The effect of green roof on improving the environmental efficiency for the residential buildings in Baghdad city

Susan Abed Hassan¹, Saad Ismail Husain²

¹ Department of Architectural engineering, College of Engineering, Al- Nahrain University-Iraq
² Renewable Energy and Environment Research Center, Ministry of Industry and Minerals, Iraq

suzana302002@yahoo.com

Abstract: Previous studies had proposed the environmental advantages of green roofs applications for the cities. This research investigated the effect of the green roof on improving the environmental efficiency for the residential buildings in Baghdad city as an example for hot aired climate. The research studied in practical applications of roof planting which represented by planting pots with Ficus plant on special desks designed contained the pots on the same type of traditional roof type, and compares it cooling loads and thermal properties with a traditional roof for a residential building. The results showed that cooling energy lost for green roof were lower in about 64% as compared to traditional roof. Also the recorded temperatures for the interior roof surface and the air temperature for the green roof were lower by 8 °C in summer months as compared to the traditional roof, while the green roof were moderate temperatures in about 3 °C for winter months.

1. Introduction

Building Rooftop receives large amount of environmental effects, such as solar radiation, air temperatures, humidity, etc. Previous literatures had studied many proposed environmental treatments to increase the environmental performance efficiency for the buildings envelop including what had been presented with proposals to change the type of roofing or the addition of thermal insulation with materials available in Baghdad city such as the study presented by [1,2] or by covering the exterior surface of the roof with layers of soil and grass to reduce fluctuation variety of the top face of the roof in the city of Antananarivo [3]. While research in AL-Najaf city found that intensive green roof can reduce thermal loads by 1.6 in average for covering ratio 39-20%, 3 °C for 40-59 %, and 3.9 °C for 60 %.[4] In the same context research studied the effect of the vegetation for roof and walls on urban temperatures and humidity for diverse climates (dry, humid, and arid) and for different urban canyon geometries. The result of research found that the magnitude reached to 10.0 for the air layer at 4m height [5]. Although of the wide spear of the researches in the world for the benefits of the green roof [6,7,8], but the study of the effect of
green roof on improving the environmental efficiency for the residential buildings in Baghdad city were never done before statically.

2. The importance and benefits of green roof
The importance and benefits of green roofs are economic, environmental and social aspects:-

2.1 Environmental benefits
- It contributes effectively to reduce the high temperatures of the surfaces in the summer and soothes the low temperatures in the winter.
- It contributes to increasing green areas in cities, especially those that lack green areas to a great extent.
- It contributes to reducing environmental pollution as it filters the air by absorbing carbon dioxide and releasing it to the atmosphere. It also works as a collector of air dust on it, so it cleans the atmosphere from dust and dust. It reduces fog, soothes odors, reduces wind protection.
- It is an area of life for small creatures, making up for the land that was used as a building. It is considered a shelter for birds.
- Green roofs use recycled materials in their layers, thus being environmentally friendly.

2.2 Economic Benefits
- Reducing the cost of cooling and heating for buildings and achieving energy efficiency
- Green roofs can be used to grow vegetables and fruits cleanly and safely and become an economic resource and a source of livelihood.
- Reducing the effects of environmental changes on cities, and thus reducing electrical energy consumption.
- It absorbs and stores rain water and converts it into a good climate and regulates the humidity of the place and keeps the movement of water vapor in the air in its natural cycle and reduces the need for drainage and increases

2.3 Social benefits
- Aesthetic social benefits in improving the roof view of buildings and transforming them into green gardens.
- The green garden on the roof is an outlet for the residents of those buildings, where the residents feel psychological comfort, because of its aesthetic.
- Reducing noise levels and its negative effects on those who live in the building.
- The possibility of providing vegetables to the city by planting roofs.

3. Methodology
To discover the research hypothesis, practical applications were arranged to achieve the research goal. The selected house sample was at AL-Jameai district in Baghdad city. Two external rooms were used on the first floor with the same dimensions (4 * 6 * 3) m and had a southern facade to conduct a study of comparing the temperature therein, as the first room covered with traditional roofing represented by (40mm precast concrete tile, 40mm sands, 100 mm river sands, 20 mm tar, 150 mm concrete slap, and 20 mm plaster) with U- value 0.885, the green roof represented by planting pots with Ficus plant on special desks designed contained the pots on the same type of traditional roof type the calculated U- value 0.321 depended on the soil of the plant pots without
the green leaf of the Ficus cause it variable value form on plant to another. Figure (1) showed the experimental test roof. For the purpose of emphasizing making the conditions of both rooms identical, they were evacuated from furniture and electrical appliances, and the two rooms were not provided with any electrical cooling method such as an evaporative cooler, air conditioner, or electric fans. In each case, the Cooling energy lost in kWh/year/m² were calculated to discover the different in cooling energy lost. The Degree day for Baghdad city were calculated Based on recent research [1], for 5 recent year with different base temperature (17,18,19,20,21,22,23,24,25, and 26) °C. Also the temperatures were recorded for the interior roof surface and the air temperature for the two rooms, in all months of the year, and an electronic multi-point scale was used to record the temperatures in several hours of the day, and several specific points were represented at the beginning, middle and end of the two rooms. Then extract the average temperature for each month and make a temperature comparison for both rooms.

