# AN ASSESSMENT ON FAULTY PUBLIC HOSPITAL DESIGN IN MALAYSIA

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ABSTRACT

Design has a significant impact on building maintenance. Aside from catering to the specific needs of various end users, a hospital building is one of the most complex and heavily used buildings. In Malaysia, the number of public hospitals is increasing because of the increasing population. The purpose of this paper is to determine the factors contributing to problems related to faulty hospital design which have direct implications on public hospital maintenance in Malaysia, and to propose possible solutions to these problems. A survey was conducted in 15 public hospitals located in the Northern Region of Peninsular Malaysia. Thirty respondents from the service provider agreed to participate. The study concludes that faulty hospital design contributes to difficulties in building maintenance. Factors such as inefficiency and inadequate knowledge of the design group lead to their inability to judge or consider the possible factors that could arise during maintenance. In this regard, the design team agrees that increasing their awareness, efficiency, knowledge, and experience is necessary to enhance their expertise in designing hospital buildings. A good coordination between design teams is also necessary to ensure the use of appropriate and suitable materials, as well as a good construction method to enhance the life cycle and value of the buildings.

**Keywords:** Faulty design, Strategy, Maintenance, and Hospital buildings.

## INTRODUCTION

At present, the high demand from public and private sectors has necessitated the rapid construction of new buildings. Hardy and Lammers (1996) emphasize the vital role of design in the early stage of project development. They state that “a functional design can promote skill, economy, conveniences, and comforts while a non-functional design can impede activities of all types detract from quality of care, and raise costs to intolerable levels.” Carr (2009) adds that a good hospital design should integrate functional requirements with the human needs of its varied users. Each functional unit offers specific types of services. Different functional units such as emergency rooms, clinical laboratories, and food services and housekeeping should be constructed with different architectural and engineering functions.

Failure in the earlier stages of project development, especially of design, would lead to deficiencies in the later stage after construction. These deficiencies will result in financial burdens for the client. In Britain, for example, building maintenance activities account for 50 percent of all annual construction activities (Baldry, 2002). In Canada, the value of the maintenance, repair, and renewal market is $104 billion, greater than that of current new construction projects ($100 billion) (Vanier, 2001).

Initially, in Malaysia, the construction of a general hospital starts before independence. These general hospitals are used to treat workers in the mining industry. For example, the state of Perak, which is popularly known for its mining sector, already had 15 hospitals by the end of the 19th century. In 1957, Malaysia had a total of 65 public hospitals, and to date, there are a total of 135 hospitals (MOH, 2010). To pursue its national development mission, the government has aggressively focused on hospital development in the Seventh Malaysian Plan (7MP). Under 7MP, the government endorsed the construction of 31 new general hospitals (MOH, 2006), with the construction cost of each ranging from RM90 million to RM900 million for a total contract sum of RM4 billion. For example, in the northern part of Peninsular Malaysia, two public general hospitals were constructed under the 7MP in Alor Setar and Sungai Petani. Each hospital incurred costs of RM550 million and RM468 million, respectively. These two hospitals have been in operation for a few years. However, before the project handover, the quality and cost of these two hospitals have been issues because the project was not completed on schedule, incurred higher cost, and had functional failure.

Although the government has invested a great amount of money in building hospital facilities, the projects were subject to numerous problems since they were handed over to the government. According to Maizon (1999), Lim and Zain Mohamed (1999), Chan and Chan (2004), and Flyubjerg (2007), a complex project design, advanced technology, and large scale of a project contribute to project complexity. Project complexity increases the probability of the existence of building defects. Two constructed public hospitals were reported to have failed in relation to sewage pipe leakage, fungal infection, and ceiling collapse, among others (*The Star, 21st Oct 2004*).

