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A Study on Green Roofs with the Examples from the World and Turkey

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ABSTRACT

The green areas that should have been in the urban have been replaced with the concrete structures because of the intensive housing activities and work places constructions. Insufficient green areas are gradually changing the climate of urban. Air pollution has become a major problem of the urban. Thus, green roofs have become a necessity for architecture.
In this study, firstly the concept of green roof, the advantages and disadvantages of green roofs, their applicability and its place in the design of the structure as an architectural element are tried to be elaborated. Then, the green roof samples in Turkey and other countries are analyzed and compared.

Keywords: *Green roofs, sustainability, ecological architecture*

1. INTRODUCTION

The changing nature and life-style of the urban has left people far away from their natural environments and reduced the green areas. The green areas that should have been in the urban have been replaced with the concrete structures because of the intensive housing activities and work places constructions. This situation has led to the planning of several projects aiming to prevent the reduction of the green areas in urban and that has brought many problems. One of the effective solutions of the dwindling green in the urban is regaining the plant areas from the structures that destroyed themselves; that means making the roofs green.

In recent years, roof garden practices have become widespread in mainly Europe, Asia, transatlantic countries like USA and our country, too. Only in Germany, there are hundreds of roof gardens and at the end of the 2001, 13, 5 square meters of roof garden was built [1]. In Asia, Japan has become the center of the roof garden technology. Tokyo is the first city to turn necessarily at least 20% of the new building's roofs into the green roofs (Photography 1).

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Figure 1. Honda Wako Building, Kume Sekkei, Tokyo

The Millennium Park in Chicago is the biggest intense green roof. [2], (Photography 2).

Figure 2. Milennium Park, Terry Guen, Chicago, Illinois

In this article; it's aimed to examine the architectural issues such as comparing the roof gardens in Turkey with the roof concept in the world, how this concept is discussed around the world, and what type of new materials are used to build roof gardens and what new approaches are introduced to roof gardens in general terms. For this purpose, ID cards are primarily designed over 20 buildings applied in Turkey and other countries and the analysis tables are created to determine the characteristics of the roof gardens (There are 10 building samples to discuss in the paper because of the limit of pages.). By evaluating the findings on these issues, the results of the survey have been obtained.

2. THE CONCEPT OF GREEN ROOF GARDEN

In Europe and United States in recent years, the buildings with roof gardens are subjected to some assessments in the name of "Green Architecture" or "Sustainable Building". These assessments are made according to certain criteria and supported by the various certification programs. Thus, a better living space is tried to be presented to people by encouraging not only public, but also local government and private sector toward these structures.

In our country, the effects of the climate change are some important matters on today. The retrospective studies have revealed that there is effect of large block of heat on urban areas in the western regions of our country. In the scenarios for the future, the temperature increase is foreseen in addition to effect of large heat block on urban in summer seasons. Therefore, there are needed for new building technologies that can adapt to climate change in our country. International studies have revealed that the roof gardens known as planted roof system, green roofs or ecological roofs are one of the building systems that adapt the climate change.

2.1. Positive and Negative Effects of the Green Roof

Recent studies have shown that green roof gardens have many benefits from regional scale to building scale [3 - 6].

