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Anniz Fazli Ibrahim Bajunid

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POTENTIALITY OF ECOLOGICAL FRIENDLY EFFECT ON HUMAN BEHAVIOR OF GREEN BUILDING DESIGN

Wan Zuriea Wan Ismail[1], Dr. Faridah Ismail[1], Asso. Prof Dr. Ahmad Ezanee Hashim[1], Dr. Adi Irfan[1] and Rohaslinda Ramele @ Ramli[1]

[1]Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, Shah Alam, MALAYSIA
Email address of corresponding author: ezanee54@yahoo.com

ABSTRACT

Green buildings are considered as a fairly new concept in Asia countries even though lots of benefits gained in its concept. It promotes environmental, economy and aesthetic value. An understanding of how green buildings affect human comfort and human behavior is crucial for its guideline for future implementation. The objectives of this study are to identify the full potential of green roof buildings and problems associated, perceived from facility management pointo f view in Malaysia. The finding revealed the potential of green buildings in the Malaysian construction industry is increasing as there is awareness on providing a sustainable built environment. They provide leisure and operational space, visual amenities value and health and therapeutic value. Problems identified are the absence of green roofs components, damaged waterproofing, and presence of unwanted animal, water ponding and breeding of mosquitoes. The study point out the benefits, make recommendations on planning and design intent at early stage of green roof development and providing user friendly green buildings.

Keywords: Green building, human comfort, human behavior

1. INTRODUCTION

The world population are expected to rise to 9 billion by year 2050 (Population References Bureau, United Nations) and many cities in the world are fast becoming highly urbanized with the construction of buildings and structures in close proximity to each other. As we construct buildings, roads and parking lots, these will disturb the natural environment. The balance between green areas and concrete built-up areas cannot be ignored in order to maintain a pleasant living environment (Wong et al., 2002). Widespread concern about sustainable architecture makes green roofs as part of building design option (Abdul Samad, 2008) and sparked a growing interest in green roofs project across the world. In Asia, the use of green roofs has arisen in Japan, Singapore, Hong Kong and China. Although the idea of green roofs in Asia is new, these countries are active in developing, practicing and conducting research on green roofs, particularly in Singapore.

Many cities in Malaysia will be urbanised in year 2050 with the percentage urban growth expected at 87.9% (Population References Bureau, United Nations). The expansion of rural into urban areas involves bigger ecological foot print and the impact of this growth will be a challenge for future development (Abdul Samad, 2008). Ecological foot print will be destroyed in order to permit the development and construction of buildings. According to Wong (2005) as cited in Getter and Rowe, 2006, roofs present 21%-26% of urban areas and this can provide a unique opportunity to improve the environment if green roofs are used. In urban areas such as Kuala Lumpur, George Town and Johor Baharu, there are a lot of opportunities to incorporate green roofs in the development because of rapid expansion in these areas. By having a green roof, the areas taken from nature are made to come alive again in our immediate environment. Green roofs

in Malaysia are considered as a fairly new though lots of benefits are offered. Green roofs in Singapore, the country that has a similar climate with Malaysia, have grown remarkably compared to us. The impetus for green roof development in Singapore is due to limitation of space and it cannot be denied that Malaysia may face the same problem as Singapore in future, Compared to Singapore, we are far behind in terms of policies, research done, technology and practice in this area. The potential of green roof has not been explored in Malaysia. There has been no study carried out on the effects of green roofs on the humanco mfort and human behavior, and there is no monitoring system to record the beneficial returns of incorporating green roofs in development. Perception towards green roof is very important to determine the potential of green roofs in future planning (Yuen, 2005). An understanding of how people see and perceive benefits of green roofs is crucial to determine the potential of green roof. The lack of awareness on benefits and performance might hinder the development of green roofs.

