

Assessing Practice and Criteria for Green Roof Maintenance on High-rise Residential Building in Malaysia

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Abstract. Urbanisation inevitably shows a positive sign in increasing the economic reputation of a country. Nevertheless, it has led to several problems including the deficit in green spaces and destruction of the natural environment, therefore green building is introduced as an alternative to overcome crucial environmental issues. Numerous approaches were also adopted to reduce other environmental issues such as urban heat island, air pollution and lack of green spaces. One of the sustainable approaches that help to minimise the environmental problems is by using the means of vegetation or plant material on rooftops or also known as the green roof. The implementation of the green roof on top of buildings is becoming a trend in the urban cities as it provides numerous benefits to the green development. The green roof is also part of criteria in green building and among the benefits, implementing green roofs will reduce heat flux, optimise energy efficiency and improve stormwater management. However, despite the benefits, enhancement on the green roof installation and maintenance consideration are two factors which are still largely unexplored as the main significant factor in the viability of the green roof installation. Hence, this paper is aimed to determine the vital criteria of maintenance and its ranking towards the establishment of best practice maintenance for the green roof, by focusing on high-rise residential. Questionnaires were distributed by email and through an online survey to 30 maintenance managers of green roof of high-rise residential in Kuala Lumpur and the samples are drawn by using purposive sampling technique. The results showed that the most significant maintenance criteria of the green roof are drainage, followed by waterproofing, irrigation, water retention, and roof slab. The outcome of this study has provided a significant contribution to the current maintenance practice of green roof by prioritising the criteria of maintenance and key address of green roof, where it may help to standardise the maintenance practice of the green roof in the tropical climate of Malaysia.

1 Introduction

Urbanisation raises the economic development and growing population of a country. According to the Department of Statistic Malaysia, the level of urbanisation in Malaysia has increased from 62% in 2000 to 71% in 2010 [1]. It is expected to increase over the years with the common pattern of urbanisation and predicted to reach 83% in 2030 [2]. The rapid growth of urbanization also has created lots development and has intensified the impervious area, as well as the human comfort and material life, but at the same time, they prompt threats to human beings especially when it is not being controlled. Even though urbanisation brings numerous economic and social benefits, various environmental issues have occurred such as urban heat island, air pollution and lack of green spaces.

According to a study by [3], the green areas in Kuala Lumpur have decreased from the original city area of 24,222 hectare to 59.4% or 14,386 hectares, which consist of trees, shrubs, grassland and water bodies. This shows that urbanisation affects the green areas, whilst creating many environmental problems. At the same time, it has led to a high demand for urban green spaces as well as high-rise buildings, due to the rapid growth in population and the increased urbanisation rate in the country. Recently, the growing urban population rate is 2.19% annually, with 76% or more than half Malaysian's population living in the urban areas [4]. Since the population is increasing and the area is becoming scarce and has been taken up with buildings and infrastructure in the urban areas, the recent development has come out with few sustainable approaches. The green roof implementation is one of the promising choices for these

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densely populated urban areas with the addition of more green spaces.

Green roof is where the top layer of the roof is being planted with vegetations, where a layer of soil and growing medium is needed for the growth of vegetation on the roof in order to improve the roof performance and its features [5], [6]. It is where the means of vegetation or plant material is left to grow on the rooftops as to remove the damaged vegetated footprint caused by the construction [7]– [9]. Other than that, green roof is also recognised as living roof, vegetated roof or eco-roof [10].

Due to the land constraints and the need to sustain the environment, the implementation of the green roof on top of buildings has become a trend in the urban cities as it provides numerous benefits to the green development growth. As in Malaysia, some successful green roofs applications were applied in few buildings and were identified since the green roof appliance in Malaysia is still at the preliminary stage [11]. However, Kuala Lumpur has been implementing green roofs and green facades in the contemporary modern high-rise design and has made it a recent trend in the urban areas [12], [13]. Meanwhile, the common type of green roof implemented in Malaysia is the intensive green roof as compared to the extensive one [14]. This is due to the limited plant selection for the extensive green roof compared to the intensive one, which lower its aesthetic value. Green roof offers a lot of benefits such as reducing heat flux, optimising energy efficiency, improving stormwater management, enhancing carbon sequestration and pollutant trap, as well as developing building and urban cooling.

