CRITICAL FACTORS THAT LEAD TO GREEN BUILDING OPERATIONS AND MAINTENANCE PROBLEMS IN MALAYSIA

Izran Sarrazin MOHAMMAD
Universiti Teknologi Malaysia, Johor, Malaysia
izran@utm.my

Nurul Nadiah ZAINOL
Universiti Teknologi Malaysia, Johor, Malaysia
nanad2509@gmail.com

Shardy ABDULLAH
Universiti Sains Malaysia, Malaysia
shardy@usm.my

Neo Bee WOON
Universiti Teknologi Malaysia, Johor, Malaysia
nbyun0503@gmail.com

Nur Aqlima RAMLI
Universiti Teknologi Malaysia, Johor, Malaysia
aqlimaramli@gmail.com

Abstract
The development of green buildings has become a trend in recent years in the effort to enhance the well-being of the community, environmental health, and life-cycle cost. However, many have argued that the complexities rendered by green buildings during the operational and maintenance phase often overshadow the benefits that can be gained through the development of green buildings. Several factors that lead to complexities in managing and maintaining green buildings have been highlighted by several scholars and practitioners in the construction industry. These factors are perceived by many as barriers to achieving the benefits that can be gained from green building development. However, the criticality of these factors has yet to be empirically explored in the Malaysian context. This paper determines the factors that lead to green buildings operations and maintenance problems in Malaysia. As an effort to shed light into this issue, a questionnaire survey was carried out involving green building maintenance management teams in Malaysia. Frequency and criticality index calculations were carried out to rank the factors according to level of criticality. The result indicated that the most critical factor that leads to green office building operations and maintenance problem is the failure to consider the aspect of maintainability during the design stage.
Keywords: Green office building, operations and maintenance

Theoretical and Empirical Researches in Urban Management
Volume 9 Issue 2 / May 2014

1. INTRODUCTION

Construction, characteristic, operation, and demolition of buildings are recognised as the main factors that impact the environment and urban development. The environmental impact is expected to increase with population growth, demographic changes and economic development. Thus, green buildings were introduced in the effort to reduce the impact of the built environment on the natural environment. Environmentally sensitive building is not a particularly recent phenomenon, but the modern practice of green building began emerging in the 1990s (Fischer, 2010). Green buildings have an important role in achieving the aim of sustainable development (Fisk, 1998) which is to protect the environment and to improve the quality of life. Gaining momentum in recent years, the development of green buildings has become a trend in the construction industry particularly among those who are aware of the benefits that include not only noble environmental concerns but also profits that can be garnered through higher rental rates and incentives from the government such as tax and stamp duty exemption.

However, without a sufficient experience, the operational and maintenance of green building have faced with some complexities and difficulties which may lead some people to cancel or postpone the development of this kind of buildings. While in the context of green building, Commonwealth of Pennsylvania (2011) has insisted that the impacts of the operation and maintenance of a building and associated grounds on the health of its occupants and the environment at large can be significant. Furthermore, Zainol et al. (2013) have mentioned that maintenance of green building is not only having impacts on operation cost but also affect social and environmental aspect. Internationally, there are many theoretical factors that lead to green building operations and maintenance. However, there have been no empirical studies on the factors that lead to green building operations and maintenance problems in Malaysia. Therefore, as the basis in conducting this research, the main research question is to determine what are the factors that lead to green buildings operations and maintenance problems in Malaysia?

2. THE BENEFITS OF GREEN BUILDINGS

Green buildings are designed, constructed, and operated to boost environmental, economic, health and productivity performance over that of conventional buildings (US Green Building Council, 2003). It has proven to be successful in contributing towards sustainability of the environment, economy and society (Anuar et al., 2012). Most green building definitions incorporate non-technical benefits (economic and social benefits) (Anuar et al., 2012). For example:

i. The way structures are designed, constructed and maintained in order to improve cost efficiency and sustainability of the natural and built environment (Beatley, 2008).

ii. The practice of increasing the cost efficiency of buildings, and reducing their impact on human health and the environment (US Green Building Council, 2003).

