



فصلنامه مدیریت شهری  
(ویژه نامه لاتین)

Urban management

No.43 Summer 2016

■ 337 - 352 ■

Received 23 Jul 2015; Accepted 11 Feb 2016

## **The Green Future: Architecture + Sustainability; Green Architecture and Impacts of it on Urban Planning and Urban Design**

**Seyed Amir Yazdani** -*Department of Architecture, Mahdishahr Branch, Islamic Azad University, Mahdishahr, Iran*

**Hadi MahmoudiNejad<sup>1</sup>** -*Department of Architecture, Mahdishahr Branch, Islamic Azad University, Mahdishahr, Iran*

### **Abstract**

Green architecture, or green design, is an approach to building that minimizes harmful effects on human health and the environment. The “green” architect or designer attempts to safeguard air, water, and earth by choosing eco-friendly building materials and construction practices. So, green architecture is Building and structure design philosophy that aims at minimal use of non-renewable and/or polluting materials and resources in construction and use of a facility. Today, architecture finds itself at a crossroads. Building materials and new construction, along with the operation and maintenance of buildings, account for a significant sum of the world’s greenhouse gas emissions. Faced with this fact, how are architects to responsibly pursue the act (and art) of building without further deteriorating the planet’s environmental make-up or depleting its resources? What forms of high and low technology can be developed to curtail the injurious side of building? Can good or even great architecture be sustainable? In this paper discuss the problem such as: The Future Is Green: Architecture + Sustainability and have been surveyed Green Architecture and impacts of it on urban planing and urban design.

**Key words:** *sustainable development, green roof, green wall, green architecture consumption*

1. Corresponding Author, Tel: 09131970806, Email Address: hadi\_urban@yahoo.com

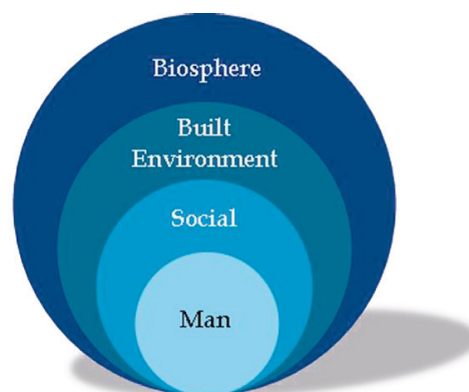
## Introduction

Introduction Urban sustainability is one of the urgent challenges of the 21st century (Wu, 2014), since more than 50% of the world's population live in urban areas, and this figure is estimated to reach 66% by 2050 (UNDESA, 2014). Continuously spreading cities and the growth of intensive agriculture are the major causes of habitat loss and fragmentation worldwide (Grimm et al., 2008). However urban greenspaces can play a key role in biodiversity conservation (Goddard, Dougill, & Benton, 2010) and enhance urban ecosystem resilience (Colding, 2007). In particular, green roofs can partially compensate for the loss of green areas by replacing impervious surfaces, contributing to an increase in urban biodiversity (Brenneisen, 2003, 2006). In fact, by replicating specific habitat features and conditions, these artificial biotopes can host native flora and fauna in can become established (Köhler, 2006; Kadas, 2006; Baumann, 2006). The first known study on the biotic colonisation of green roofs dates back to 1940, when Kreh (1945) listed the plant species colonising some tar-paper-gravel roofs in Stuttgart, Germany. This roofing technique was developed at the beginning of 19th century in Silesia and consisted of a combination of tar and four layers of paper covered by a mixture of gravel and sand (Köhler and Poll, 2010). In Kreh's study (1945), species were categorised according to the following functional group: bryophytes, CAM (Crassulacean Acid Metabolism) species and therophytes, substrate depth preferences (5–20 cm), pollination and dispersal strategies. Even if several studies and researches have demonstrated that green roofs significantly contribute to energy saving, indoor thermal comfort, urban heat island mitigation, rain-water management and air pollution reduction, environmental benefits of green roofs mainly depend on use of primary energy, natural resources or raw materials used in the construction. Today, because of the negative consequences of the industrial world, such as pollution, natural

resources depletion and energy crisis; green architecture in the cities is an effective step to minimize the negative effects of buildings on the environment to align with nature. In a green city, the energy of nature is harnessed and used the best in urban structure and buildings, so in a green building it is tried consumable materials do not harm the environment and have the capability return to the cycles of nature; also placement of green buildings must be done simultaneously with a green urban design. Such a city; promote the well-being of residents and the highest quality of human life can be achieved which led to the emergence of sustainable urban as well. (Kamel Nia et al., 1393). Green architecture may have many of these characteristics:

1. Ventilation systems designed for efficient heating and cooling;
2. Energy-efficient lighting and appliances;
3. Water-saving plumbing fixtures;
4. Landscapes planned to maximize passive solar energy;
5. Minimal harm to the natural habitat;
6. Alternate power sources such as solar power or wind power;
7. Non-synthetic, non-toxic materials;
8. Locally-obtained woods and stone;
9. Responsibly-harvested woods;
10. Adaptive reuse of older buildings;
11. Use of recycled architectural salvage;
12. Efficient use of space.

While most green buildings do not have all of



▲ Fig 1. The relationship between human perception with social value and built environment factor; source: authors.



▲ Fig 2. Off Grid Home in Extramadura (2013 A+ Jury Prize); Cáceres, Spain; Designed by ĀBATON & Fig 3. Caterpillar House (2013 A+ Awards Special Mention); Carmel, California; Designed by Feldman Architecture.

these features, the highest goal of green architecture is to be fully sustainable.