In relation to the privatization policy adopted by the Malaysian government to ensure the efficiency and productivity of hospitals and to reduce its financial and administrative burdens, the government has outsourced the maintenance work done at all general hospitals since 1996. According to Sangaralingam and Raman (2003), privatization is designed to increase the participation of the private sector in economic development, to reduce the financial and administrative burden on the government, to improve efficiency and productivity, and to facilitate economic growth. In 1996, contracts for the maintenance of hospital buildings have been outsourced to three large consortium firms. Faber Mediserve has been awarded a contract to manage all hospitals in the Northern Region of Peninsular Malaysia, which includes the states of Perlis, Kedah, Pulau Pinang, and Perak, and also Sabah and Sarawak.

Al-Zubaidi (1996) states that the primary aim of building maintenance is to preserve the initial effectiveness of a building so that it can serve its purpose efficiently. In addition, Adenuga et al. (2005) mentions that the high level of performance of hospital buildings requires that maintenance considerations be taken into account in the early stages of design. Previous studies have reported a reliable link between design and maintenance issues. Ramly (2006) reports that design plays a major role in determining the conditions of a building after completion, mainly in terms of managing defects and maintenance. Design would also affect the structure and materials installed and the life cycle of each building component. The performance and physical characteristic of the building as well as its durability of withstanding environmental conditions and social interfaces are influenced by design indirectly. To identify how design plays a role in public hospital maintenance, the current paper has the following objectives:

1. To identify problems related to faulty hospital design.
2. To identify a strategy to overcome the effects of faulty hospital design on maintenance work from the perspective of the hospital service provider.

## LITERATURE REVIEW

A defect can be defined as a shortcoming in the performance of a building element. A defect will occur after the building has been occupied. According to Chanter and Swallow (2007), the cost of maintenance work is usually higher than the cost of new construction work because of several factors: it is always conducted on small scale, which leads to diseconomies of scale; there is a need to strip out the existing work before the repair or replacement work can be conducted; it has to be performed in confined or occupied spaces; the cost of general clearing is disproportionately high and incurs substantial disturbance costs on the operation of the building and, perhaps, loss of production.

There are many causes of maintenance. The Building Research Establishment (BRE, 1998) reveals 24 main causes including, among others, cracks, condensation, detachment, entrapped water, rain penetration, dampness, design and specifications, execution, and materials of components. The contribution factors range from faulty design, poor workmanship, improper material selection, lack of supervision, non-adoption of building codes and standards, and execution of civil works at the site.

### Factors of Faulty Hospital Design

Design is a very important part of project development and has been proven to influence building construction. Calder (1997) identifies defects that can be attributed to construction drawings, which include lack of references, conflicting details, and lack of details. Seeley (1987) finds that 58% of defects are caused by faulty design, whereas Ransom (1981) finds that 20% of building defects can be attributed to poor design decisions. Marsh (1979) mentions that defects could also be attributed to poor detailing. Poor understanding of the use and combination of materials and the use of mastic to fill gaps comprise poor detailing. Andi and Minato (2003) also identify that inadequate information, unawareness, wrong assumptions, and lack of knowledge, alongside other organizational and motivational factors, contribute to defects at the design stage. A study by Holloway (1981) finds that insufficient attention to detailing and the failure to select suitable materials for elevation wall claddings affect maintenance work.

Porteous (1992), however, divides the causes of defects into three groups: the management, technical, and human resource sub-systems. However, Assaf *et al.* (1996) conduct a thorough study on maintenance and identify six types of defects as follows:

1. Defect in civil design. These defects occur during the early stage of design, particularly in structural design. Some examples are inadequate provisions for movement and disregard for aggressive environmental and biological effects.
2. Defects in architectural design. Some examples are designing narrow stairs, passages, and doors, specifying exterior finishes incompatible with climate, specifying finishes that need complete replacement, and designing inadequate joints between finished surfaces.
3. Design defects in maintenance practicality and adequacy includes defects caused by improper planning and exclusion of the requirements of preventive maintenance during the design stage. Some examples are the lack of access for maintenance equipment, designing permanent fixtures, and the disregard for maintenance equipment availability and maintenance requirements in the design.
4. Defects due to consultant firm administration and staff such as lack of a quality assurance or quality control (QA/QC) program during design, insufficient technical updating or staff training, hiring unqualified designers, lack of designer field experience (Watt, 1999), and designer ignorance on material performance.
5. Defects due to construction specifications such as unclear specifications (Peacock, 1986), inadequate definition of material type (Peacock, 1986), overlooking QA/QC construction procedures, overlooking allowable load limits, and specifying inadequate concrete mix design.
6. Defects due to construction drawings such as lack of references, conflicting details, and lack of details.