According to Adler et al. (2006), green building is often developed under the guideline of a rating system, which provides guidance on "green" measurements. In Malaysia, the Green Building Index (GBI) tool is used as the rating system for assessing green buildings. The GBI tool provides an opportunity for developers and owners to design and construct green and sustainable buildings that can provide energy savings, water efficiency, a healthier indoor environment and better connectivity to public transport (Green Building Index Sdn Bhd, 2012). According to GBI Malaysia, a building will be rated based on six key criteria which are energy efficiency, indoor environmental quality, sustainable site planning and management, material and resources, water efficiency, and innovation (Greenbuildingindex Sdn Bhd).

However, "green" development is often focused merely on design, material selection, construction and building technology (equipment and systems) in order to acquire green certification. The operations and maintenance aspect remains largely ignored, in spite of its significant impact on operation expenses and the life span of the building (SIVECO, 2011). Operations and maintenance forms the largest part of the life-cycle of a building. This implies that the success of a building is not only dependent on good design and construction but also sound operations and maintenance undertakings.

According to Mohd Faris et al. (2010), there is the need for sustainable maintenance for green buildings. Sustainable maintenance is a maintenance system that meets the value system of the present users without compromising the ability of meeting the value system of the future users (Olanrewaju and Kafayah, 2008; Mohd Faris et al., 2010). Maintenance contributes to sustainability by holding noxious to the bare minimum level, reducing energy and resources emission by ensuring the durability and availability of the building facilities, and providing information to the designers on the features of already installed components (Sherwin, 2000).

Even though the cost to design and construct a green building is higher in comparison to a conventional building, the drawback is overshadowed by operational benefits (i.e. energy and resource saving) during occupancy (Lucuik et al., 2005). The operational benefit can only be obtained when operations and maintenance is given priority in the building's life cycle. The maintenance of green buildings does not only impact operations cost but also affect social and environmental aspects. According to Olanrewaju and Kafayah (2008), a building that is not well maintained will affect the quality and productivity of the

Theoretical and Empirical Researches in Urban Management
Volume 9 Issue 2 / May 2014

users and the environment. People's comfort and productivity is relative to the performance of the building they live, learn and work in (Rendeau, Brown and Lapides, 2006).

3. GREEN BUILDINGS OPERATIONS AND MAINTENANCE ISSUES

Several researches have shown that many green buildings are underperforming especially in energy performance.

i. Green buildings use more energy than it was intended to (Sakina et al., 2011).

ii. 28% - 35% of LEED buildings are actually using more energy than their conventional counterparts (Newsham et al., 2009).

iii. Several LEED certified buildings are performing worse than the energy code baseline (Turner and Frankel, 2008).

iv. A research building that was designed to be an energy saving building use double energy in the O&M stage (Gabe, 2008).

There are many researches and studies about building maintenance. Some of researchers emphasised the main factors that lead to building operations and maintenance problems such as faulty design (Lam, 2007; Al-Khatam, 2003; Arditi & Nawakorawit, 1999; Al-Hammad et al., 1997; Assaf et al., 1995; etc), financial factors (Azlan et al., 2010; El-Haram & Horner, 2002; etc), faulty construction (Al-Hammad et al., 1997; Assaf et al., 1995, etc) and maintenance related defects (Azlan et al., 2010; Lam, 2007; Al-Khatam, 2003; Assaf et al., 1996; etc). Saghatforoush et al. (2012) categorised all the issues and problems during the operations and maintenance stage of building into five aspects namely:

i. Technical defects

Technical defects are important critical sources and expensive reworks during the operations and maintenance phase of a building. These factors do not belong to a specific phase and can occur during planning, design, construction or even maintenance (Saghatforoush et al., 2012). The term "technical defects" refers to:

a) Design problems

Design problems will prevent maintenance work to be carried out easily, quickly and economically. Arditi and Nawakorawit (1999) have stated that the condition of a building subsequent to its completion is strongly dependant on its design, particularly in the aspects of defects and maintenance. The huge amount of operations and maintenance cost is the result of the increasing number of failings attributed

by design defects (Fatimah et al., 2011; Al-Hammad et al., 1997). Design for maintainability is often neglected by many in the industry. The industry tends to focus too much on glamorous new construction and still leaving the maintenance aspects of the design and construction process ('Eizzatul et al., 2012; Lam, 2007).