a. Effects on environment

1. They have the features of retention, storage and filtering of the rainfall water: Less water is able to pass through the soil because built-up areas have become more and more hard and impermeable. One of the most important effects of the green roofs in urban areas is to keep the rain water in extreme downfalls and delay it to reach to the sewage systems. [7].
2. They serve as natural filters by absorbing many harmful substances in the form of gas: Green roof plants, like other plants, use carbon dioxide for breathing and therefore they reduce the negative effects of pollutants.
3. Plants contribute to the environmental pollution by producing O_2.
4. They increase the relative humidity of the external environment and reduce the temperature of the vicinity environment: A large part of the world's population live in urban areas constructed densely and covered with hard surfaces such as roads and large amount of concrete parking spaces. These areas damage the biological formation of the earth's surface and they negatively affect the quality of life as a result of the deterioration of air quality, decrease in water quality and the creation of large heat blocks on urban areas. Green roof plants provides shadow effects with their leaves, protect hard surface from the heat absorbed too much and create to cool air by providing moisture to the environment. All living plants contribute to the city by improving regional climate.
5. Plant cover and being low of solar radiation reflection of the soil have important effects on temperature rise.
6. Plant cover and low rate of sound reflection help to reduce environmental noise: Traffic noise and other sounds increase the noise level by reflecting off the buildings and pavement surfaces. Soft surfaces like grass and green roofs reduce the sounds in the city instead of reflecting them.
7. Plant cover contributes to environment by absorbing dust particles in the air: A part of pollution in cities is the nitrogen compounds in exhaust smoke from traffic and industry. These compounds can be captured by plants and used as food. Rare and intensive green roofs increase both indoor and outdoor air quality by providing evaporation and filtration through the plants. [7].
8. They provide a new living environment for plants and animals and allow to protect the natural balance.

b. Effects on building

1. Plant cover and soil provide sound insulation.
2. They reduce thermal expansion and temperature differences in structure.
3. They protect the water insulation against UV radiation and other factors.
4. They protect water insulation and other layers against mechanical effects.
5. Heat losses depending on the wind can be reduced by 50% by plant cover of green roof.
6. They extend life of the roof by protecting the components of the roof.
7. Green elements of the roof gardens can be applied with solar panels (Photography 3). In addition, green roofs can be used with filter bearings, rain gardens, bio-storage systems, cisterns and rain barrels.

Figure 3.Green roofs and solar panels

8. They allow the use of roofs.
9. They have an effect on reducing the electromagnetic radiation. [7].
10. They provide resistance to fire.
11. Plant cover and soil protect the structure from solar radiation, prevent increasing of heat, save the energy spent to keep the building cool and get the building cooler.

c. The Social – Psychological – Aesthetic Satisfaction of the User

1. They provide aesthetic and visual satisfaction by creating recreational areas that users can benefit.
2. They allow social and cultural activities.

3. The Study on Green Roofs through Examples applied in the world and Turkey

The examples of the contemporary and pilot 10 buildings have been determined in this study. These buildings have been certificated as sustainable and ecological structures by some certification foundations or appeared in literature. Indeed, there have studied on 20 buildings 10 of which is from Turkey and 10 of which is from the other countries. In this paper, 10 buildings are sampled because of limit of pages. Firstly, the ID cards have been prepared for the selected samples. Secondly, the inquiry-based analysis tables have been created to determine the features of green roofs as an effective design element of ecologic and sustainable architecture.

Table 1. Mesa Hospital Building ID card and Roof Garden Analysis

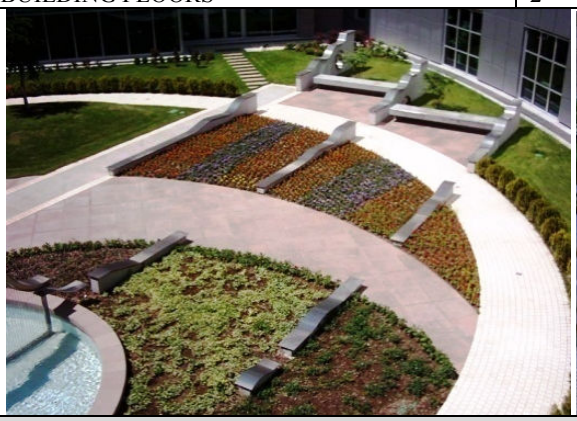
MESA HOSPITAL BUILDING ID CARD [8-9]	**Example 1**
PROJECT NAME	Mesa Hospital
CONSTRUCTION YEAR	2004
OWNER	Mesa Company
LOCATION	Ankara - TURKEY
TECHNICAL TEAM OF THE PROJECT	
ARCHITECT	M. Turhan Kayasu, MTK Architecture
CIVIL ENGINEER	Unknown
LANDSCAPE ARCHITECT	Unknown
FEATURES OF THE BUILDING	
BUILDING TYPE	Sanitary
BUILDING FLOORS	2
	