Fig 1. The showed the roof planting pots with Ficus plant
4. Results

4.1 Cooling energy lost

A comparison for degree days for Baghdad city was made between different base temperatures 17, 18, 19, 20, 21, 22, 23, 24, 25, and 26 °C for the periods between (2012-2017) yeas are shown in Figure (2). Consumed cooling energy lost for the green and traditional roofing types according the relationship between degree days and the thermal loss for building envelop is expressed in the equation (1):

\[
\text{Cooling Energy Lost} = \left( 24 \times \text{CDD Annual} \times U \right)/1000 \text{ kWh/year/m}^2
\]  

(1)

The results of comparative cooling energy lost for both roofs are expressed in Table (1) and Fig. (3).

Fig 2. The showed the degree days for Baghdad with different base temperatures (2012-2017)

Table 1. Cooling energy lost in kWh/year/m² for traditional and green roof according to different base temperatures

| Base T. | Traditional roof | Green roof | Cooling energy lost kWh/year/m² |
|---------|------------------|------------|---------------------------------|
|         |                  |            | 26                              |
| 17      | 67.7             | 24.9       |                                 |
| 18      | 63.4             | 23         |                                 |
| 19      | 58.4             | 21.1       |                                 |
| 20      | 53.5             | 19.4       |                                 |
| 21      | 49               | 17.7       |                                 |
| 22      | 44.5             | 16.1       |                                 |
| 23      | 40.3             | 14.6       |                                 |
| 24      | 36.4             | 13.2       |                                 |
| 25      | 32.5             | 11.8       |                                 |
| 26      | 28.9             | 10.5       |                                 |
Fig 3. The results of comparative cooling energy lost for green and traditional roofs

4.2 Thermal temperatures
The recorded average temperatures for the interior and exterior room of green and traditional roofs surface for summer months are expressed in tables (2,3). The results showed that that green roof contributed to decrease temperatures in hot summer months and moderate temperature in the winter months. The rate of temperature reduction for the green roof of the building reached to 8 °C degrees in the summer compared to the traditional roof, The rate of raising the building temperature for the green roof of the building reached to 3 °C degrees in the winter compared to the traditional roof, the results of comparative average temperatures for both roofs in summer months as shown in Figure (4).

Table 2. Average Temperatures for traditional roof in summer months

| Hours | October | August | July  | June  | May   | April |
|-------|---------|--------|-------|-------|-------|-------|
| 0     | 30      | 35     | 32    | 30    | 29    | 22    |
| 2     | 30      | 34     | 32    | 30    | 29    | 20    |
| 4     | 30      | 33     | 32    | 30    | 28    | 20    |
| 6     | 35      | 35     | 32    | 32    | 27    | 21    |
| 8     | 35      | 40     | 33    | 32    | 29    | 25    |
| 10    | 40      | 42     | 35    | 35    | 32    | 26    |
| 12    | 42      | 45     | 40    | 36    | 33    | 28    |
| 14    | 43      | 44     | 42    | 40    | 35    | 30    |
| 16    | 43      | 42     | 45    | 40    | 32    | 30    |
| 18    | 40      | 40     | 40    | 40    | 30    | 25    |
| 20    | 35      | 40     | 33    | 29    | 30    | 20    |
| 22    | 30      | 38     | 33    | 28    | 30    | 18    |
Table 3. Average Temperatures for Green roof in summer months

| Hours | October | August | July | June | May | April |
|-------|---------|--------|------|------|-----|-------|
| 0     | 23      | 25     | 25   | 25   | 25  | 18    |
| 2     | 23      | 26     | 26   | 25   | 25  | 18    |
| 4     | 24      | 27     | 27   | 25   | 25  | 15    |
| 6     | 25      | 27     | 27   | 25   | 25  | 15    |
| 8     | 25      | 27     | 27   | 26   | 30  | 18    |
| 10    | 25      | 27     | 27   | 26   | 30  | 18    |
| 12    | 25      | 30     | 30   | 26   | 30  | 18    |
| 14    | 25      | 30     | 30   | 27   | 30  | 18    |
| 16    | 23      | 30     | 30   | 27   | 29  | 18    |
| 18    | 22      | 26     | 26   | 27   | 29  | 18    |
| 20    | 22      | 26     | 26   | 25   | 29  | 18    |
| 22    | 22      | 25     | 25   | 25   | 29  | 18    |

Fig 4. The results of comparative average temperatures for both roofs in summer months

5. Conclusions
The results of the research showed that the environmental efficiency of the building is increased by adopting green roof compared to the traditional roof. It contributed to a decrease cooling energy lost for about 64% as compared to traditional roofs. Also it contributed to lowering the temperatures of the building in the hot summer months by 8 °C and a moderate temperature in the winter months. The rate of raising the building temperature for the green roof of the building reached to 3 °C degrees in the winter compared to the traditional roof. The roofing type method by
planning pots with Ficus plant on special desks on the traditional roof type in the green plant modules provided the ease, simplicity and economy of installation and construction compared to other methods adopted in green roofs.

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