b) Construction related defects

The construction defect issue is one area of concern in green construction. If a new system has not been specified or used previously, then the contractor will have no experience with this system and may build it incorrectly (Fatimah et al, 2011). Green buildings are the subjects of high-end technology application. The more advanced the technology the greener the buildings are perceived. Green buildings are awarded higher levels of certification by green building assessment tools when high-end green technology is applied. Cohen in Wells (2010) believes if a building is closer to the basic level of LEED certification (LEED certified or Silver level), that building probably is not doing anything exotic in terms of the system or technology. However, as builders move up the chain for LEED certification to Gold or Platinum levels, more sophisticated and unproven technologies come into play where the technologies has unknown potential risks or construction defect risks. This will lead to difficulties during the operations and maintenance phase as the technologies have not been reviewed before the installation and the compatibility, as well as the performance is not thoroughly studied prior to application. Construction related defects are also caused by contractors. Contractors should be aware about the construction techniques used and skilled labour hiring. The carelessness would affect the efficiency and durability of any building (Al-Khatam, 2003).

c) Building characteristic defects

Building characteristics always have an influence on the maintenance costs (Azlan et al., 2010; El-Haram and Horner, 2002). This includes building materials; building age; building height; and building structure. Bad quality materials will lead to frequent replacement, correction and more maintenance work in the future (Al-Khatam, 2003). The maintenance cost increases as the building age increases (Wong, 2002). Additionally, higher maintenance cost and remedial cost are required for aged plumbing and drainage systems in buildings because of corrosion problems (Azlan Shah et al., 2010). The height of the building could have an impact on maintenance cost because of the additional cost of equipment, for instance scaffolding which is needed to carry out maintenance tasks such as external decoration, and window repairs (Skinner, 1982). Maintenance cost is significantly subjected to the type of structure in buildings (Azlan Shah et al., 2010). The structure requires a great amount of financial resources for inspection, maintenance, repair, rehabilitation and replacement (Neves et al., 2004). The structural

Theoretical and Empirical Researches in Urban Management
Volume 9 Issue 2 / May 2014

stability of a building must be inspected and maintained from time to time in order to ensure the occupants' safety.

d) Maintenance related defects

Flores-Colen and Brito (2010) stated that buildings may fail for a number of reasons and one of the reasons is faulty maintenance. Faulty maintenance can be divided into two parts which are maintenance that has been carried out incorrectly; or no maintenance has been carried out during the life of the building. This problem is caused by facilities managers or maintenance staffs that do not operate the building as intended due to unsystematic building maintenance guideline (Sakina et al., 2011; Myeda et al., 2011; Natasha et al, 2008).

ii. Managerial problems

Managerial problems have always been the reason for many mistakes and reworks in construction projects (Saghatforoush et al., 2012). This includes:

a) Project management problems

Incomplete construction documents, plans and specifications will create interpretation problems which will affect the quality of the project. This problems will affect the quality of a building after the completion of the building and eventually leads to difficulties of maintaining the building (Arain, Low and Assaf, 2006). Besides, infrequent communication between property or facilities managers and designers causes design-related maintenance problems (Rooley, 1992 in Arditi and Nawakorawit, 1999). Time limitation may occasionally force the designer to wrap up the necessary design works at a lower quality (Arain, Low and Assaf, 2006). Green buildings, which are more complex than conventional buildings, require some additional time in the design and construction phase to ensure that the system and technology are properly integrated (Lucuik et al, 2005).

b) Maintenance management problems

According to Horner et al. (1997), the main objective of maintenance management is to minimise the need of repair on building defects by enhancing planning and implementation, adopting suitable materials and tools at the appropriate time and minimising the total life cycle cost. Poor maintenance management practices are neither cost effective nor optimum, and often cause a lot of problems, such as defective buildings, poor building functionality and others (Azlan Shah et al, 2010).

c) Resource management problems

Resource management problems are related to people, equipment and materials. High maintenance cost is attributed by poor quality of spare parts and materials used in the building components, elements, services or facilities (Azlan Shah et al, 2010); and unavailability of the required spare parts, tools or materials to perform maintenance tasks (Al-Hammad et al., 1996). Besides, Khalid et al. (2006) noted that poor workmanship is the predominant cause of defects emerging on the projects or maintenance works. Employing labour with the requisite skills will assist to improve the quality of work, minimising cost and reduce work time span. Therefore, just having the right tools does not mean the job will be properly performed (Al-Khudair, 1988 in Al-Khatam, 2003).