## Strategy to Overcome the Effect of Faulty Hospital Design

Design plays a major role in reducing building defects. The burden goes to architects who can utilize their knowledge and expertise to reduce maintenance cost. A few important aspects that architects must consider are design, construction detail, and material selection (Kasturi, 1981). For example, if an architect details that the design should consider the sitting or location of a building because of air circulation and the penetration of the sun must be kept to a minimum to reduce the load on air-conditioning, then a designer must take particular care in determining whether the design meets real needs, especially if clients are unsure of their specific requirements. A designer must consider the implications of a complicated design.

Holloway (1981) has an opinion similar to that of Kasturi (1981). He mentions that a designer should also consider the attitude of the users, vandalism, and the misuse of equipment, as well as the design, selection of finishes, materials, and equipment in buildings, which are all important. BRE (1991) and Richardson’s (1991) research on defects reveal the importance of weather, environmental conditions, soil impact, poor design, chemical attack, structural movement (due to poor structural design), installation method, workmanship, maintenance issues, and site working conditions. Defects could have been prevented if considerations were made on the conditions of the building elements.

Assaf *et al.* (1996) report that a designer should provide adequate structural design, proper access to maintenance equipment, proper exterior finishes compatible with climate conditions, and sufficient detail in construction drawings. Graham (1979) proposes solutions that can be taken by appropriate authorities, which include directing the awareness of the design team to the consequences of poor, ill considered, and irresponsible designs; introducing critical studies on building construction, specifications, choice of materials, and maintenance characteristics into study course for the design team; enlisting the assistance of experienced maintenance managers; re-examining the methods of allocation of building work to contractors; and improving the standard of construction.

## RESEARCH METHODOLOGY

In the current study, the population includes public hospitals in the Northern Region of Peninsular Malaysia receiving maintenance services from Faber Mediserve Sdn Bhd. The respondents were chosen based on a study by Assaf *et al.* (1996), who selected maintenance service contractors and owners of different types of buildings as their respondents. Fifty questionnaires were distributed by hand to 15 public hospital service provider outlets. Each hospital had at least one respondent depending on its size. For example, a smaller hospital is run only by a facility manager, whereas a larger hospital will have a bigger team comprising the Engineering Department. From 50 respondents, only 30 (60%) respondents returned the survey with complete answers. The respondents hold various positions, such as Facility Manager, Facility Head of Engineering, Civil Engineer, Civil Technician, Electrical Technician, and Mechanical Technician. Aside from the Facility Manager, these people were chosen as respondents because they are involved directly with building maintenance.

The questionnaire comprised three parts. Part A was on the general information of the respondent, Part B was on the problems related to faulty hospital design, and Part C was on strategies to overcome the effects of faulty hospital design. Questions in Part B were based on those by Assaf *et al.* (1996), and questions on Part C were based from those of Kasturi (1981), Holloway (1981), Assaf et al. (1996), and Graham (1979). The five-point Likert scale used were 1=strongly disagree to 5=strongly agree. The questionnaire was piloted on three engineers. All the data in the current study were analyzed using the Statistical Package for Social Science (SPSS, version 17.0).