Modern green roofs can be classified as intensive, extensive and simple-intensive (German guidelines; FLL, 2008). Extensive greenroofs consist of a shallow substrate ranging from 6 to 15 cm, planted or sown with drought tolerant plant species, and require low maintenance; intensive green roofs consist of a >20 cm thick sub-strate (normally top-soil), planted with woody and/or herbaceous species, and generally require irrigation and high maintenance; and simple-intensive green roofs can be seen as an intermediate roof type, consisting of 15–20 cm thick substrate (including top-soil), hosting perennial grasses and tall herbaceous species, and requiring medium maintenance. Green roofs are considered as a solution to many urban issues including urban heat island mitigation, noise and air pollution reduction, storm-water management and support of biodiversity and are quite often addressed as the best building choice to increase the environmental sustainability in an urban setting. Recent initiative at European level (CEN TC 350 WG1) also promote a benefit for those building covered by a green roof as a reduction in Land use impact. Generally speaking, it is now quite clear that green roofs can be used to reduce or mitigate issues as urban heat island effect, water runoff, air and water quality (Liu et al., 2003; Wong et al., 2003). Most of the reasons that stop building owners in building a

green roof lay in the idea that beside the initial costs, cost form maintenance of green roof during the life cycle of the building are quite high. In fact, some studies have demonstrated that intensive or deep soil roof systems have a higher life cycle cost (LCC) than conventional practice (Wong et al., 2003), but this is not always true for extensive green roof system that might cost less than a conventional roof.

Introduction Green roofs are intentionally vegetated areas of roof. In the last ten years they have become much more common in urban areas due to the numerous benefits (green roof services) they offer (Getter and Rowe, 2006; Oberndorfer et al., 2007). These include: increased stormwater retention (Berdntsson, 2010), reduced urban heat island effect (Bowler et al., 2010; Santamouris, 2014), moderated building temperature (Jaffal et al., 2012), air pollutant retention (Speak et al., 2012) and urban wildlife habitat creation (Getter and Rowe, 2006; Oberndorfer et al., 2007; Dunnett and Kingsbury, 2010). The most common type of green roof, known as an extensive green roof, has a relatively shallow layer of substrate (50–120 mm) in which hardy plants are established (Oberndorfer et al., 2007). Due to their exposed roof location and shallow depth, plants are often exposed to extremes of temperature, moisture, sunlight levels and wind shear (Oberndorfer et al., 2007). In addition, substrates used on green roofs also have low organic matter levels (5–20%) to discour-

مدیریت شهری

فصلنامه مدیریت شهری  
(ویژه نامه لاتین)  
Urban Management  
No.43 Summer 2016

■ 355 ■

Pitched roof	Extensive Green roof HD	Extensive Green roof LD	Intensive Green roof HD	Intensive Green roof RC
	Sedum	Sedum	Sedum	Grass
	Medium A 80 mm	Medium B 80 mm	Medium C 150 mm	Medium D 150 mm
Clay roof tiles	Filter layer	Filter layer	Filter layer	Filter layer
Ventilated air cavity 60 mm	Drainage/insulation layer	Drainage/insulation layer	Drainage/insulation layer	Drainage/insulation layer
Thermal insulation EPS 80mm	EPD 80mm	EPD 80 mm	EPD 80 mm	EPD 62 mm
	Root barrier	Root barrier	Root barrier	Root barrier
Light concrete screed 40 mm	Light concrete screed 40 mm	Light concrete screed 40 mm	Light concrete screed 40 mm	Light concrete screed 40 mm
Clay blocks floor slab 160 mm	Clay blocks floor slab 160 mm	Clay blocks floor slab 160 mm	Clay blocks floor slab 160 mm	Clay blocks floor slab 160 mm
Plaster 15 mm	Plaster 15 mm	Plaster 15 mm	Plaster 15 mm	Plaster 15 mm

▲ Table 1. Roof types used for the life cycle assessment (LCA).

age excessive plant growth and weed invasion (Ampin et al., 2010; Nagase and Dunnett, 2011).

Our cities in the past were themselves the best examples of sustainable models. Attention to ecological limitations like place of water, proper development and compatible with nature, saving resources, use of local materials, innovation of effective and suitable methods to survive, such as aqueducts, windcatcher, artistic use of water and plants to soften air and creating pleasant landscapes and creating gardens in yards, public spaces were all examples of effective factors in this sustainability. But today by following the classical models of development and blindly following of the stereotypical models of urban development which does not respect local conditions and characteristics and sustainable urban development, Not only has created unstable conditions in cities but also led to the surrounding instability (Kameli et al., 1393). So the design of new towns with green architecture approach can be an effective step to protect natural resources

and improve the quality of desirable urban life (Kamel Nia et al., 1393).

### Green Architecture

#### Criteria for Green Architects

Architects who style themselves as green, will have the standard degrees in architectural design and practise, and may have taken additional qualifications to demonstrate their green or environmental knowledge. However, the most important sign of an architects competence in green matters, is their skill and experience. It is one thing working with the environment and the planets ecology, but listening to a clients needs and translating them into a workable design plan is the crucial matter. To be sustainable in all matters relating to the design; from initial consultation, through to site visit and early designs, right through to liaison with builders and if necessary, plan modification. The architect that anyone considering a green building chooses, must be able to demonstrate this, through their portfolio and their approach. Do ask if it is possible to visit any previous projects the architect has worked on, to really get the feel of their eye for work and environmentally friendly detail.