d) Economical and financial problems

Usually, maintenance is viewed as a "necessary evil", an unavoidable cost burden for projects (Moua and Russel, 2001). Thus, maintenance activities are not carried out on the basis of actual need. This will lead to over budget issues during the operations and maintenance stage due to deferral of some maintenance activities. Failure to execute maintenance at the right time is often due to insufficient budget allocation (El-Haram and Horner, 2002). As a result, further implications occur such as excessive damage, wear and tear and defects (Narayan, 2003). Additional cost or expense that is not allocated in the budget is then required for such maintenance and repair works (Azlan Shah et al, 2010).

iii. Political and legal factors

The factors under this category will cause problems for operations and maintenance stakeholders of infrastructure projects, which result in an inefficient and ineffective management process (Saghatforoush et al., 2012). Political and legal factors include:

a) Political or governmental restrictions/standards

The right-to-buy policy was introduced by the government in order to give tenants the choice of buying the property in which they live from the Local Authority or of continuing to pay the rent. The policy has led to the ownership of some buildings (blocks of flats) being shared by the local authority and private owners. Shared ownership has caused some problems in performing maintenance activities on common building elements, such as roofs where the responsibility for repairs or replacements may be divided between the local authority and private occupiers (El Haram and Horner, 2005).

b) Contractual defects

This factor includes (i) Missing contracting requirement. Maintenance budgets in most local authorities are significantly less than the real maintenance needs. Thus, the cut-off line usually falls somewhere in

Theoretical and Empirical Researches in Urban Management
Volume 9 Issue 2 / May 2014

the middle of a priority (in maintenance plan) category. This means that maintenance managers are often faced with the difficult task of deciding which items should be included in the next maintenance programme, and which items should be moved to the backlog list (Shen, 1997). (ii) Turning the type of selected contract to turnkey model. Under the turnkey contract, it may be more difficult for the employer to exercise his variation power properly. He may be distanced from the design, reducing his understanding of the processes used and his ability to verify the need for a variation and whether the variation proposed will affect the performance of the finished work. Where the engineers design and co-ordinates the construction, the employer knows at each stage how the works may need to be altered. In the absence of the engineer, the employer's understanding of the process of the design and construction of the works may be diminished (Huse, 2002).

iv. Environmental and biological effects

Environmental and biological effects are external factors that cause many major problems during the operations and maintenance phase.

a) Environmental effects

This factor include degradation which is caused by physical and operational (utilisation of the building by the occupants) environment; environmental friendliness constraints; and indoor and outdoor environmental changes (weather conditions). The environment acts on a building or component through mechanical, electromagnetic, thermal, chemical and biological agents causing degradation over time. The degradation process is a continuous interaction between durability factors (which counters degradation) and degradation factors (which promotes or cause degradation).

One of the degradation factors is indoor and outdoor environmental changes such as external and internal climate (Duling et al, 2006). During the design phase, the designer should always specify materials that can tolerate existing weather conditions. Aggressive environment, abrasive uses of the facility and weather conditions cause early deterioration to materials (Al-Hammad et al, 1997).

b) Biological effects

This effect includes biological growth (algae, fungi, lichens, mosses and higher plants which may lead to difficulties of operations and maintenance works); and pests. Excessive biological growth may indicate a serious problem with the structure (Eklund and Young, 2013). Besides, without proactive steps, resources for pests could not be minimised, thus increasing pest infestation during the building's functional life cycle.

v. Social and cultural problems

Social and cultural defects will involve the end-user (Saghatforoush et al., 2012). This includes:

a) User related defects

This factor includes user awareness, delays in reporting problems; and accessibility to the property. Early response to the building failure is necessary to reduce the maintenance cost. However, early response to the building defect or failure cannot be done if there is a delay and failure in reporting the problems (El-Haram and Horner, 2002). Inability to gain access to the property is one of the major factors that affect maintenance cost.