## FINDINGS AND ANALYSIS

Based on the survey of 30 respondents, 50% (15 respondents) were from the Civil Department, 26% (8 respondents) were from the Electrical Department, and 23.3% (7 respondents) were from the Mechanical Department. 23.3% or 7 respondents were facility managers, civil technicians, and electrical technicians, respectively. Another 16.7% (5 respondents) were civil engineers, and 13.3% (4 respondents) were Facility Heads of Engineering. About 30% (9 respondents) have been working in a public hospital for 11–15 years, 23.3% (7 respondents) have been in this field for 6–10 years while another 20% (6 respondents) had been working for less than 5 years and 16–20 years. Only 6.7% (2 respondents) have been working for more than 21 years. A total of 56.7% (17 respondents) had a diploma, whereas 30% (9 respondents) had a first degree, and the balance of 13.3% (4 respondents) had certificates.

## Factors of Faulty Hospital Design

Table 1 shows the primary factors contributing to faulty hospital design. Based on the given data, Group two had the most agreement on the factors of faulty design. The detailed items will be analyzed based on group classification. The Likert scale of 3.5 and above (agree and strongly agree) is used as a cut-off point for perceived agreement on the faulty hospital design factors.

For the civil design group, the two major factors contributing to faulty hospital design were ignoring important process in construction method (mean=3.77) and ignoring biological effects, (mean=3.50). For Group two, most of the respondents agreed that the misjudgment of user’s intended use (mean=3.80), insufficient technical updating or staff training (mean=3.67), designer lack of information on construction (mean=3.63), designer ignorance of material performance (mean=3.53), and designer’s lack of a technical background (mean=3.53) as the major factors of faulty hospital design.

For the construction specification group, the top three defects are inadequate definition of material type (mean=3.90), overlooking QA/QC construction procedures (mean=3.87), and specifying inadequate mix design (mean=3.77). The defects of specifying incompatible exterior finishes with the weather (mean=3.77), ignoring weather effects on exterior shapes (mean=3.60), and ignoring safety factor comprise the major defects of the architectural design group (mean=3.50).

For the construction drawing group, only detail conflict (mean=3.53) had a higher mean from respondents. Ignoring maintenance requirements in the design (mean=3.53) was among the top defects identified by the maintenance practicality and adequacy group

Table 1: Mean value on factors of problem related to the faulty hospital design.

| Factor of Faulty Hospital Design | Mean | Std. Deviation |
|---|---|---|
| Group 1: Civil design | | |
| Ignoring important process in construction method. | 3.77 | 1.104 |
| Ignoring biological effects. | 3.50 | 1.106 |
| Inadequate structural design. | 3.23 | 0.971 |
| Locating ductwork at structural locations. | 3.20 | 0.847 |
| Ignoring aggressive environmental effects. | 3.20 | 0.925 |
| Ignoring variation in soil conditions. | 3.17 | 0.791 |
| Inadequate concrete cover on reinforcement | 3.03 | 0.928 |
| Inadequate provisions for movement | 3.00 | 0.695 |
| Ignoring wind effects on the structure | 2.83 | 0.874 |
| Ignoring load impact on structural stability | 2.77 | 0.626 |
| Exceeding allowable deflection limits | 2.77 | 0.679 |
| Group 2: Consultant firm administration and staff | | |
| Misjudgement of user's intended use | 3.80 | 0.925 |
| Insufficient technical updating or staff training | 3.67 | 0.884 |
| Designer lack of information on construction | 3.63 | 0.850 |
| Designer ignorance of material performance | 3.57 | 0.971 |
| Lack of designer's technical background | 3.53 | 0.973 |
| Misjudgement of climatic conditions | 3.17 | 0.648 |
| Lack of designer field experience | 3.07 | 0.944 |
| Hiring unqualified designers | 3.07 | 0.980 |
| Group 3: Construction specification | | |
| Inadequate definition of material type | 3.90 | 0.995 |
| Overlooking QA/ QC construction procedures | 3.87 | 0.730 |
| Specifying inadequate mix design | 3.77 | 0.817 |
| Unclear specifications | 3.17 | 0.648 |
| Overlooking allowable load limits | 3.00 | 0.643 |
| Group 4: Architectural design | | |
| Specifying incompatible exterior finishes with the weather | 3.77 | 0.626 |
| Ignoring climatic effects on exterior shapes | 3.60 | 0.855 |
| Ignoring safety factor | 3.50 | 1.042 |
| Specifying finishes which need complete replacement | 3.47 | 0.860 |
| Designing inadequate joints between finished surfaces | 3.43 | 0.728 |
| Designing narrow stairs, passages and doors | 3.20 | 0.887 |
| Group 5: Construction drawings | | |
| Detail conflict | 3.53 | 0.776 |
| Lack of detail | 3.47 | 0.776 |
| Lack of reference | 3.37 | 0.964 |
| Group 6: Maintenance practicality and adequacy | | |
| Ignoring maintenance requirements in the design | 3.53 | 0.937 |
| Designing permanent fixations | 3.47 | 0.900 |
| Ignoring access for maintenance equipment | 3.43 | 0.935 |
| Ignoring maintenance equipment availability | 3.33 | 0.994 |