#### Some Aspects of Green Architecture and Design

An architect should be able to tell and advise a client what makes a building energy efficient. The architect should also be able to translate the clients ideas into reality, using both common architectural sense, and the most up to date technology and methods. This might include solar panels, thermal mass building construction, green materials, including wood, stone, or earth (or even recycled waste materi-



▲ Fig 4. General constraintsof greenroof according to public perspective, source: authors.



Green Architecture Features	
Energy-efficient lighting and appliances	Right enjoyment of energy
Planning for the use of solar energy in design in terms of energy and the environment	
Water saving plumbing	
Water and protect it in green architecture	
The use of alternative energy sources such as wind energy and solar energy	
Design and applying of effective natural ventilation systems	Compatible with the climate
Use non-toxic and non-artificial materials in everyday use of materials and resources	Reduce the use of undesirable sources
Reducing environmental pollution	Respect the users
	Quality of indoor designed
Minimizing damage to natural habitat Sustainable site design, the main principles of green architecture	Respect the site
Reusing old buildings	Holism
The use of recycled materials of architecture	
Efficient use of space	

▲ Table 2. Green Architecture Features

als, such as tyres or glass or plastic bottles). It is both the design and the construction which can make a building truly sustainable and green, and the architect should pay careful attention to both aspects of the entire process. On a site visit, a green architect should pay close attention to the environment that the potential building site is located within. This should guide the architect in their design, with an intention to respect the immediate ecology of the area, and for a prospective new green building to be in harmony with this. In the case of an existing building, or a building to be constructed on a so-called brown field site, which is usually in an urban area, where often industrial or residential properties are or have been demolished; the architect should pay particular care to what already is on the site, and how it has been used and treated. Green architecture can be wonderful examples of the possibility of humans living harmoniously within the environment. The opportunities exist to design

beautiful, energy efficient and environmentally friendly residences and workplaces that demonstrate our human ability to adapt to and peacefully live within the ecology of the natural world. As time moving, landscape is evolving where the application is not only on the ground but also on the building's rooftop that known as a green roof. Green roof is defined as a roof covered with vegetation (Study on Green Roof Application in Hong Kong, 2007; Tan & Sia, 2008; Niekerk et al., 2011; The GRO Green Roof Code, 2011). There are two types of green roof, which are extensive and intensive. green roof is recognised as a roof garden. According to Rahman et al., (2013), the number of a roof garden in Green architecture is known more with the term sustainable architecture, a macro term which describes techniques in architectural design. This approach is along with environmental attitudes which have been shaped based on the idea of respect for nature. Although green architecture is actually

not a new trend and has existed fundamentally in many ancient civilizations and traditional architectures including traditional Iranian architecture. Green architecture or green design is defined as an approach that seeks to reduce negative and harmful impacts on human health and the environment. Green architecture is trying to protect from the weather and the earth by choosing environmentally friendly building materials and proper construction methods. Studies show that green architecture may have the following features:

Although may be a lot of green buildings do not have all of these features; however, this is the highest goal of green architecture to be compatible with the environment ([www.architecture.about.com](http://www.architecture.about.com)). Green architecture is in search of a way to minimize the negative impact of buildings on the environment and tries to be in harmony with nature through increasing the efficiency and optimization the consumption of materials. Thus green architecture is along with nature, harnesses the energy existing in it and uses it in the buildings the best (Jafari et al., 1390).

Green design is an action for solving problems during which natural resources received the least damage possible before, after and during the process of production. Moreover materials should be useful in the course of this operation, have long shelf life and can return to the cycles of nature. utilization of materials with long life seems to be useful and yet, be the biggest obstacle against extravagance and waste. Some believe that more life and durability of materials qualitative is better than reuse and recycling them because recycling requires obviously the use of time and energy and possible pollution can not be removed completely.

To sum up this topic it should be noted Since resources are already declining, the main concern of architects and building experts should be searching for a solution for the future.

Heat transfer through conventional or green roof is unsteady and depends on short- and

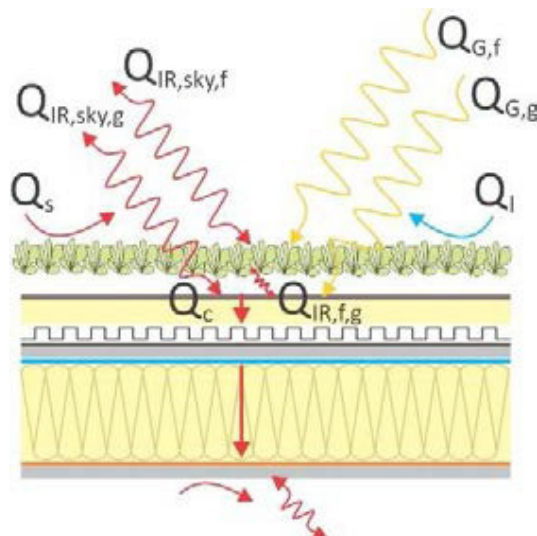
long-wave radiation, air temperature difference and heat accumulation in roof construction as well as moistened green roof growing media. It can be determined considering one-dimensional transient conduction within roof construction, green roof drainage and growing media coupled with energy balance equation for outer roof surface. For the green roof heat and mass transfer model a coupled heat balance equations are formed for the foliage (vegetation) layer (Eq. 1) and for the green roof growing media surface (Eq. 2). Green roof energy balance equations take into account the main heat fluxes that influence thermal response of the roof construction as it is shown in Fig.1: global solar radiation absorbed by the foliage  $Q_{G,f}$  and the growing media  $Q_{G,g}$ , long-wave radiation exchange between the sky and the foliage  $Q_{IR,sky,f}$  or growing media  $Q_{IR,sky,g}$  as well as between the foliage and the growing media  $Q_{IR,f,g}$ , foliage sensible heat flux  $Q_s$ , latent heat flux by evapotranspiration  $Q_l$  and conduction within growing media  $Q_c$ .