Sometimes, the residents or tenants may not allow maintenance staff to access to their unit space for privacy reasons. Azlan Shah et al (2010) provided another example involving cracks found on the surface of external walls of a parcel unit in the sixth floor. However, the maintenance team is restricted from accessing the unit space. Hence, the maintenance staff can only get access from the external building and additional equipment like scaffolding would be required to repair the affected portion.

b) Third party vandalism

Vandalism by tenants is often discussed as a factor that affects building maintenance cost. According to Olubodun and Mole (1999), vandalism is one of the factors that causes the defects on building components. In Malaysia, it is found that the Kuala Lumpur City Hall (DBKL) spends RM 2.5 million solely for repairing faulty lifts and it is said that 95 per cent of the faulty lifts are caused by vandalism (Azlan Shah et al, 2010).

c) Cultural practices

People's behaviour and way of living is influenced by their cultural background. Therefore, the way in which people perform their duties and deal with others can differ from one culture to another. There are many problems faced by the maintenance management team to maintain and operate the building due to the influence of culture practices (Al-Arjani, 1995). Improper use of toilet bowls due to customaries influenced by culture is one example of how maintenance work becomes more difficult due to cultural practices. Destructive behaviours that are influenced by cultural practices (e.g. urinating idly) can cause high maintenance cost.

Theoretical and Empirical Researches in Urban Management
Volume 9 Issue 2 / May 2014

3.1 Green Building Operations and Maintenance Issues in Malaysia

According to Mohd Reza et al. (2011), the Malaysian government expressed interest in greater implementation of green buildings though Malaysia is still very much lacking behind in green building developments as compared to other Asia Pacific countries such as Australia, Japan and Singapore. Green buildings in Malaysia are assessed and certified by the GBI rating tool. At present, the GBI rating tool assesses buildings in two phases. The first phase involves assessment on the design of the building (Design Assessment) prior to construction.

This is then followed by the second assessment phase known as the Completion and Verification Assessment (CVA) after construction has been completed. To date there are 134 buildings that have acquired the Design Assessment certification and 11 buildings that have been awarded the CVA certification. However, the GBI rating tool does not assess how the completed building is operated and maintained. The GBI rating tool merely assesses the "greenness" of green buildings based on the design and the actual building after completion.

It is unknown whether the green buildings in Malaysia are actually performing as expected. This is due to the fact that green operations and maintenance is not part of the requirements for green building certification. It is argued by operations and maintenance contractors, as well as green building owners and management that green operations and maintenance is costly, impractical and difficult to implement. For example, a green building designed largely with glass walls reduces the need for artificial lighting in the building.

However, the glass walls would require large amounts of water for cleaning which in the end leads to higher water consumption. The cleaning contractor who deals with this task without considering green cleaning approaches would simply clean the glass walls in a conventional manner (more glass more water). In this example, the designers' decision to improve lighting through the use of glass walls is a flaw that leads to higher water consumption which is subsequently dealt by the cleaning contractor through high use of water. The green design turned out to be not so green when it comes to cleaning the building.

4. RESEARCH METHODOLOGY

A survey was conducted to probe further into the factors that lead to green building operations and maintenance problems. The development of the questionnaire as a research instrument is entirely based on literature findings that were acquired from numerous secondary sources such as working

papers, journal articles, text books, reports and other previous publications. The criticality level of the factors was represented by Likert scale.

The respondents of the study comprising 50 respondents from green building maintenance management teams in Malaysia and 50 respondents from Green Building Index (GBI) accredited facilitators which are selected randomly. The questionnaires were then sent to the respondents via post and electronic mail. Due to the background of the respondents, a bi-lingual (Bahasa Malaysia and English) questionnaire was prepared and used for the data collection process. The validity of the questionnaire content was tested by conducting a pilot test that involved 30 selected respondents ranging from academicians to professionals in the construction industry. Moreover, the reliability issue has been covered by conducting Cronbach's Alpha test. The collected data has been analysed using the statistical methods such as frequency and Criticality Index.

5. DATA ANALYSIS

5.1 Reliability Result

Cronbach's Alpha was used to verify the reliability of the survey instrument. Based on Table 1, it was revealed that the final values of Cronbach's Alpha for this study is 0.768 was achieved for the questionnaires, indicating that the instrument is reliable to be used in this study. According to Litwin (1995), when the final values of Cronbach's Alpha is above 0.7, it indicates that the survey instrument utilized the research is reliable and internally consistent.