2. LITERATURE REVIEW

2.1 Green Roof

A green roof is defined as one with plants growing on its surface. This can range from spontaneous growth of moss to a full scale garden with scrubs and trees on roof surface (Scholz-Barth, 2003). As Velazquez L. (2005) defined green roofs which are sometimes called eco roofs, sky garden or sky rise garden as simply vegetated roof covers constructed atop and across a roof deck. Green roof classifications are generally separated into two categories as identified in the international landscape industry: extensive and intensive systems which are depending on the soil depth, plant selection, method of irrigation (Nelms et al,. 2005), visual appearance, maintenance and planned usage of the roof area (Getter and Rowe 2006). Besides these two classifications, Dunnett and Kingsbury (2008) indicate that semi-extensive green roof is also another classification of green roofs. Intensive roof systems are designed and constructed like a conventional garden that can be accessed by the public for recreational enjoyment including walkways, water features and irrigation systems. Intensive green roofs require intense maintenance and modification to the structural capacity of the design due to the required soil depth (Nelms et al,. 2005) and normally incorporated into the original building design because of the high structural loading involved. Intensive green roofs typically use a wide variety of plant species that may include trees and shrubs and thus require deeper substrate layers (usually > 15.2cm) than extensive green roofs (Getter and Rowe, 2006). This can allow more complex ecosystems to develop more energy efficient and last longer than extensive green roofs (Kwok, 2007). Extensive green roofs are not intended for regular human use and in some instances cannot be seen on a regular basis, but may provide for natural view from adjacent rooms or neighboring buildings. Extensive green roof generally required minimal maintenance and technical expertise for installation. The systems have a shallow, lightweight growing medium, which can support only small plants such as herbs, grasses and wild flowers (Liu and Baskaran, 2005). Substrate depth can range between 2- 15cm and many existing buildings can be retrofitted to accommodate extensive systems because the structural loading demands are low. Semi-extensive green roof systems combine many of the environmental benefits of extensive green roofs with some of the aesthetic potential of intensive green roofs. It consists of lightweight's substrates, modern green roof technologies and slightly deeper layers of growing medium (10-20cm) for a wider range of plants to grow (Dunnett and Kingsbury, 2008).

2.2 Benefits of Green Roof

Green roofs have been used extensively in Europe to mitigate such adverse effects of urbanization and their benefits are well documented through many research projects carried out in Europe,

North America and Asia. In Malaysia, the developers, owners, operators, insurers, and the public at large are beginning to value and market the benefits of sustainable buildings (Shafii and Othman, 2008). Green roofs promote a range of benefits that can solve the problem of ecological steps, limitation of space, greenery balance, global warming, aesthetics and lost of wildlife habitat that occur in many urban areas. Teicholz (2001) indicates that the most effective way in overcoming the obstacles to sustainable development is to stress the benefits of the approach to building owners, operators and users. Understanding the benefits will determine the purpose of implementing green roofs and achieve a desired objective. The benefits can be classified into main three areas which are environmental, economic and amenity and aesthetics (Dunnett and Kingsbury, 2008).

2.2.1 Environmental Benefits

2.2.1.1 Biodiversity and habitat

Green roof can provide some habitat for wildlife although green roofs are not intended to be replacements for natural areas located at ground level (Dunnett and Kingsbury, 2008). The enhancement of biodiversity through the use of green roofs is closely linked to the type of vegetation being used. Green roofs may provide natural habitat for resident and migratory birds and insects through the provision of one or more of birds' basic needs – food, water, shelter, and place to breed (Final Report, Urbis, 2007). From the studies that have been done in Germany, Switzerland and England, it can be concluded that variations in substrate depth across the roof are very important in designing roof that support biodiversity (Dunnett and Kingsbury, 2008).

2.2.1.2 Alleviating urban heat island effect

Urban heat island effect is defined as larger temperatures in urbanized areas as compared to surrounding areas with relatively larger amount of vegetation (Ahmad et al,. 2006) and it is a common phenomenon in major cities around the world, including Malaysia. Temperature in the city areas can be 10°C or more above suburban green areas because of the heat radiated into the surrounding air (Embi and Mohd Dom, 2007). According to a research on an experimental plot in Bangi, Selangor that was conducted by Ahmad et al., (2006), extensive green roof can lower the ambient temperature 1.5°C compared to concrete rooftops. In Singapore, through a field test conducted by a research team supported for National University of Singapore, National Parks Board and the Building and Construction Authority, the use of green roofs with plants has been proven to decrease the surface temperature by as much as 30°C and air temperature by about 4°C with or without plants in tropical environments (Wong et al., 2003). It will result up to 15% annual energy consumption savings. From those experiments, they identified that the soil thickness and type of plants on green roofs can play a significant role in reduction air temperature. (Ahmad et al., 2006)

2.2.1.3 Storm water management

Green roofs provide a reduction of total amounts of storm water runoff and peak runoff rate (Liu and Baskaran, 2005). Green roofs capture and retain huge amounts of water that otherwise would go down to the storm drain and other places. As cited in Getter and Rowe (2006), DeNardo et al., (2005) indicate that green roofs may reduce runoff by 60% to 100%, depending on the type of green roof system. Through field experiments, Ahmad et al (2006) claim that the green roofs method could reduce peak flow and its magnitude, improving the water quality through soil infiltration and seepage process. The experiments also note that the rainfall of 8.9mm is considered as a threshold value of which the green roof can store rain water. Green roofs will

prevent storm water from overwhelming the city's sewer system by storing and delay the water runoff, which tends to flood over during heavy storms and allowing untreated sewage to flow into the river. This implies that a green roof method is the best management practice for storm water discharge.