In the presented green roof model a heat accumulation in the foliage layer is neglected. Sensible heat flux is determined with equations presented in which takes into account leaf area index LAI, aerodynamic resistance to heat transfer and leaf-air temperature difference. Latent heat flux is determined from the evapotranspiration rate  $ET$ , which is calculated using FAO Penman-Monteth equation for hourly or shorter time steps.

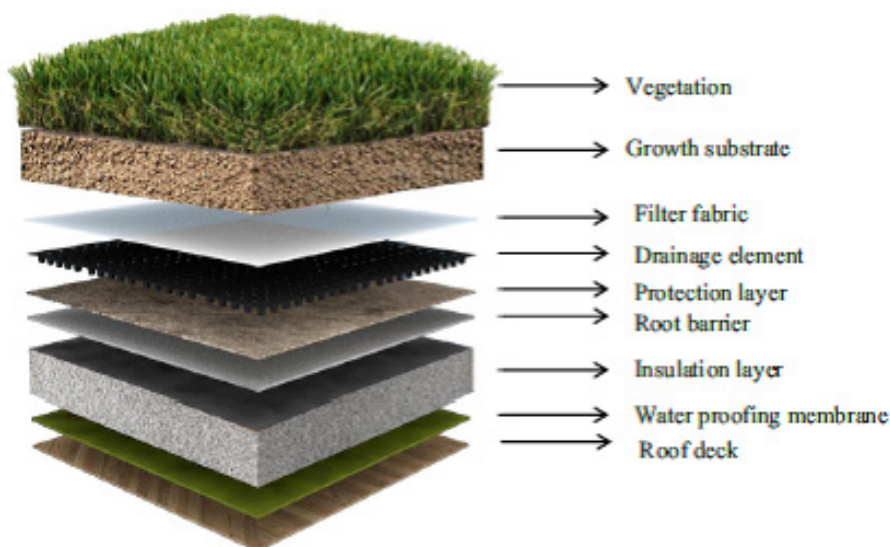
Design experts should expand their expertise and activities in this field so that the resource is protected and be the supporter of posterity and future generations. Looking at the past shows green process has always existed in architecture. The only new subject is understanding that green architecture is the most favorable solution for modern buildings that should be considered in building design, so that all resources applied to building, its materials, objects or the fuel used by the inhabitants be along with each other and in the direction



▲ Fig 5. Schematics of proposed green home.  
The goals of green architecture



▲ Fig 6. Energy balance of a green roof; sources: Farrell, C., Mitchell, R.E., Szota, C., Rayner, J.P., Williams, N.S.G., 2012.  
 $Q_G f + Q_{IR\ sky\ f} + Q_{IR\ f,\ gm} - Q_s - Q_l = 0$  (1)  
 $Q_{G,\ g} - Q_{IR,\ sky,\ gm} - Q_{IR,\ f,\ gm} - Q_c + Q - Q - Q = \nabla Q$  (2)



▲ Fig 7. Schematics of different green roof components.

of establishment of sustainable architecture (Zohouri et al., 1390).

### The green wall

Using the technology of green wall which is of the advanced green space techniques, despite difficulties in implementing and construction is economical in many ways and can be a good alternative for urban parks. living walls are combination of panels with pre-planted vegetation which are installed with the distance to the building façade vertically and by

the structure style system or are independently self-standing. Living walls can also be used in interior spaces and have different implementation details depending on the manufacturer, the gender of panels and its exterior or interior type. Living wall Compared to the green façade is complex and more costly system and needs more attention in terms of irrigation and providing additive nutrients for plants. One advantage of living walls is the diversity of its plants. Another benefit is its covering



and pre-planted plants that reach faster the desired result in terms of ultimate plant growth. Living walls are divided into two types: passive and active.

“Also on the basis that the plants in living walls have major role in indoor air purification or not, the living walls are divided to two general categories of passive and active living walls. In active living wall plants have an effective role in air purification and for this reason specific tools such as small fans are used to for moving air around the plants in order to increase their function. In this type of wall growth medium is usually hydroponics. In passive living wall plants have little role in air purification and their growth medium is hydroponics or semi-hydroponics” (Johnston, J, Newton, J. 2004)

Physical characteristics of the wall that must be considered when designing:

