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A DISCUSSION ON METHODOLOGIES IN IDENTIFYING THE MAINTENANCE CRITERIA OF GREEN ROOF IN HIGH-RISE BUILDINGS

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Abstract

Numerous problems arise due to the development growth of a country such as the destruction of natural environments and the deficit in green spaces. Thus, in order to overcome these issues, one of the sustainable approaches in a green building that can be implemented is the green roof. The utilization of a green rooftop over structures has gradually turned into a pattern in urban communities as it gives various advantages to the nation. Unfortunately, the maintenance consideration is still largely unexplored and often being neglected during the planning stage of the green roof implementation. In view of this, this project was initiated to establish maintenance best practice of green roof for high-rise residential, with criteria identification and ranking. This paper presents the methodologies proposed in analyzing the criteria of maintenance in approaching towards the establishment of the maintenance best practice for green roof, by concentrating on high-rise buildings. The data were collected from intensive literature from journals and articles in Malaysian and international contexts. The result of the study discovers past experiences in green roof implementation which leads to the establishment of best practice maintenance for this research.

Keywords: green roof; maintenance; green roof maintenance; high-rise buildings; Malaysia

1.0 INTRODUCTION

The level of urbanisation in Malaysia by 2019 has expanded to 77% (Department of Statistics Malaysia, 2020). It is expected to rise year by year through the common pattern of urbanization, and by 2030, it is predicted to reach 83% (United Nations, 2002). The quick growth of urbanization with many developments and intensified impervious areas has however caused threats to human beings and surroundings especially when it is uncontrolled. A study by Yusof & Johari (2012) mentioned that the original city area of Kuala Lumpur of 24,222 hectares had decreased to 59.4% or 14,386 hectares. It shows that the extreme urbanization and construction affect the green areas, while creating many other environmental problems. On the other hand, the development and application of the green roofs in Malaysia is still lagging behind. Even though some buildings declared to be green with the addition of a green roof on top of the buildings, they are actually not classified as green buildings as they do not meet certain requirements (Mastor, 2008). One of the factors which contribute to the lack of greenness of a building is the operation and maintenance system. The case of non-functioned green roof to perform its intended purpose due to the lack of maintenance is seen as another issue to the green roof application (Ismail *et al*., 2015).

This paper aims to deliberate on the methodologies that can be adopted in analyzing the criteria of maintenance in approaching towards the establishment of maintenance best practice for the green roof, by focusing on high-rise buildings. In order to achieve this aim, the methodologies applied by past research from both local and abroad, have been studied, their findings examined and the data have been used to formulate appropriate tools to be used in the present study.

1.1 Green Roof and its Implementation in Malaysia

The implementation of green roof on top of buildings in urban cities has become a trend. The reason for this trend is because of the limitation of lands and the need to preserve the environment. It also offers many advantages to green development growth. A green roof can be found on the top layer of the roof where vegetations are planted, and where a layer of soil and growing medium is required to help with the growth of vegetation on the roof, as to increase the performance and features of the roof (Aziz & Ismail, 2011; McIntyre & Snodgrass, 2010). In order to reduce the damaged vegetated footprint occurred owing to the construction, the green roof is applied as a means of vegetation or plant material where it is left to grow on the rooftops (Chow & Abu Bakar, 2016; Fauzi & Malek, 2013; Getter & Rowe, 2006). A green roof is also known as living roof, vegetated roof or eco-roof (Fauzi *et al.*, 2013). Generally, the green roof can be divided into two distinct categories, that is, extensive and intensive green roofs. Table 1 summarised the differences between these two types of green roof. In Malaysia, the basic category of green roof installed is the intensive type of green roof rather than the extensive green roof (Rahman *et al*., 2013).