Nevertheless, the operation and maintenance system is seen as an observable fact, where it appears to be an additional challenges to the green roof implementation as the lack of maintenance can lead to the roof garden not functioning as intended [15]. Moreover, based on the study by [11], it is also confirmed that majority of the respondents agree that the maintenance of green roofs is complicated and tedious. It indicates that the maintenance consideration for the green roof in Malaysia is still largely unexplored as the main significant factor in the viability of the green roof installation. Up to now, a clear policy framework for green roofs maintenance in Malaysia is still not available.

Therefore, towards the establishment of best practice maintenance for the green roof, this paper is aimed to identify the current practice and the necessary vital criteria in maintaining the green roof by focusing on high-rise residential buildings in Malaysia. In addition, the study will also determine the level of importance for each maintenance criteria by ranking the criteria listed. Thus, the result and findings are to be discussed and analysed to determine the direction of future green roof maintenance practice in Malaysia.

2 Method

This study was purposely carried out to identify the current practice and the crucial vital criteria for green roof maintenance on high-rise residential buildings in Malaysia. Hence, determining the rank of each maintenance criteria obtained according to the level of importance. In achieving the objectives of the study, quantitative method was used, where a set of questionnaires was distributed to the maintenance managers in Kuala Lumpur who have experience in handling maintenance on the intensive green roof of high-rise residential buildings by using purposive sampling. The author identified 25 high-rise residential buildings or projects that were being installed with intensive green roof in Kuala Lumpur. There are about 19 different companies among them which carrying out the maintenance on the intensive green roofs. Every company hold 1 or 2 management staffs of the maintenance management. Hence, the sampling frame for the study involved 30 respondents who have experience in handling the maintenance of intensive green roof in high-rise residential buildings in Kuala Lumpur, Malaysia. The data for this study is collected through electronic, which is via email, and online survey.

The questionnaire was divided into three (3) sections of close-ended and open-ended questions. Section A is concerning on the background of respondents and companies, while Section B is on the current practices and vital criteria needed for green roof maintenance in Malaysia, and Section C where they were required to rate the importance of the vital criteria needed for green roof maintenance in Malaysia. The close and open-ended questions were used in the early part of the questionnaire. Meanwhile, likert-scale scaling response ranged from five fixed choice formats (from very important to not important) were designed to measure the respondents' opinions on the level of importance of each of the maintenance criteria obtained. The data then were analysed using Statistical Package for the Social Sciences (SPSS) to produce descriptive statistic and presented in tabular form as well as graphs.

3 Result and discussion

3.1 Demographic background

Based on the study, there are 30 respondents selected and only 20 returnable questionnaires attained as in Table 1. The total number of 20 respondents responded to the survey out of 30 respondents represents a 67% response rate, and according to [16], a valid response rate is 50% and above. Hence, the number of respondents involved is sufficient for this study, as it is carried out by using purposive sampling, where the respondents chosen were based on the high-rise residential buildings with intensive green roof.

Table 1. Summary of demographic of responds and company background

Items	Sub-Items	Maintenance Managers (n=20)	
		Frequency (N)	Percentage (%)
<u>Company particulars</u>			
Years of company established	Below 5 years	2	10
	5-10 years	2	10
	10-15 years	5	25
	Over 15 years	11	55
Problems or failures occur during the maintenance process of green roof	Yes	4	20
	No	1	5
	Sometimes	11	55
	Most of the time, yes	4	20
Types of problems or failures	Leaks	16	80
	Plant loss	12	60
	Inadequate drainage	13	65
	Soil erosion	5	25
	Slope instability	3	15
<u>Respondent particulars</u>			
Engaged in the green roof maintenance	Yes	13	65
	No	7	35
Years involved in the green roof maintenance based on working experience in the industry	1-5 years	18	90
	6-10 years	2	10
The importance of maintenance for green roof	Important	19	95
	Not important	1	5

Based on **Error! Reference source not found.**, in regard to the company particulars, it shows the amount of years the company which the respondents are working for have been established. 55% of the respondents work with the companies which have been established for more than 15 years, another 25% work with the companies that have been operating between 10 to 15 years, while 10% respondents shared the same percentage for both companies which have been established between 5 to 10 years and below 5 years.

The table also illustrates the percentage of the occurrence of problems or failures during the maintenance of green roof. Most of the respondents rated the problems or failures do occur throughout the operation of maintenance on the green roof, and the least 5% of the respondents considered that no problems or failures have occurred.