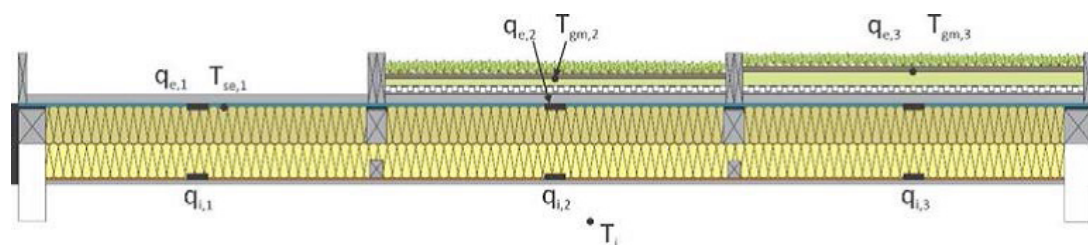
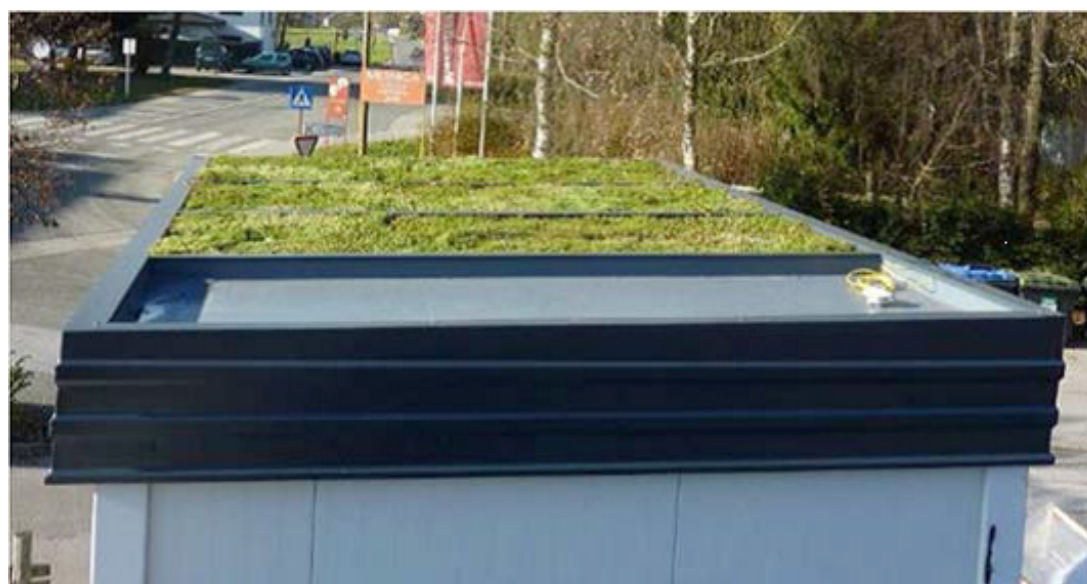
• **Orientation:** northern and southern sides of the wall have different conditions in term of

light and heat. Also if a part of the wall is in the shade of trees or other buildings, vegetation will grow differently.

• **Wind:** green walls at lower risk against the storm than walls made with other materials. in places that much wind blows, protective network is required that well be screwed to the wall.

• **Weight:** some information should be gained about the additional burden that the structure can tolerate before installing green wall.

• **Insulation:** Green Walls should be connected by style structure and with the distance to the facades of buildings. An architect or a civil engineer should ensure the integrity of the building façade and the possible need to the insulation the facade walls and if necessary, before installing green wall, repairment, preparation and insulation is done (Johnston, J, Newton, J. 2004).



▲ Fig 8. Lightweight extensive green roof modules on the flat roof of thermostated building; Reference flat roof and two green roofs with 2 cm and 4 cm thick lightweight mineral wool growing media with indicated measured temperatures and heat fluxes; sources: Farrell, C., Mitchell, R.E., Szota, C., Rayner, J.P., Williams, N.S.G., 2012.



## Green Roof

The term green roof refers to the a portable system which is composed of pre-fabricated layers and created a single system with roof. And enables the growth of plants in particular growth medium, in all or parts of the roof. Planting layer of green roof is different from the ordinary soil and needs less depth for growing different plants and is much lighter. Layers forming the green roof from top to bottom usually consists of vegetation, growth medium or planting layer, stabilizers and root protector; drainage layer, aeration and water storage; protective layer of moisture, insulating to protect the constructive layers of the roof. (Qyabkly, 1388) Green roofs, depending on the depth of the planting layer, plant type and amount of required facilities are divided into three groups:

1- Extensive green roof: Requires minimal installation, maintenance and thus lower cost. This type of the green roof has planting layers between 5 and 15 cm and therefore is lightweigh entering little load on roof. Often there is no need to modify the structure of the building due to the lightness of extensive green roof and is more suitable for existing buildings. Extensive green roof depending on depth of the planting layer, increases the roof weight between 70 to 170 kgas saturated with water. Extensive green roof can be used both on flat roofs and steep, up to 30%. The only limitation of extensive roof is the type of implantable plants that plants with short roots. Should be used. Wild flowers, lawn, Sodom and moss species, and a variety of plants that require less care and watering are suitable for planting in extensive roofs.

2- Intensive the green roof: It has thicker planting layer and therefore there is no limitation in terms of vegetation choice. there can be used a variety of plants, shrubs and trees that are implantable on the ground. Planting layer thickness of intensive green roof varies from 20 to 60 cm. Intensive green roofs need for maintenance, irrigation and other conventional care

of green spaces on the ground and because of the heavier weight, should be built on roofs that their structure have more bearing capacity or the building has capacity of strengthening to accommodate the additional load. Intensive green roofs as saturated with water, add 290 to 970 kg load to the roof. The best option for this type of green roof is implementation of it on new buildings and considering the extra load on the roof in preliminary designing and calculations.