Table 1: Differences between extensive and intensive green roof

Intensive Green Roof	Extensive Green Roof
Require intensive maintenance	Require extensive maintenance
Accessible	Inaccessible
Require deeper substrate (min 15 cm)	Require shallow substrate (only 2-15cm)
Heavyweight (saturated weight between 200 to 500 kg/m²)	Low weight (saturated weight between 60-150 kg/m²)
High cost	Low cost

Source: Chow & Abu Bakar (2016)

There are a few successful green roof implementations executed in a few buildings in Malaysia, where they acknowledged the execution of green roof in Malaysia although it is still at the primary stage (Ismail *et al.*, 2012). This has made it a current trend in the city area such as in Kuala Lumpur City, where the city has applied green roofs and green facades in the modern contemporary high-rise projects (Zahir *et al.*, 2014; Zahir *et al.*, 2013). Table 2 displays a few of the green roofs that have been successfully installed in Malaysia which are mostly found in the urban cities such as Kuala Lumpur.

Table 2: List of some green roof projects in Malaysia

Building	Type of Green Roof	Year
Rice Garden, Musem (Laman Padi), Langkawi	Intensive	1998
Ministry of Finance, Putrajaya	Extensive and Intensive	2002
Putrajaya International Convention Centre (PICC)	Intensive and Extensive	2003
Putrajaya City Hall, Putrajaya	Extensive	2004
Malaysian Design Technology Centre (MDTC), LKW	Extensive	2004
Fakulti Sains Sosial & Kemanusiaan, UKM	Retrofit Extensive	2007
Sime Darby Oasis, Damansara	Extensive	2009
KL Sentral Park @ Platinum	Intensive	2009
Newcastle University Medicine Malaysia, Nusajaya	Extensive	2011
Heriot-Watt University, Putrajaya	Extensive	2014

Source: Zahir *et al*., (2013)

2.0 LITERATURE REVIEW

This section discusses the methodologies employed in previous research to explore the insight on green roof maintenance issues. Locally and internationally, there were previous studies that have been conducted on matters concerning the maintenance issues in green roof and have been documented in various publications (Chen, 2013; Coelho *et al*., 2015; Ismail *et al*., 2015; Kamarulzaman *et al*., 2014; Lee *et al*., 2016; Maryanti *et al*., 2014; Raposo &

Pinheiro, 2013; Shams *et al*., 2018;).This publication is partly an exploratory study in determining the suitable methodologies that can be used for this project. This is important as identifying past methodologies will help to determine the key factors in developing a better result. Table 3 and Table 4 summarise the methodologies and its findings from past research.

Raposo & Pinheiro (2013) deliberated on the technical requirements specifications of the green roof system in order to develop a "Best Practice Guidelines" for the design, installation and maintenance of green roofs. The samples used in this study were 2 case study buildings with green roofs in Portugal. Meanwhile, Coelho *et al.* (2015) used different methods to collect the maintenance criteria of the green roof. The author obtained the data through visual inspection on 11 buildings with green roofs and also acquired the data of technical documents from owners, designers, installers and maintenance technicians of the buildings. It was concluded that the most affected system element was the vegetation layer (28%), followed by the drainage system (24%), substrate (12%) and paths (12%). Investigation by Chen (2013) summarized all the benefits of green roof focusing with its plant selection, installation and maintenance. From these findings, the authors proposed a future cost benefit analysis of green roofs in tropical and subtropical areas. Another study by Lee *et al.* (2016) distributed questionnaires to the citizens who lived in green roof projects area and the data were analysed by using SPSS 12.0.0 for Windows given a frequency analysis, variance analysis, factor analysis and regression analysis for the study. It is then revealed that 64.8% respondents had a positive awareness on green roof projects, however, the respondents still had a low degree of awareness on the 'satisfaction of plant maintenance'. Shams *et al*. (2018) conducted an intensive literature review on green roof; then conducted a field investigation on the existing building, followed by a face-to- face interview with professionals who were involved in green roof projects and also there were questionnaire surveys given to a number of students, NGOs and the people involved with public and government services. Both qualitative and quantitative results were used to cross verify each other.