At the meantime, the types of problems or failure which mostly occur during the maintenance process of green roof is leaking, with the highest percentage assessed by the respondents (80%) which is equal to 16 respondents, followed by inadequate drainage with (65%) or 13 respondents, then plant loss with 12 respondents (60%), soil erosion with (25%) or 5 respondents and the least was (15%) which is equivalent to 3 respondents for slope instability.

In regard to the respondents' particulars, 65% or more than half of the respondents have involved in the maintenance of the green roof, meanwhile another 35% of the respondents have never involved in the related field. Besides, the majority or 95% of the respondents have involved in the maintenance of the green roof, which is between 1 to 5 years, while another 10% respondents involved between 6 to 10 years in the area. In addition, 19 respondents (95%) emphasized that the maintenance on the green roof is important, while only 5% or equivalent to 1 respondent marked the green roof maintenance as not important.

3.2 Current practices and vital criteria for green roof maintenance in Malaysia

3.2.1 Maintenance strategy

This study attempts to discover which maintenance strategy that is mostly being adopted by the maintenance managers of high-rise residential buildings with green roof. 10 respondents (50%) indicated that they adopted preventive maintenance as the main maintenance strategy for the green roof. Meanwhile, 6 respondents (30%) stated that they chose corrective maintenance while 4 respondents (20%) used condition-based maintenance for the green roof maintenance strategy as illustrated in Table 2 and Fig. 1 below.

Table 2. Maintenance strategy

Maintenance strategy	Frequency (N)	Percentage (%)
Preventive	10	50
Corrective	6	30
Condition-based	4	20

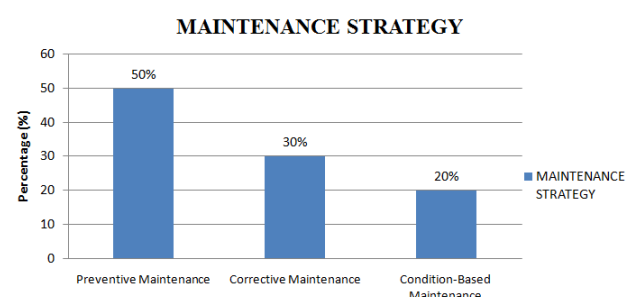


Fig. 1. Maintenance strategy

3.2.2 Maintenance procurement strategy

It is also revealed that 75% or more than half of the respondents agreed on outsourcing the maintenance works of the green roof to other organisations. Only 25% of the respondents alleged that it was an in-house project. Table 3 and Fig. 2 indicates the results of the maintenance procurement strategy implemented by most of the maintenance managers.

Table 3. Maintenance procurement strategy

Maintenance procurement strategy	Frequency (N)	Percentage (%)
Out-source	15	75
In-house	5	25

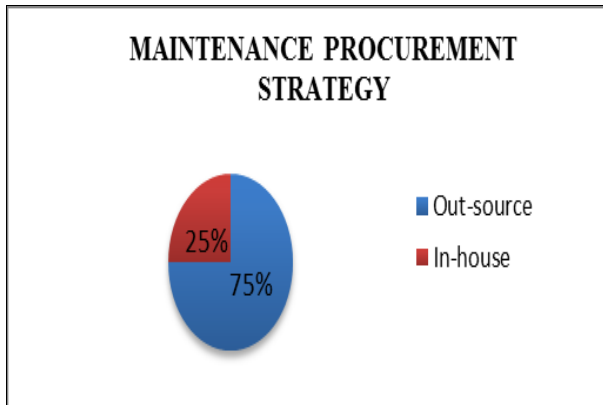


Fig. 2. Maintenance procurement strategy

3.2.3 Vital Criteria needed for the maintenance of green roof

The study shows the vital criteria needed for the maintenance of green roof in high-rise residential buildings in Malaysia. The criteria which represent the highest percentage are drainage and waterproofing, where each presents 85%, followed by roof slab (80%), water retention (75%) and vegetation (70%). At the meantime, insulation and safety are the two least criteria being rated by the respondents, where each criterion constitutes 40%. The results are illustrated in Fig. 3 below.