TABLE 1 - CRONBACH'S ALPHA RELIABILITY TEST

Factors	Cronbach's Alpha if Item Deleted
Building characteristics defects	0.797
Construction related defects	0.805
Design problems	0.775
Maintenance related defects	0.791
Project management problems	0.785
Economical and financial problems	0.755
Resource management problems	0.709
Maintenance management problems	0.798
Political and government restrictions and standards	0.681
Contractual defects	0.682
Biological effects	0.796
Environmental effects	0.845
Cultural practices	0.740
Third party vandalism	0.760
User awareness	0.805
Cronbach's Alpha	0.768

Theoretical and Empirical Researches in Urban Management
Volume 9 Issue 2 / May 2014

5.2 The Output of Critical Factors

From 100 questionnaires that have been distributed to the related respondents, a total of 30 questionnaires were successfully returned. 21 of the response were from green building maintenance management teams in Malaysia and 9 from Green Building Index (GBI) accredited facilitators. The data was then analysed using frequency calculation. This was then followed by criticality index calculation to rank the factors according to level of criticality. The formula that has been used is as follows:

$$\textbf{Criticality Index} = \frac{5n_1 + 4n_2 + 3n_3 + 2n_4 + n_5}{5\,(n_1 + n_2 + n_3 + n_4 + n_5)}$$

where,

n_1 = number of respondents who answered 'strongly agree'

n_2 = number of respondents who answered 'agree'

n_3 = number of respondents who answered 'neutral'

n_4 = number of respondents who answered 'disagree'

n_5 = number of respondents who answered 'strongly disagree'

The findings of the survey (Figure 1) indicate that technical defect is the most critical aspect that leads to green building operations and maintenance problems in Malaysia. This is followed by the managerial problems; social and cultural problems; political and legal factors; and environmental and biological effects.

		Aspects	Criticality Index
Highest	1	Technical defects	0.86
	2	Managerial problems	0.78
	3	Social and cultural problems	0.66
	4	Political & legal factors	0.52
Lowest	5	Environmental & biological effects	0.50

FIGURE 1 - LEVEL OF CRITICALITY FOR ASPECTS THAT LEAD TO GREEN BUILDING OPERATIONS AND MAINTENANCE PROBLEMS

The criticality of the factors were then determined and the result (Figure 2) indicates that design problems in technical defects aspect is the most critical factor that leads to green building operations and maintenance problems.

Maintenance management problems (ranked at number 4) is the most critical factor that leads to green buildings operations and maintenance problems in managerial aspect. Meanwhile, in social and cultural aspects, user awareness (ranked at number 9) is the critical factor compare to the other factors. Contractual defects (ranked at number 13) in political and legal aspect is more critical compared to political and government restriction and standard.

In environmental and biological aspect, environmental effect (ranked at number 11) is more critical than biological effect.

Factors	Criticality Index	Ranking	
Design problems	0.913	1	Technical
Construction related defects	0.860	2	
Building characteristics defects	0.840	3	
Maintenance related defects	0.800	4	
Maintenance management problems	0.780	5	Managerial
Project management problems	0.733	6	
Resource management problems	0.700	7	
Economical & financial problems	0.640	8	
User awareness	0.620	9	Social & cultural
Third party vandalism	0.580	10	
Cultural practices	0.540	12	
Contractual defects	0.520	13	Political & legal
Political & government restrictions & standards	0.453	15	
Environmental effects	0.547	11	Environmental & biological
Biological effects	0.500	14	

FIGURE 2 - CRITICAL FACTORS THAT LEAD TO GREEN BUILDING OPERATIONS AND MAINTENANCE ISSUES

6. FINDINGS

The finding indicates that design problem is the most critical factor that leads to green building operations and maintenance problems, and this followed by construction related defects; building characteristics defects; and maintenance related defects.

This preliminary study has shown that a successful green building is more than just green design and technology. In order for a green building to truly be “green”, operations and maintenance should also be carried out in a “green” way. The critical factors that lead to green building operations and maintenance

Theoretical and Empirical Researches in Urban Management
Volume 9 Issue 2 / May 2014

problems identified in this study will shed light on the priorities for a successful green building. Design for maintainability needs to be given the utmost attention as suggested by the result of the preliminary survey. This study also calls for the GBI rating tool to include green operations and maintenance for green building certification. Assessment that goes beyond green design, construction and technology is vital to ensure that Malaysian green buildings are totally "green" in its life cycle.