Scale: Less than 1.49=strongly disagree;1.5-2.49=Disagree;2.5-3.49=either agree or disagree; 3.5-4.49=Agree and 4.5=5.0=strongly disagree.

Strategy to Overcome the Effect of Faulty Hospital Design

Table 2 shows the perceived strategies that should be implemented to overcome the effects of faulty hospital design. Most of the items were ranked as agree, and one item was ranked as strongly agree. The only item that was ranked as strongly agree was directing awareness of design team to poor design (mean=4.57). Among the groups that received higher ranks were standard of construction, design team, and design aspect. The ranks of other groups or items are shown in Table 2.

Table 2: Mean value on strategy/ suggestion to overcome the effect of the faulty hospital design on the maintenance work

| **Strategy/ suggestion** | **Mean** | **Std. Deviation** |
|---|---|---|
| Group 1: Standard of construction | | |
| Strict monitoring during construction | 4.47 | 0.860 |
| Improve standard of construction | 4.43 | 0.626 |
| Conduct test on construction material | 4.37 | 0.615 |
| Group 2: Professional workers | | |
| Hire qualified designer | 4.37 | 0.669 |
| Assistance of experienced manager | 4.10 | 0.607 |
| Group 3: Detail of construction | | |
| Sufficient detail in construction drawing | 4.30 | 0.750 |
| Expansion joint in floor and wall | 4.13 | 0.860 |
| Architect consider the construction detail | 4.13 | 0.900 |
| Group 4: Design team | | |
| Directing awareness of design team to poor design | 4.57 | 0.817 |
| Cooperation between Ar. & Ir. regarding to const. drawing | 4.43 | 0.679 |
| Give attention to long-term cost | 4.43 | 1.073 |
| Introduce maintenance manual for building | 4.27 | 0.907 |
| Group 5: Design aspect | | |
| Provide adequate structural design | 4.47 | 0.629 |
| Ensure building is environmental friendly | 4.30 | 0.535 |
| Proper access to consider maintenance equipment | 4.30 | 0.794 |
| Architect take care of design | 4.23 | 0.626 |
| Provide proper access to consider maintenance | 4.23 | 0.898 |
| Group 6: Studies on construction | | |
| Critical studies on construction method | 4.40 | 0.724 |
| Re-examine method of building work | 4.33 | 0.661 |
| Group 7: Selection of materials | | |
| Consider ease of replacement of repair | 4.37 | 0.615 |
| Used material appropriately | 4.33 | 0.758 |

| | | |
|---|---|---|
| Exterior finishes compatible with climate condition | 4.23 | 0.817 |
| Group 8: Occupation and surrounding condition | | |
| Consider attitude of user | 4.40 | 0.724 |
| Consider the equipment of building | 4.37 | 0.809 |
| Consider vandalism | 4.30 | 0.915 |

## DISCUSSION

To accommodate the healthcare needs of citizens, new hospital buildings have been constructed. Some of the new buildings replaced older buildings, especially in urban areas where the original hospital cannot cater to the increasing population. However, small hospitals in non-urban areas still maintain their capacity in offering their services. Identified as the most complex building, a hospital needs to accommodate various kinds of end users such as specialists, patients, nurses, service providers, and the general public (Carr, 2009). Based on their experience in running daily hospital maintenance jobs, the respondents have been selected to give their perceived opinion on factors contributing to faulty hospital design. Compared with a previous study, the current study supports that of Assaf *et al.* (1996). Based on the analysis, the result derived from the current study will be discussed in detail.