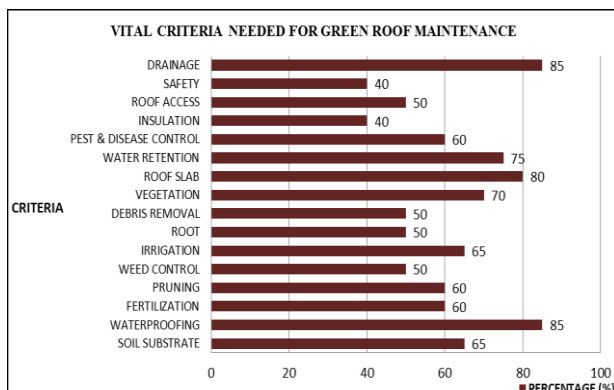


Fig. 3. Vital criteria needed for green roof maintenance

3.3 The ranking of maintenance criteria for green roof practice in Malaysia

This section is where 16 criteria were listed, and the respondents were expected to rate the importance of each criterion stated in maintaining the green roof in Malaysia by using a five-level numerical likert-scale of importance, ranging from “1” equal to “not important” to

“5” equal to “very important”. The interpretation of the results were simplified and presented in descriptive statistics using mean and standard deviation score as in Table 4.

Table 4. The rank of maintenance criteria for the green roof practice in malaysia

No.	Criteria	Mean	SD	Rank
1.	Drainage	4.50	0.889	1
2.	Waterproofing	4.40	0.940	2
3.	Irrigation	4.30	1.031	3
4.	Water Retention	4.30	1.031	4
5.	Roof Slab	4.25	1.164	5
6.	Insulation	4.10	1.021	6
7.	Soil Substrate	4.05	1.099	7
8.	Vegetation	4.00	0.973	8
9.	Safety	3.85	1.182	9
10.	Roof Access	3.75	1.209	10
11.	Root	3.70	1.218	11
12.	Fertilization	3.60	1.046	12
13.	Pest & Disease Control	3.60	1.353	13
14.	Debris Removal	3.55	1.050	14
15.	Pruning	3.50	1.100	15
16.	Weed Control	3.40	1.142	16

Based on Table 4, it illustrates the analysis for the ranking of maintenance criteria regarding the green roof practice in Malaysia, as evaluated by the respondents. The table shows that all mean values range from the highest mean (4.50) to the lowest mean (3.40). A smaller dispersion of the standard deviation (sd) value on the distribution of data displays that the obtained sd score is less than the mean, as it ranges from 0.889 to 1.142. Therefore, the standard deviation means that the level of importance is consistent between all the 20 respondents. Hence, the data are described as reliable.

The results in Table 4 also signifies drainage as the most important criteria in maintaining the green roof as being ranked by the respondents with a mean of 4.50 (sd=0.889). It is then followed by waterproofing, irrigation, water retention and roof slab. For this reason, these five criteria were identified as the main items that are very essential when performing the maintenance on the green roof. The result also stipulates the criteria of weed control with the lowest mean, which is 3.40 (sd=1.142). Even though it is ranked with the lowest mean, the criteria should still be considered crucial when maintaining the green roof.

Based on the acquired mean score (3.40 to 4.50) and by referring to the mean value, it can be inferred that all maintenance criteria ranges from moderately important to very important. None of the mean score indicated that the importance falls in the category of slightly important or not important. Accordingly, this can be concluded that every criterion contributes significantly to the maintenance practice on the green roof of high-rise residential buildings in Malaysia.

4 Conclusion

This paper concludes that according to the current practice, the maintenance strategy that is mostly being adopted by the facility manager or maintenance manager for the green roof maintenance in high-rise residential buildings in Malaysia is preventive maintenance strategy. Meanwhile, the maintenance works for the green roof in high-rise residential buildings were usually being outsourced to other organisations. The study also revealed 16 criteria which are important when maintaining the green roof. Among the maintenance criteria specified are soil substrate, waterproofing, fertilization, pruning, weed control, irrigation, root, debris removal, vegetation, roof slab, water retention, pest and disease control, insulation, roof access, safety, and drainage. The ranking of the maintenance criteria indicated that drainage is ranked as the most significant criteria, followed by waterproofing, irrigation, water retention, roof slab, insulation, soil substrate, vegetation, safety, roof access, root, fertilization, pest and disease control, debris removal, pruning, and weed control. This study contributed towards the establishment of best practice of maintaining for the green roof, by focusing on high-rise residential, where it helps to highlight the important criteria that need to be emphasized when carrying out the maintenance works on the green roof. At the same time, it is hoped to give some benefits to the maintenance team especially the ones that involved in green roof projects in order to improve the current exercise on the maintenance of green roof in high-rise residential buildings in Malaysia by carrying out the maintenance works in a standardised way.

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