2.2.1.4 Improving air quality

Plants can filter out particulate matter and gaseous pollutants in the air (Getter and Rowe, 2006). Plants absorb carbon dioxide and release oxygen into the atmosphere through the photosynthesis process, thus improving the air quality. Studies on the effect of green roof towards improving air quality have been done. As cited in Getter and Rowe (2006), a German study demonstrated that green roof vegetation can significantly reduce diesel engine air pollution (Liesecke and Borgwardt, 1997), Yok Tan and Sia (2005) found a 37% and 21% reduction of sulfur dioxide and nitrous acid respectively directly above a newly installed green roof.

2.2.1.5 Noise abatement

Substrate and plants contribute in absorbing sound in the green roof (Dunnett and Kingsbury, 2008). The insulation of airborne sound will improve if the green roof thickness increases. Kohler and Porche (2003) indicated that substrate depth of 20cm can improve sound absorption up to 46dB (A). According to Burke (2003) as cited in (Dunnett and Kingsbury, 2008), acoustic insulation was one of main reasons for the installation of the green roof at the Gap's 901 Cherry Hill office in California. The roof intended to reduce sound transmission by as much as 50 decibels because the building is located next to a noisy freeway and on the flight path of San Francisco International Airport.

2.2.2 Economic benefits

2.2.2.1 Roof life cycle

Green roof can extend the life of a roof when properly constructed. Growing media and plant material on top of the roof can protect the roof membrane from solar exposure and ultraviolet radiation that can damage the traditional bituminous roof membrane. A longer service life of roofing systems would mean less roof replacements during the life of the building, thereby reducing future maintenance and replacement costs (Wong et al., (2002).

2.2.2.2 Insulation and energy efficiency

In green roofs, layers of drainage, substrates and vegetation will act as insulation; therefore heat transmitted through a green roof is less compared to conventional roofs. (Wong et al,. 2003). Media depth, shade from plant material and transpiration can reduce solar energy up to 90% compared to a nonshaded building (Getter and Rowe, 2006). Air temperatures above the building have been shown to be 30 °C lower when vegetated compared with a conventional roof (Wong et al, 2003) resulting in up to 15% annual energy consumption savings. The plants can absorb large quantities of solar energy and the remaining solar energy will less impact the internal temperature compared to conventional roofs (Wong et al,. 2003). An energy consumption study has been conducted in the tropical climate of Singapore over a range of roofs. The study showed that intensive green roof could result in a saving of about 15% in the annual energy consumption, up to 80% in the space cooling load and up to 80% in the peak space load (Wong et al,. 2003)

2.2.3 Amenity and aesthetic benefits

2.2.3.1 Leisure and open space

Green roofs can play an important part in the provision of recreational areas in neighborhoods if the load-bearing capacity of the roof is sufficient and the construction of the green roof is planned for recreation use. Recreational space at the roof level will reduce problems that are normally encountered at public green spaces such as vandalism, assault and other social problems. Residential buildings especially in high density towns and cities, can apply green roof for green space provision in order to create a healthy living and environment.

2.2.3.2 Visual amenity value

An unpleasant view from building rooftops in the majority of urban areas can be diminished with addition of green roofs which can create pleasing, vigorous, sustainable native and naturalized plant communities (Velazquez, 2005). The aesthetic value of green roofs can be seen when the green roof can integrate a building into its surroundings.

2.2.3.3 Health and therapeutic value

Even though green roofs are only perceived as visual relief, the benefits may include relaxation and restoration (Hartig et al. 1991), which can improve human health. Stress reduction, lowering of blood pressure, relief of muscle tension and increase in positive feelings are the therapeutic effects of having green plants and nature around (Ulrich and Simons 1986). Higher therapeutic values appear to accrue to properties with roof or façade greening (Ulrich 1999).

2.3 Human Comfort and Behaviour in Relation to Green Building

Human comfort is governed by many physiological mechanisms of the body and these vary from person to person. In any particular environment, it is difficult to get more than 50% of the people affected to agree that the conditions are comfortable.