Consultant firm administration and staff have been receiving most of the concerns of the respondents in relation to faulty design. The quality of buildings showed that design consultants had inadequate knowledge and information about construction. According to Assaf *et al.* (1996), qualified consultants usually implement QA/QC programs during the design stage to avoid defects and mistakes in the design. This procedure requests one group to do the design and another group to review and highlight the design defects. Neglecting these stages can cause building defects. Furthermore, public hospital buildings will be heavily used by the public who could have minimal knowledge about building usage, so underestimating their misuse of services is dangerous (Carr, 2009). In reality, building design has always been conducted by a junior architect who has minimal experience in the industry. Insufficient technical knowledge greatly influences building performance because expertise is important in choosing materials and construction methods.

Architectural design was second in the list of factors contributing to faulty hospital design. Design must be aligned with environmental factors such as climate, safety requirements, and end user’s needs. The most important concerns were factors related to the choices on exterior finishes, climate effects, and safety factors. According to Assaf *et al.* (1996), the selection of color and type of exterior finish of a building should be suitable to the weather and environmental conditions. Some examples are painting buildings using dark colors in a dusty area where a large amount of cleaning is necessary, or using paints that cannot resist heat and humidity. Kasturi (1981) also mentions that physical exposure is easier to overcome and is the most obvious because its effects can be predicted and quantified. Exposure is influenced by rainfall, solar radiation, prevailing winds, atmospheric pollution, and the orientation and height of a building. Interestingly, according to Kasturi (1981), a building should be designed in such a way as to avoid collection of moisture, water, or dust. A hospital building is operational for 24 hours, so building conditions must ensure the comfort of end users (Carr, 2009).

Modern hospital buildings are designed to meet more complicated needs than those of previous times. Improved space standards, higher environmental standards, and new patterns of use all affect the design and construction of buildings, and should be considered in selecting a construction method. However, rushing the completion of a building could deteriorate all of its important elements.

A hospital building has to deal with the environment, so the consideration of biological effects is very important. According to Assaf *et al.* (1996), a designer should be familiar with the building location, the type of plants and insects existing in the area, and if any special treatment or ventilation provision against these biological factors should be specified in the design drawings. Disregarding this factor could result in different problems, such as the fungal problems identified in Sultan Ismail Hospital in Johor Bahru (The Star, 21st Oct, 2004). The presence of the fungus possibly caused damage to the air-conditioner valve or leakage. Inadequate structural design, especially in new hospitals, can be attributed to building cracks which may result in collapse. Assaf *et al.* (1996) state that building collapse occurs when the designer provides insufficient details on the structural elements in the building. Variations in the weather could lead to the movement or expansion of a building.

Building maintenance directly involves maintaining building materials, equipment, and structure within acceptable conditions, and specifying these components and systems is essential for the efficient operation of the building throughout its entire life cycle. Crocker (1990) argues that inadequate designs specify materials in general, and the lack of detailed specifications can possibly lead to problems in building maintenance. The contractor should provide materials that meet the general guidelines; otherwise, a building will not serve its purpose properly. This problem could happen when consultants overlook QA/ QC construction procedures and defects. Crocker (1990) mentions that most construction contracts do not specify the relationship between the owner, the inspector, and the contractor. Most contracts also do not have provisions for proper communication to avoid any defect or to solve any problem. In addition, most contracts do not specify the responsibility of each party.