3- Typical the green roof: It is actually a combination of extensive and intensive roofs. Recently prefabricated models enter the market of this technology that requires no infrastructure and are implemented on every roof and balcony. These prefabricated components with diverse and pre-planted vegetation are offered from different plants to trees and shrubs. Psychological research on the impact of plants on human behavior suggests that contact with nature and enjoy its beauty is a simple way but important to relax and soften the human spirit and its abundant development in collective residential complexes could reduce violence, depression, suicide, etc. (Johnston, J, Newton, J. 2004)

## Green wall and roof in Iran

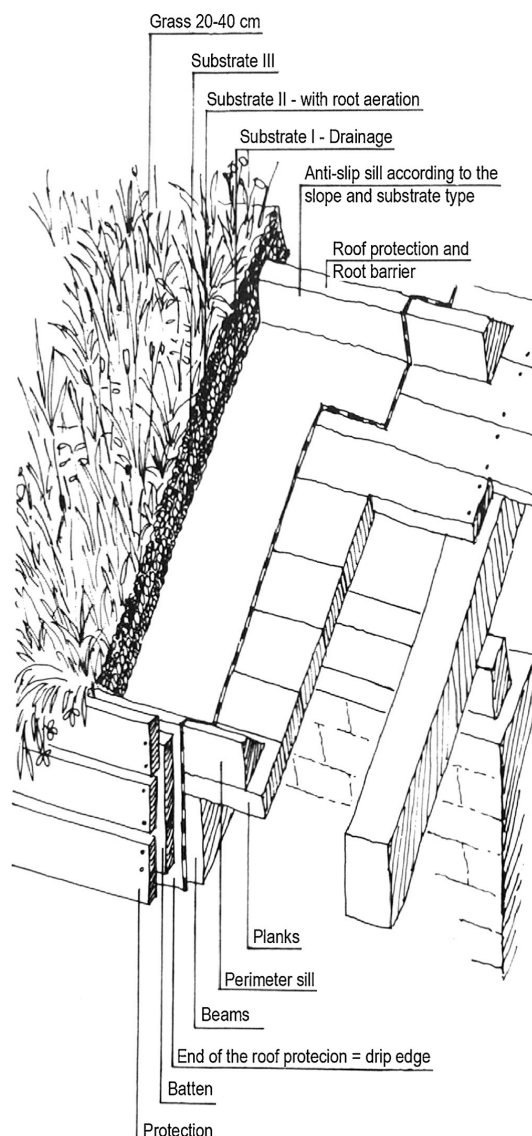
Use of capacity of building façade and roofs for creating green space, along with the international community aas attracted the attention of Tehran Municipality. According to available physical resources for the development of green space of Tehran, the projec of “determining the cost of encouraging services and economic indicators to attract and participation of citizen in creation and development of green space on the body and unused spaces of the buildings in Tehran” is also located in the municipality of Tehran. Due to limitations of existing physical resources for development of green space of Tehran, the projec was approved at the meeting of Tehran’s City Council and according to a single article of the project, Tehran municipality was obliged to act to develop the green space both vertically and

مدیریت شهری

فصلنامه مدیریت شهری  
(ویژه نامه لاتین)

Urban Management  
No.43 Summer 2016

■ 361 ■



▲ Fig 9. Detailed sketch of system Minke used in investigated roofs (after Minke & Witter, 1983, p. 42, modified).

horizontally to the body of unused buildings and eligible spaces of the urban places (public, private). (Fazelbeygi, 1386).

Given the historical background using mud brick and in Persian architecture, moss, lichen and a variety of herbaceous plants on the roof of buildings in different regions such as Azerbaijan, Gilan and Mazandaran roof of mountainous home and villages can be seen traditionally from long ago. Very good example of that, the Masoulch is Village houses where the roofs of lower houses act as a yard for the uppers. Due to the high value added of land in major cities in Iran and consequently the verti-

cal growth of these cities, limited green space according to international standards of urban green space per capita, and its unjust distribution at the neighborhood level, the use of green roof technologies on the roofs of these cities seems to be a good choice. According to article 19 national building regulations concerning energy saving and the benefits of green roofs in the field of energy saving and thus sustainable urban development, planting the roofs can act in line with the policies of national construction. Also, given that in the Fourth Development Plan, a core called "green government" has been identified and discussion of energy saving and the creation of environmental culture has been proposed, roof planting could pave the way for achieving the objectives of green government. Fortunately, the use of capacity of building façade and roofs for the construction of green space recently attracts urban management attention and the Department of Parks and green spaces, according to the value added and scarcity of land in large cities, has provided a project using capacity of building facades and rooftops in order to develop the urban green space. roof planting requires research and implementing pilot projects to adapt this technology at the local level is green. Research on the type of implantable plants on the roofs of cities across the country with different climatic conditions, how to transfer this technology, studies related to regulating green roofs project by the municipality are of the issues that can be addressed along with the establishment of pilot projects and modeling associated with green roofs. In addition to Europe and America, Asian countries such as Japan, Singapore, South Korea, UAE, Turkey, Hong Kong by matching the green roof technology at the local level, defining new standards in construction, approving applicable laws by the government and allocation of subsidies to municipalities, are taking steps towards further expansion of green roofs.



## Types of Green Roofs

### Extensive Green Roofs or Ecoroofs

Typically 3-6 inches deep with a saturated weight of 15-30 lb/sq.ft. They are ideal for the growth of drought-tolerant plants, particular succulents like Sedum. They don't need irrigation and only little maintenance. Due to the low maintenance, they are the roof of choice for building owners looking to reduce costs and improve the environment.

### Semi-intensive Green Roofs

Usually 6-12 inches deep with a saturated weight of 30-50 lb/sq.ft. Whether irrigation is necessary or not depends on the regional climate and on the kind of plants that are used. Shrubs, perennials, herbs and grasses can be used on semi-intensive roofs. Maintenance is still quite labor intensive because the design of most semi-intensive greenroofs is still garden-like.