The principal factors affecting human comfort can be conveniently considered under personal and physical variables.(Macmullan 2002) Activity, clothing, age and sex act as the personal elements in order to give a comfortable temperature. Meanwhile, room temperature, air movement, humidity and ventilation can also affect human comfort as the physical factors. For example, the movement of air in a room helps to increase heat lost from the body by convection and can cause the sensation of draught and stress. A person experience stress when an event in the environment present a constraint. Some event in the person 's environment present an excessive physical or psychological demand. Undesrstanding stress due to the environment in an organization is important because it can have negative effects. Dysfunctional stress in an organization will led to high absenteeism rates, high turn over, reduces productivity. To the individual it is associated with increase cardiact risk and abused of drugs (Champoux 2003)

Human behavior can be defined as a collection of behaviors exhibited by human beings and influenced by culture, attitudes, emotions, values, ethics, authority, rapport, hypnosis, persuasion, coercion and genetics. Behavior of people falls within a range with some behavior being common, some unusual, some acceptable, and some outside acceptable limits. In sociology, behavior is considered as having no meaning, being not directed at other people and is the most basic human action. Behavior should not be mistaken with social behavior, which is more advanced action, as social behavior is specifically directed at other people. The acceptability of behavior is evaluated to social norms and regulated by various means of social control. Organisation and their managers have several methiods for managing employees ethical behaviour. These include codes of ethics, a written statements describing prohibited behaviour by the organization and policy guide lines which covers the ethical responsibilities of the

organisatio, employee rights, and the quality of work environment (Champoux 2003). Luthans (2005) stated in an organization climate that this feeling must be conveyed by through physical layout, the way workers interact, and the way members of the organization interact wit customers.

2.4 Managing Green Roof Building

Facility manager is a key player in implementing environmental management in the building (Hinnells, M. et al., 2008). Facility managers manage all facilities in the buildings including green roofs. According to BuildingGreen, Inc., (2001), facility managers probably manage more resources and have more impact on the environment than any other group in the world. Entire changes in direction relative to energy and environmental quality are possible through collective action of facility manager's. After the green roof has been designed and constructed, the facility manager is involved directly with the green roof in terms of management and maintenance. Their point of view in terms of benefits perceived and problems associated with green roof is very important as guidelines for future development of green roof.

3. METHODOLOGY

Two methods of primary data collection were used in this study namely field observations and interviews with the facility manager of the three selected buildings incorporating green roofs. A series of interview sessions and site visits were conducted for the three case studies to obtain information and data. The observations commenced from January 2009 and ended on April 2009. Subsequently interviews with the facility manager of the buildings were undertaken to compliment and round-up the study.

3.1 Case Study

Only three case studies were examined due to limitation of buildings that applied green roofs as a special feature in Malaysia. A healthcare building was chosen for the first case study since it would involve different categories of end-users that consist of visitors, patients, staffs and building professionals. A hospital was chosen for the case study as it was the only hospital in Malaysia that integrated 5 acres of intensive green roofs in the building design in order to cerate a therapeutic garden. A commercial building, was chosen for the second case study. This retrofitted semi-extensive green roof is provided for visitors and tenants to view at the building. A convention hall building, was selected as a third case study. The building integrated an extensive green roof as part of their roof element and special feature. The similarity for these 3 case studies is that the green roofs are managed by the facility management department. Therefore, the perceptions of the facility managers will be identified and studied. In identifying the perceptions, the benefits perceived, design features, facilities provided, problems associated and other related subjects relevant would be taken into consideration and discussed. This will also encompass how the facility managers perceived the natural environment generally. Good perceptions towards green roof can play a vital role in promoting green roofs in future development.

3.2 Field Observation

Three (3) green roof projects were selected for the case study. The case studies consisted of intensive, extensive and semi-extensive green roof in Klang Valley area. The researcher took the opportunity to examine the design, physical conditions, facilities provided, environment, problems and level of usage of green roofs. This is an observation study, therefore seeing and listening are keys to the study (Powel and Steele, 1996). The direct observation provides the

opportunity to document the information on green roofs without having to depend upon people's willingness and ability to respond to questions. The components to be observed consist of green roof design elements, components, facilities provided, consideration, level of usage and problems encountered with green roofs.

3.3 Interviews

Overall, interviews within the 3 companies were carried out. The interviewees consist of all personnel responsible for their company's facility management of that building including the green roof. The study was primarily based on thematic interviews. The interviews contained various sections such as general perception towards natural environment, the green roof perceived benefits, the facilities provided, design features, the barriers, problems and respondents' views on the future of green roofs. Interviews were conducted before and after the field observations. These interviews added substance to the case studies. Semi - structured interviews are considered as part of the research instrument to obtain the data from the respondents (facility managers). The interviews used 'open' and 'closed ended' questioning but the question were not asked in a specific order. The aim of the interview was to discover full spectrum about the green roof and issues related to the green roof.