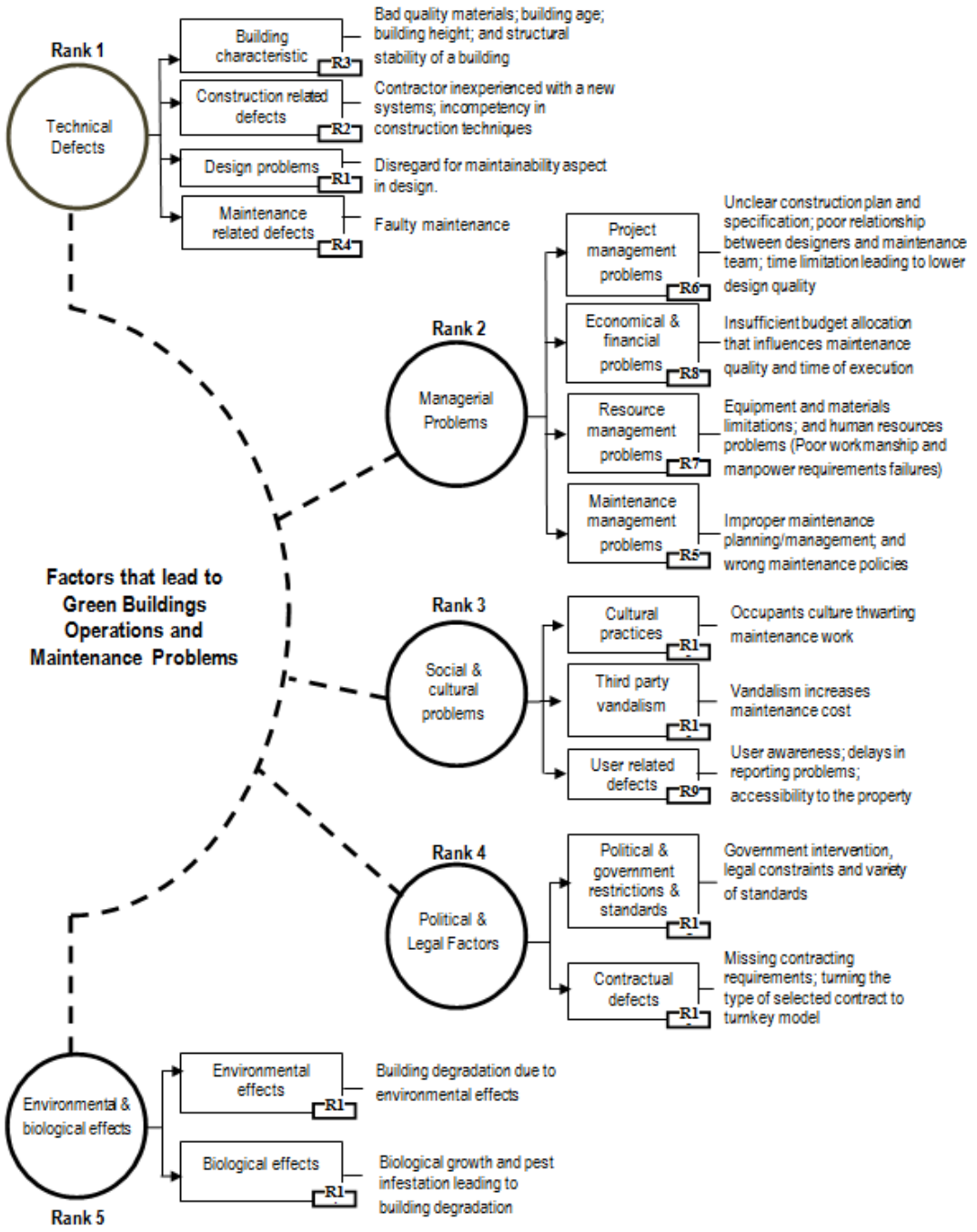

FIGURE 3 - THE SUMMARY OF FINDINGS

7. CONCLUSIONS

This paper has discussed the critical factor of green building operations and maintenance in Malaysia. The result from the survey clearly indicates that technical defects are the most critical aspect that leads to green building operations and maintenance problems. Design problems have been identified as the most critical factor that leads to green building operations and maintenance problems. Other aspects and factors though less critical should also be considered in the operations and maintenance of green buildings. The presence of these factors are actually a typically occurring issue which has always been a hindrance which stunts or even halts the related green building development or implementation or processes. As a result, the responsible parties should adapt specific initiatives and approaches to mitigate the issues. Continuous disregard will cause this situation to become more serious and subsequently the aim to have more green buildings in Malaysia will merely be an unachieved wish.

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