ROOF GARDEN ANALYSIS	
ROOF TYPE	Green roof
AREA COVERED BY GREEN ROOF	1000 m^2
GREEN ROOF FLOOR	On the roof-top
ROOF SLOPE	% 1
GREEN ROOF TYPE	Sparse- Intensive Planting
GREEN ROOF USABILITY	Open to the Public
GREEN ROOF ACCESIBILITY	Accessible
PLANTS USED ON THE GREEN ROOFS	• Grass • Ground Concealer • Bushes
POTENTIAL ADVANTAGES	• It has reduced the amount of waste water in city. • It created less dusty environments. • It reduced the ambient noise. • It increased the thermal insulation of the roof. • Water Efficiency • It has provided for aesthetic aspects.
CLIMATE FEATURES	• It has the territorial climate features.

Table 2. Kanyon Shopping Centre Building ID card and Roof Garden Analysis

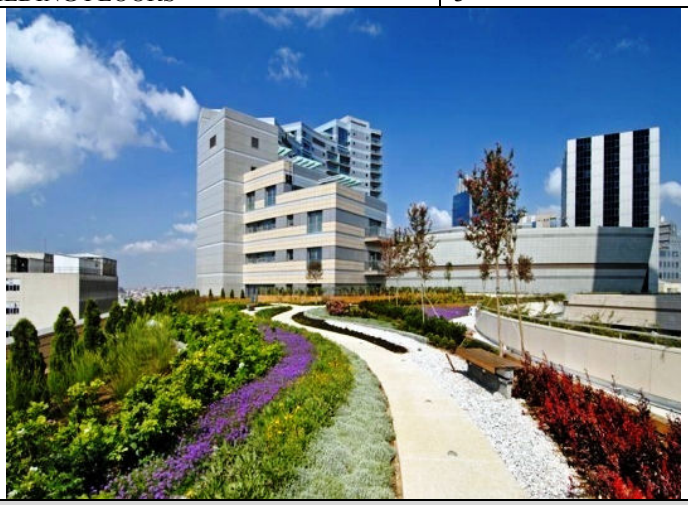
KANYON SHOPPING CENTRE BUILDING ID CARD [8-9]	**Example 2**
PROJECT NAME	Kanyon Shopping Center
CONSTRUCTION YEAR	2006
OWNER	Kanyon Administration
LOCATION	Levent / Istanbul - TURKEY
TECHNICAL TEAM OF THE PROJECT	
ARCHITECT	Serhan Bayık - Ozan Bayık, OSO Architecture Co Ltd.
CIVIL ENGINEER	ARUP Engineering
LANDSCAPE ARCHITECT	Unknown
FEATURES OF THE BUILDING	
BUILDING TYPE	Shopping Centre
BUILDING FLOORS	3
	
ROOF GARDEN ANALYSIS	
ROOF TYPE	Green roof
AREA COVERED BY GREEN ROOF	4500m^2
GREEN ROOF FLOOR	On the every floor
ROOF SLOPE	Unkonown
GREEN ROOF TYPE	Intensive Planting
GREEN ROOF USABILITY	Open to the Public
GREEN ROOF ACCESIBILITY	Accessible
PLANTS USED ON THE GREEN ROOFS	• Perennial plants • Seasonal flowers • Drought-resistant plants
POTENTIAL ADVANTAGES	• It has reduced the amount of waste water in city. • It created less dusty environments. • It reduced the ambient noise. • It increased the thermal insulation of the roof. • Water Efficiency • It has provided for aesthetic aspects.
CLIMATE FEATURES	• It has the temperate climate features.