4. RESULTS AND DISCUSSIONS

From the study, it discovered the potential of using green roof buildings in Malaysia. It promotes a range of benefits that can solve the problems of ecological steps, limitation of space, greenery balance, global warming, aesthetics and these factors have an effect on human comfort and daily human activities and behavior. In Malaysia, there is beginning demands by the public and private sector to optimize energy use, promote resource efficiency and improve indoor environmental quality and this is due to increasing public awareness in green buildings (Shafii and Othman, 2007). Increasing interest in green building strategies and sustainable development has sparked a growing interest in green roof projects.

Clement Wong (2009), with a keen interest and knowledge in green building design has applied the concept while renovating his linkhouse into a green home. A roof garden has been created as a heat insulation to cool down the building. The soil in the roof garden have been mixed with polystyrene crumbs in order to reduce the weight to the lower part. Maximum natural lighting, constant airflow, cross-ventilation and the escape of hot air from the internal space are also being applied to this green home. This project has definitely became an alternative to make linkhouses more liveable in the tropical heat, while effecting the occupant's human comfort and human behavior in a good way.

Based on the interview that have been carried out, the facility managers were optimist towards the green roofs and would like to see more green roof design as part of the building facilities. Facility managers perceived benefits of intensive a green roof are it improved air quality, reduced air pollution, encouraged biodiversity, provided leisure and functional open space, visual amenity value and health, and therapeutic value. It provides energy efficient building, reduced air temperature, storm water management, and reduced noise pollution. Research on green roof's benefits should be carried out especially on existing green roofs to stress the benefits of the approach to building owners, operators and users. The benefits should be well documented and promoted as a sustainable development. Teicholz, E. (2001) suggests that cost savings from energy efficiency is one the most easily documented benefits of green design. If the benefits are proven, the green roof will be considered in any development.

The study identify problems encountered with green roof are on the technical problems for example damage on water proofing, leaking on below structure and green roof floor level. Lack of supervision during construction especially absence of waterproofing at certain areas will

involve high cost to rectify the problems. The designer knowledge is one the factors that contribute to the problems occurred for example not provide an access for maintenance to green roofs, the required of drainage layer, root barrier and filter mats as a basic components. Observation also found that level of usage at the green roofs is very low. There is difficulty in finding the access to the green roofs in certain locations and no indication of direction to the green roofs is provided. Signage and direction play an important role to promote green roofs to the end-users. The plant selection does not suit to the soil depth, therefore the roots penetrate the flat roof slab. Lack on research technology and material availability is those factors that contribute to the problems. The variety of materials to suit to our local condition is very few since green roofs are not fully develop in this country. If the demand for green roofs is higher, more research and product on the green roof components that suit to our local condition will be produced. All facility managers agreed that they have a problem in less awareness on benefits and performance of green roofs. There was no benefit and performance measured in their green roofs. More problems occurred on intensive green roofs as the system is more complicated and has a big floor area. Less problems occurred in extensive green roofs as the system is simpler.

5. CONCLUSIONS

In Malaysia, the potential of green roofs is increasing as there is awareness on providing a sustainable built environment. Facility managers would like to see more green roofs to be part of facilities in the buildings. However, in their opinion, a few considerations must be taken into account before implementing green roofs as part of building design and facilities. At design stage are the designer and client intent, location, access, safety, plants selection and facilities provided. At construction stage are the specification and supervision and at operation stage need to have organized maintenance programme and end-user participation. The potential of green roof buildings in Malaysia is bright in view of the facility manager. If it is well constructed it perceives more benefits. It provides internal comfort and conducive environment and a saving energy building.

From the study findings, the study generally is able to create better green roofs in the future. From the interviews and observations, the respondents are optimistic towards green roof buildings. For further improvement, it is suggested that research study area are:

5.1 Comprehensive research on green roof

Research on existing green roofs from the perspective of building owners, operators and end users. Issues and benefits on environment, economic and aesthetic should be documented and published to be promoted as sustainable green development

5.2 Green roofs planning and design intent

The integration of good planning and design are essential for the success of the green roofs. Before implementing the green roofs, the clients and architects must be clear on the purpose of the green roofs. The planning and design must reflect the design intent

5.3 Providing user friendly green roofs.

User friendly green roofs are very important in designing green roofs that are intended for regular human activities. Accessibility and facilities provided must reflect the end-user expectations. Green roofs must be easy to access, disabled friendly, visible access, no obstacles such as locked entrance, and provide signage to encourage end-users to visit the green roofs. Green roofs will be neglected and abandoned if the end-users did not fully realize the potentiality.

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