### Intensive Green Roofs

For intensive greenroofs, the growing media is fairly deep – usually more than one foot – and supports shrub and tree growth. A roof top garden or a patio is an example of an intensive roof. The saturated weight is 70 lb/sq.ft or more and irrigation is necessary in most cases. They also require a lot of maintenance, like any other well-kept garden does.

### Green Roof model in Energy Plus

As with a traditional roof, the energy balance of a green roof is dominated by radiative forcing from the sun. This solar radiation is balanced by sensible (convection) and latent

(evaporative) heat flux from soil and plant surfaces combined with conduction of heat into the soil substrate. A step forward, researchers have integrated these mathematical calculation models in the most advanced building energy simulation software in order to assess the contribution of the green roof to the global performance of the building, in decreasing total heat flow and internal overheating and consequently reducing the yearly energy bill. Currently, however, there are few design tools available to assist developers and architects in assessing the likely magnitude of energy savings associated with various implementation options. The "Green Roof" module was introduced in EnergyPlus in 2007 and it allows user to monitor various characteristic parameters of a green roof, such as the Leaf Area Index (LAI), plant height, stomatal conductance (ability to transpire moisture), and soil moisture conditions (including irrigation).

### Conclusion

Sustainability is often defined as meet present needs without risking the ability of future generations to meet their own needs. Many people are trying to achieve this goal by changing patterns of development and consumption and reducing demand on natural resources and help to maintain quality of the environment. Since the 60s, that the quality of the urban texture environment and ecological threats in major cities such as pollution, urban heat island phenomenon, energy crisis, etc. attracted the attentions, the cultivation of roofs is taken into

مدیریت شهری

فصلنامه مدیریت شهری  
(ویژه نامه لاتین)

Urban Management  
No.43 Summer 2016

363



Benefits of green roof in archicture		
For the building owner	For the community	For the environment
1. Expand roof life by two to three times; 2. Reduce summer air conditioning cost; 3. Reduce winter heat demand; 4. Storm water management tool; 5. Possibly get incentives, earn LEED credits; 6. Improve public relations; 7. Use dead space as a garden	1. Reduce stormwater runoff; Reduce city heat island effect; 2. Reduce smog; 3. Reduce noise; 4. Reduce energy demand; 5. Improve air quality; 6. Improve aesthetics	1. Prevent combined sewer overflow; 2. Reduce carbon dioxide impact; 3. Remove nitroge polution in rain; 4. Neutralize acid rain effect; 5. Provide habitat for birds and insects

▲ Table 3. green roof in archicture; sourcess: authors.

consideration this time because of its environmental benefits and as a ecological solution which itself is the characteristics of sustainable urban development. Despite numerous environmental benefits of green roofs, The high cost of implementation, installation, irrigation and maintenance of the green space in this type of roof, and briefly economic issues prevent that this new technology will find its proper place in contemporary sustainable cities. Background Green roofs are widely understood to offer stormwater management capabilities via the retention of rainfall and the detention of runoff. In this context, retention refers to rainfall that is held within the roof system and does not leave the roof as runoff; Retained rainfall may subsequently leave the roof as evapotranspiration.

### References

- 1- Kamelnia, H, Jabanpanah, S, Mortazavi, 1393, *green architecture in new cities, the first national conference on green building*, Mashbad
- 2- Kameli, M, Hosseini, b, 1393, *ecological design and sustainable urban development with the impact of green architecture, the first national conference on green building*, Mashbad
- 3- Fatima Ghani, 2012, *Issues in Sustainable Architecture And Possible Solutions*, *International Journal of Civil & Environmental Engineering Vol: 12 No: 01*
- 4- [Http: www.architecture.about.com](http://www.architecture.about.com)
- 5- Jafari, A, Mehdi Nejad, M., 1390, *green architecture, a way into the future, the first Regional*

*Conference on Civil Engineering and Architecture, Mashbad*

6- Zobouri Khosroshahi, H, Zobouri Khosroshahi, M., 1390, *green architecture, a new reading of modern architecture, Structures National Congress, way, architecture, Chalus*

7- Johnston, J, Newton, J. 2004, *Building Green guide to using plants on roofs, walls and pavements*, *Greater London Authority*

8- Qyabakh, Z, 1388, *green wall an option to reduce energy*, *Tebzan University, College of Fine Arts*

9- Fazelbeigi, M., 1386, *Evaluation of economic development indicators and environmental sustainability, our common future and a sustainable environment*, No. 429, *Etemad Melli*.

10- Sharghi, A., 1386, *green space in tall buildings, Sciences and environmental technology, Volume IX, Issue IV*

11- Amiryar Ahmadi, M., 1378, *to the humanist urban planning, processing and urban planning company*, Tebran

12- Farrell, C., Mitchell, R.E., Szota, C., Rayner, J.P., Williams, N.S.G., 2012. *Green roofs for hot and dry climates: interacting effects of plant water use, succulence and substrate*. *Ecological Engineering*, 49, 270–276.