Table 3: Past researches methods and findings on maintenance issues of green roof in other countries

Authors	Method(s)	Target Sample(s)	Findings
(Chen, 2013)	Literature review	-	Proposed paper on future cost benefit analysis of green roofs in tropical and subtropical areas.
(Raposo & Pinheiro, 2013)	Observation	2 case study buildings	Development of a "Best Practice Guidelines" for the design, installation and maintenance of green roofs systems
(Coelho *et al.*, 2015)	Field survey on 11 green roof buildings and data from the target samples	Owners, designers, installers and maintenance technicians	The most affected system element was the vegetation layer (28%), drainage system (24%), substrate (12%) and paths (12%).
(Lee *et al.*, 2016)	Questionnaire survey	Citizens who lived in GRPs areas	64.8% respondents are aware of GRPs. However, respondents had a low degree of awareness of 'satisfaction of plant maintenance.
(Shams *et al*., 2018)	Literature review, Field investigations, face-to face interview, questionnaires	Students, NGOs and people involved with public and government services	Only 24% are in favour of using green roofs. Lack of awareness and high installation and maintenance cost are the major challenges to the application of green roofs in BSB.

3.0 RESEARCH METHODOLOGY

This study which was initiated to establish maintenance best practice of green roof for high-rise residential, with criteria identification and ranking, is proposing a mixed method of survey questionnaire and interviews based on the methods used by Shams *et al.* (2018) where questionnaire surveys were distributed to the maintenance managers and analysed by using

SPSS software. Descriptive analysis of mean ranks and standard deviation was then used to gauge the sample data obtained. After the data in terms of the criteria incorporated from the survey earlier were analysed, a qualitative research method of semi-structured interview to the industry practitioners and relevant stakeholders from various agencies was carried out via focus group discussion. The findings were then analysed by using Atlas.ti 8 software and from the data analysis obtained, the maintenance best practice was then established. In order to cross verify each other, both qualitative and quantitative results were used for this project.

4.0 RESULTS AND DISCUSSION

The literature that discussed the maintenance issues of green roofs in Malaysia were very limited. A study by Maryanti *et al*. (2014) used face-to-face interviews with structured questionnaires on 20 property developers. From the interview, it was identified that Iskandar Malaysia had a high potential for green roof projects based on their knowledge about the benefits of the rooftop garden, but cost and profit have become their main concern before implementing this concept in their property development project. Meanwhile, Ismail *et al*. (2015) applied different methods in the study, which are, condition survey assessments and verbal information through interviews with managing agents and maintenance managers at five selected buildings. It was determined that the main aspects of green roof maintenance could be assessed in two main aspects, namely structural and vegetation maintenance.

Table 4: Past researches methods and findings on maintenance issues of green roof in Malaysia

Authors	Method(s)	Target Sample(s)	Finding(s)
(Kamarulzaman *et al*., 2014)	Literature review	-	Proposed papers.
(Maryanti *et al.*, 2014)	Interview	20 property developers	The major barriers of green roof implementation and expansion in Malaysia is due to a high cost in its development and maintenance
(Ismail *et al.*, 2015)	Building condition assessment and interviews	Managing agents and maintenance managers	Green roofs maintenance is carried out in two main aspects, namely structural and vegetation maintenance.

Therefore, from the review of past research, this study which was initiated to establish maintenance best practice of green roof for high-rise residential, with criteria identification and ranking,

5.0 CONCLUSIONS

The global trend of green movement in the construction industry has gradually increased the implementation of green roofs in most countries. However, the concern towards the green roof maintenance has not yet been addressed or prioritized in terms of the viability of its application. The outcome of the paper revealed different types of methodologies used in both the local and international contexts in assessing the maintenance issues by considering the maintenance criteria towards the establishment of the maintenance best practice for green roofs. The results of this study lead to the proposal of using a mixed method of survey questionnaire and interviews with the maintenance managers for the project. This is because both qualitative and quantitative results can be used to cross verify each other, hence strengthening the methodologies used for the project. It is also recommended that future research should not only emphasize on finding means to promote green roof among all building professionals, but also suggest improvements to existing policies, guidelines and green roofs campaign in Malaysia, particularly in the maintenance aspects as it may affect the cost and profit of certain green roof projects.

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