Table 3. M1 Square Shopping Centre Building ID card and Roof Garden Analysis

M1 SQUARE SHOPPING CENTRE BUILDING [8-10]	**Example 3**
PROJECT NAME	M1 Square Shopping Centre
CONSTRUCTION YEAR	2007
OWNER	Metro Group
LOCATION	Umraniye / Istanbul – TURKEY
TECHNICAL TEAM OF THE PROJECT	
ARCHITECT	Turgut Alton Architecture Consulting Co. Ltd.
CIVIL ENGINEER	Unknown
LANDSCAPE ARCHITECT	Unknown
FEATURES OF THE BUILDING	

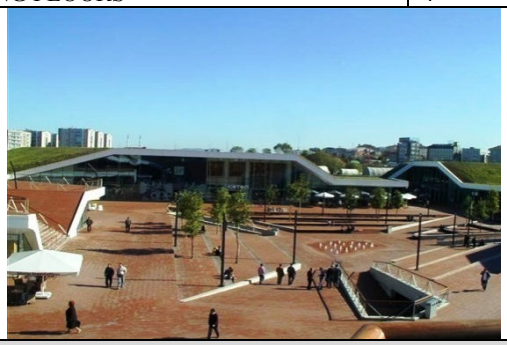
BUILDING TYPE	Shopping Centre
BUILDING FLOORS	4
 	
ROOF GARDEN ANALYSIS	
ROOF TYPE	Green Roof
AREA COVERED BY GREEN ROOF	55 000m^2
GREEN ROOF FLOOR	On the roof-top
ROOF SLOPE	Unknown
GREEN ROOF TYPE	Intensive and Sparse Planting
GREEN ROOF USABILITY	Open to the Public
GREEN ROOF ACCESIBILITY	Accessible
PLANTS USED ON THE GREEN ROOFS	• Grass • Ground Concealer • Bushes • Shrubs
POTENTIAL ADVANTAGES	• It has reduced the amount of waste water in city. • It created less dusty environments. • It reduced the ambient noise. • It increased the thermal insulation of the roof. • Water Efficiency • It has provided for aesthetic aspects.
EXPLANATIONS	It was the Winner of the following award; . 2008 Turkey Program Process Category of European Environmental Awards, . 2008 ULI European Excellence Award, . 2008 Best Property Award . 2008 Award of Architect of The Year . The first of Shopping Centre Category of the Property Awards.
CLIMATE FEATURES	• It has the temperate climate features.

Table 4. Turkcell R&D Building ID card and Roof Garden Analysis

TURKCELL R&D BUILDİNG ID CARD [11]	**Example 4**
PROJECT NAME	Turkcell R&D Building
CONSTRUCTION YEAR	2008
OWNER	Turkcell
LOCATION	Gebze – TURKEY
TECHNICAL TEAM OF THE PROJECT	
ARCHITECT	Erginoglu & Calıslar Architecture
CIVIL ENGINEER	Erginoglu & Calıslar Architecture
LANDSCAPE ARCHITECT	Erginoglu & Calıslar Architecture
FEATURES OF THE BUILDING	
BUILDING TYPE	Research and Development
BUILDING FLOORS	3

	
ROOF GARDEN ANALYSIS	
ROOF TYPE	Green roof
AREA COVERED BY GREEN ROOF	2500m^2
GREEN ROOF FLOOR	On the roof-top
ROOF SLOPE	Unknown
GREEN ROOF TYPE	Sparse Planting
GREEN ROOF USABILITY	Custom
GREEN ROOF ACCESIBILITY	Accessible
PLANTS USED ON THE GREEN ROOFS	• Grass • Ground Concealer
POTENTIAL ADVANTAGES	• It has reduced the amount of waste water in city. • It created less dusty environments. • It reduced the ambient noise. • It increased the thermal insulation of the roof. • Water Efficiency • It has provided for aesthetic aspects.
CLIMATE FEATURES	• It has the temperate climate features.
EXPLANATION	It won Building Branch Achievement Award at 12th National Architecture Awards