13- Kokogiannakis G., Darkwa J., Yuan K., 2012. *Simulating the energy performance of green roofs for Ningbo's climate*. *Proceedings of 1st Asia*

14- *conference of International Building Performance Simulation Association. Shanghai, China.*

15- Nichaou, A., Papakonstantinou, K., Santamouris, M., Tsangrassoulis, A., Mihalakakou,



- G., 2001. *Analysis of the green roof thermal properties and investigation of its energy performance*, *Energy and Buildings*, 33 (7), 719-729.
- 16- Santamouris M., 2009. *Advances in Building Energy Research*, Vol. 3, 271-288.
- 17- UNI 11235, 2007. *Istruzioni per la progettazione, l'esecuzione e la manutenzione di coperture a verde*.
- 18- Werthmann, C., 2008. *Water and Green Roofs in Dry Climates – A Speculation*. Thematic Week 2: *Water and City*. Session 6: *The Use of Water*
- 19- *in the Urban Landscape*.
- 20- Wong, E., 2005. *Green roofs and the Environmental Protection Agency's heat island reduction initiative*. In *Proc. of 3rd North American Green*
- 21- *Roof Conference: Greening rooftops for sustainable communities*. Pp. 32–44. Washington, DC. 4–6 May 2005. The Cardinal Group, Toronto.
- 22- Wong, N.H., Chen, Y., Ong, C.L., Sia, A., 2003. *Investigation of thermal benefits of rooftop garden in the tropical environment*. *Building and Environment*, 38, 261–270.
- 23- MATLAB, 2007. *MATLAB version R2007b*. The MathWorks Inc., Natick, MA. Miller, C., 2003. *Moisture management in green roofs*. In: *Proc. Greening Rooftops for Sustainable Communities*, 29–30 May, Chicago.
- 24- Monterusso, M.A., Rowe, D.B., Rugh, C.L., Russell, D.K., 2004. *Runoff water quantity and quality from green roof systems*. *Acta Hort.* 639, 369–376.
- 25- Nagase, A., Dunnett, N., 2012. *Amount of water runoff from different vegetation types on extensive green roofs: effects of plant species, diversity and plant structure*. *Landsc. Urban Plan.* 104 (3–4), 356–363.
- NERC (Natural Environment Research Council), 1999. *Flood Estimation Handbook (FEH)* CD.
- 26- Palla, A., Gnecco, I., Lanza, L.G., 2010. *Hydrologic restoration in the urban environment using green roofs*. *Water* 2, 140–154.
- 27- Palla, A., Gnecco, I., Lanza, L.G., 2012. *Compared performance of a conceptual and a mechanistic hydrologic models of a green roof*. *Hydrol. Processes* 26 (1), 73–84.
- 28- Kadas, G. (2006). *Rare invertebrates colonizing green roofs in London*. *Urban Habitats*, 4(1), 66–86.
- 29- Kenkel, N. C., & Orlóci, L. (1986). *Applying metric and nonmetric multidimensional scaling to ecological studies: some new results*. *Ecology*, 67(4), 919–928.
- 30- Klotz, S., Kühn, I., & Durka, W. (2002). *BIOLFLOR—Eine Datenbank mit biologisch-ökologischen Merkmalen zur Flora von Deutschland (BIOFLOR—a database with biologic and ecologic traits of German flora)*. *Schriftenreihe für Vegetationskunde*, 38, 1–334.
- 31- Knapp, S., Kühn, I., Wittig, R., Özginga, W. A., Poschlod, P., & Klotz, S. (2008). *Urbanization causes shifts in species' trait state frequencies*. *Preslia*, 80(4), 375–388.
- 32- Köhler, M. (2006). *Long-term vegetation research on two extensive green roofs in Berlin*. *Urban Habitats*, 4(1), 3–26.
- Köhler, M., & Poll, P. H. (2010). *Long-term performance of selected old Berlin green-roofs in comparison to younger extensive green roofs in Berlin*. *Ecological Engineering*, 36(5), 722–729.
- 33- Rahman, S. R. and Ahmad, H. (2012). *Green roofs as urban antidote: A review on aesthetic environmental, economic and social benefits*. *South East Asia Technical University Conference Proceeding*, 6, 93 – 97.
- 34- Rahman, S. R., Rosley, M. S. F., Ahmad, H. and Mohammad, S. (2012). *Designing a healthy learning environment in the library with extensive green roof*. *International Technical Conference Proceeding*, 3, 52 – 59.
- 35- Rahman, S. R. A., Rosley, M. S. F., Ahmad, H., & Mohamad, S. (2012). *Designing a Healthy Learning Environment in the Library*. In *International Technical Conference 2012 (Proceeding)* (Vol. 2012, pp. 1–7).
- 36- Rahman, S. R., Ahmad, H. and Rosley, M. (2013). *Green roof: Its awareness among professionals and potential in Malaysian market*. *Social and Behavioral Sciences*, 85, 443 – 453.
- 37- Rosley, M. S. F., Rahman, S. R., and Lamit, H. (2013). *Perceiving the Aesthetic Value of Rural Landscape through Valid Indicators*. *Social and Behavioral Sciences*, 85, 318 – 331.
- 38- Shafer, E.L. (1969). *Perception of natural en-*

مدیریت شهری

فصلنامه مدیریت شهری  
(ویژه نامه لاتین)  
Urban Management  
No.43 Summer 2016

vironments. *Environment and Behaviour*, 1 (1), 71 - 82.

39- Stovin, V., Vesuviano, G., & Kasmin, H. (2012). *The hydrological performance of a green roof test bed under UK climatic conditions*. *Journal of Hydrology*, 414-415, 148-161.

40- Taib, N., & Abdullah, A. (2012). *Study of Landscape Gardens: Expectations and Users' Perceptions of a High-Rise Office Building*. *Procedia - Social and Behavioral Sciences*, 50(July), 633-642.



فصلنامه مدیریت شهری  
(ویژه نامه لاتین)

Urban Management  
No.43 Summer 2016

■ 366 ■