poor ; 4.50-5.00: Very Poor

4.3 Environment

Table 5 shows that the environment aspect that probably caused building defects at Hospital Sultanah Bahiyah are site or location (1.80), and the possible aspects are rainwater (2.50), wind (2.50), temperature (2.67), and sunlight (2.83). The maintenance team mentioned that "*the site or location of hospital is at the center of paddy field, which can cause building defects*." The surrounding of paddy field has no large trees. Thus, wind directly hits the building. Moreover, rainwater can enter the building and run along the ducting or ceiling area when the wind and rain occur together. Therefore, leakage can happen.

Moreover, the temperature surrounding the building (location) can cause building defects (i.e., condensation and moisture problems).

Table 5 Environment Aspects

Environment Aspect	Mean
Site or Location	1.80
Rainwater	2.50
Wind	2.50
Sunlight	2.83
Temperature	2.67

Mean: Less than 1.49: Definitely; 1.50-2.49: Probably; 2.50-3.49: Possibly; 3.50-4.49: Probably Not; 4.50-5.00: Very Probably Not

Table 6 shows that the most affected building elements on site or location of building is floor with 31.6 percent, compared with roof (13.3 percent) and ceiling (13.0 percent). The roof (gutter) is affected by rainwater with 40.0 percent, followed by window and door (37.5 percent) and wall (26.3 percent). Ceiling element has been affected by wind with 21.7 percent, followed by roof (13.3 percent) and floor (5.3 percent). Sunlight issue has affected wall element with 31.6 per cent, followed by roof (20.0 percent) and window and door (18.8 percent). The most affected element by temperature is wall (31.6 per cent), followed by window and door (31.3 per cent) and ceiling (21.7 per cent).

The wall is most affected by sunlight and temperature. This problem is because of direct sunlight that discolors the wall. Temperature transfers heat between the inside and outside the building. Condensation occurs with heat transfer. High temperature outside the building and low temperature inside the building can make the external wall to sweat, stain, and grow mold. Moreover, humidity contributes to the creation of building defects. The maintenance team stated that "*September to December comprise the rainy season. The high humidity promotes considerable mold growth. However, January to March comprise the hot season, where humidity is low and no mold growth occurs.*"

Roof, window, and door are affected by the environment aspect, rainwater. They deteriorate faster because of expose to water without enough roof awning size. The roof problem is at the gutter because rainwater may overflow and become stagnant owing to workmanship problems that can cause corrosion. Moreover, the numbers of rainwater pipes are insufficient to accommodate rainwater, causing gutters to overflow and rainwater to enter buildings. Rainwater can enter the building with hard wind flow.

Table 6 Environment Aspect on Building Elements

Building Elements	Site or Location	Rainwater	Wind	Sunlight	Temperature	Not Applicable
Floor	31.6%	15.8%	5.3%	15.8%	21.1%	10.5%
Ceiling	13.0%	26.1%	21.7%	17.4%	21.7%	-
Wall	10.5%	26.3%	-	31.6%	31.6%	-
Roof	13.3%	40.0%	13.3%	20.0%	13.3%	-
Window & Door	12.5%	37.5%	-	18.8%	31.3%	-

5.0 DISCUSSION AND CONCLUSION

Maintainability represents design characteristics that minimize costs and maximize benefits from ease of maintenance. This study is categorized maintainability into three main factors based on literature review: accessibility, suitable material selection, and environment. A focus group interview has been conducted the focus group interview with both hospital engineers and Faber Medi-serve representatives to gain knowledge and point of view from experts in maintenance field. The results show that each maintenance category has an impact on the efficiency of maintenance work.

Accessibility aspect is significant to maintain hospital building. The most difficult elements to be accessed is the external roof, which obtained the highest mean or considered as poor access). External roof is followed by external ceiling and window and roof fitting (gutter). This result was supported by [15] who state that it should be provided with easy access, especially external building elements (e.g., access ways, permanent and temporary access methods, and other type access to an entire building). The maintenance team indicates that no proper access route is available to repair and maintain the roof.

Moreover, the roof has not been equipped with safety elements. The team added that building shape limits access, and that the team must find other methods for maintenance work. These other methods can incur cost and affect hospital routine. Moreover, building shape can cause difficulty in maintaining buildings [15]. The internal ceiling obtains high mean on providing access for maintenance teams (e.g., no safety access at the operation theatre). Hospital building is a complex building with a heavy M&E system. Therefore, planned inspections are important. Moreover, the maintenance team has highlighted the importance of designing rooms with appropriate room size, M&E system size, and numbers of access to the ceiling area.

Suitable materials selection had been classified into seven: durability of materials, availability of materials, suitable materials for weather condition, suitable materials for traffic usage, frequency of cleaning or maintenance, inspection with minimal inspection, and full details of material specification. However, the unavailability of full details of material specification caused problems for the maintenance

team to perform their jobs. This statement is further supported by [26] that the full details and availability of similar materials or spare parts are an important factor to minimize the building maintenance cost. Moreover, most materials selected for hospitals are good because contractors need to discuss and obtain permission from Ministry of Health and Public Work Department before contractors can select materials. Therefore, all variables under suitability of materials have been considered earlier and discussed with all parties. The issue on carpets has been raised by the maintenance team, who noted that carpets are not suitable for hospitals. However, the some of the stakeholders indicate that carpet use in first class wards is a new strategy to implement design concepts similar to those of a developed country. Such wards use clinical carpets that are anti-bacterial. However, members of the team state that carpets are difficult to maintain and raise difficulties in handling food trays. Most of them prefer vinyl, which is considered the most suitable floor finish because vinyl is easy to clean and long-lasting; hospital visitors desire a clean environment.

Location or site is the main contributor from the environmental aspect that has caused building defects at Hospital Sultanah Bahiyah, Alor Setar. The most important factor that needs to be considered by architects is the location of buildings [25], including their shape and height, which may influence the amount of wind and rain that affect the building surfaces. This study provides significant findings on the need to consider maintainability in future hospital designs in Malaysia.

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