Poor detailed design practices are believed to be the source of a large proportion of performance problems during the life of a building, especially when potential maintenance-related problems are not reviewed in detail starting from the preliminary design stage. Having the building design done by a draughtsman either inexperienced or unqualified for this exacting responsibility could be a major problem. According to Crocker (1990), poor and unchecked detailing during the production drawing stage contributes to the building design problem, which means that building designers do not really consider maintenance requirements when designing and managing buildings. This result in consistent with earlier findings by Assaf *et al.* (1996), who argue that during the design stage, designers should consider the frequency of maintenance for the elements of a building.

Respondents agreed on the strategy of “directing awareness of design team to poor design” with the mean of 4.57. According to Graham (1979), the design team should be fully aware of the consequences of poor, ill-considered, and irresponsible designs, and their attention should be focused on the long-term costs-in-use of buildings that result from design and constructional defects. A designer should be familiar with the building location and the types of plants and insects existing in the area. Furthermore, cooperation within the design team is important, especially between the architect and the engineer because of their commitments in construction drawing. A proper construction drawing and specifications will ensure that the construction is being performed with minimal defects.

The next suggestion on “giving attention to long-term cost” supports the findings of Graham (1979), who report the importance of this suggestion because of its possible effect on cost during maintenance, including replacements and so on. Quality control on the site and in the manufacture of components must be improved to achieve an acceptable performance standard and to prolong the life cycles of building components where required. Improved training of craftsmen, supervisors, and all members of the team engaged in the construction of buildings is also necessary and must be undertaken without delay if constructional defects are to be avoided. More care is required from all members of a building team to eradicate defects and to improve constructional standards to ensure that buildings would require minimal maintenance in the future.

Design is crucial in any project development. There should be an emphasis on value management during the early phases of a building’s life cycle (Arditi and Nawakorawit, 1998). According to Kasturi (1981), all designs should be simple and practicable. A building should be planned as feasible, economic, durable, and easily constructed. The respondents agreed on the aspect of “providing adequate structural design” and “proper access to consider maintenance equipment” as among the most important factors. Assaf *et al.* (1996) and Merritt and Ricketts (2000) agree that cooperation among all professionals will lead to good design. Moreover, failure to consider the attitude of users could lead to major problems in building maintenance.

Graham (1979) agrees that there is a crucial need to introduce critical studies on building construction, specifications, choice of materials, and maintenance characteristics into study courses for architects, building surveyors, and technicians to familiarize decision makers with problems on maintenance. This knowledge will help professionals choose the appropriate material, i.e., the “durable material” (Kasturi, 1981). There are many other factors associated with poor building construction, such as awarding a contract to the lowest bidder (Graham, 1979). However, quality and cost performances should be monitored, and advice should be given to the management staff when all these factors fall short of agreed acceptable standards.

Graham (1979) mentions a need to enlist the assistance of experienced maintenance managers, either within the design team or to veto and examine details, working on drawings and specifications of all components and services to correct any elements of the design, which, from their experience, will cause maintenance problems or lead to future defects. Assaf *et al.* (1996) report that a designer has to provide sufficient detail in construction drawings because defects in design are sometimes caused by poor detailing (Marsh, 1979).

## CONCLUSION

Faulty design will evidently affect building maintenance. Hospital buildings are used for 24 hours, so a service provider has to stand by for whatever complaints or defects will be reported by the customer or the end user. A service provider should normally monitor the performance of a hospital building and its components by implementing a continuous and planned periodic maintenance.

A hospital building is complicated and complex. The design of a hospital building must consider future building usage and accommodate patients and specialists with different conditions. Many aspects need to be considered to ensure the comfort of users. The current study has explored faulty building design and strategies that could be used to overcome maintenance problems. It is purposely conducted on service providers to identify their perceived ideas on the design defects in their hospital.

Covering only a limited scope that includes hospital buildings in the northern part of Peninsular Malaysia, the current study supports the importance of design on hospital building maintenance. The paper contributes to the knowledge related to hospital design and construction. However, value management in the earlier development stages should be seriously considered by a design team to reduce the burden of heavy building maintenance. Based on the data presented, the problems faced by service providers when conducting hospital maintenance have been determined. Finally, solutions to overcome the problems faced by service providers were also proposed.

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