Table 5. Metrocity Building ID card and Roof Garden Analysis

METROCİTY BUILDING ID CARD [12]	**Example 5**
PROJECT NAME	Metrocity
CONSTRUCTION YEAR	2003
OWNER	Metrosite Company
LOCATION	Leven t/ Istanbul – TURKEY
TECHNICAL TEAM OF THE PROJECT	
ARCHITECT	Dogan Tekeli
CIVIL ENGINEER	Balkar Engineering
LANDSCAPE ARCHITECT	Ahmet Yildizci
FEATURES OF THE BUILDING	
BUILDING TYPE	Shopping Centre
BUILDING FLOORS	4

	
ROOF GARDEN ANALYSIS	
ROOF TYPE	Green roof
AREA COVERED BY GREEN ROOF	6000 m^2
GREEN ROOF FLOOR	On the roof-top
ROOF SLOPE	Unknown
GREEN ROOF TYPE	Intensive Planting
GREEN ROOF USABILITY	Open to the Public
GREEN ROOF ACCESIBILITY	Accessible
PLANTS USED ON THE GREEN ROOFS	• Grass • Ground Concealer • Bushes • Shrubs • Trees
POTENTIAL ADVANTAGES	• It has reduced the amount of waste water in city. • It created less dusty environments. • It reduced the ambient noise. • It increased the thermal insulation of the roof. • Water Efficiency • It has provided for aesthetic aspects.
CLIMATE FEATURES	• It has the temperate climate features.
EXPLANATION	It was the first place in the limited competition project.

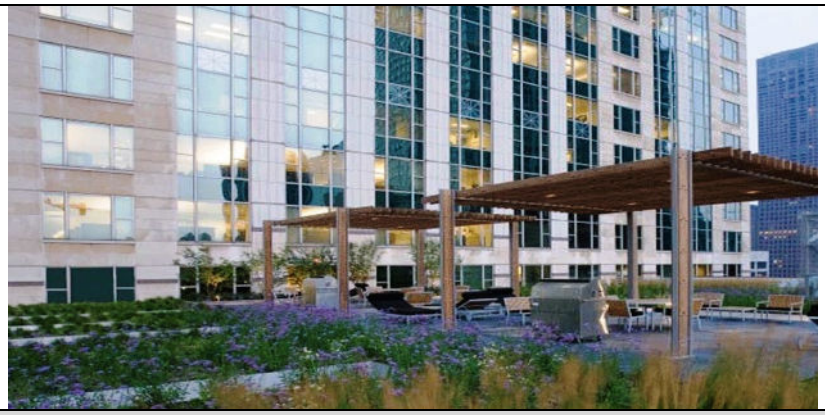
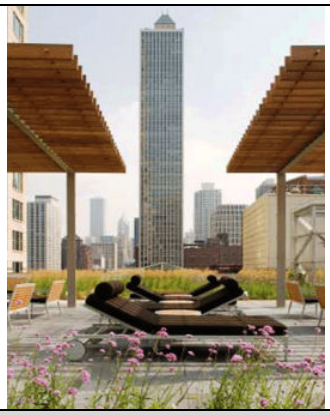
Table 6. 2010 Building of Vancouver Olympic Village ID card and Roof Garden Analysis

2010 BUILDING of VANCOUVER OLYMPIC VILLAGE ID CARD [13]	**Example 6**
PROJECT NAME	2010 Vancouver Olympic Village
CONSTRUCTION YEAR	2006
OWNER	Vancouver
LOCATION	Vancouver, KANADA
TECHNICAL TEAM OF THE PROJECT	
ARCHITECT	Unknown
CIVIL ENGINEER	Millennium Development Corporation
LANDSCAPE ARCHITECT	Durante Kreuk
FEATURES OF THE BUILDING	
BUILDING TYPE	Custom
BUILDING FLOORS	Unknown


ROOF GARDEN ANALYSIS	
ROOF TYPE	Green Roof
AREA COVERED BY GREEN ROOF	26 662 m^2
GREEN ROOF FLOOR	On the different floors
ROOF SLOPE	%2
GREEN ROOF TYPE	Intensive and Sparse Planting
GREEN ROOF USABILITY	Custom
GREEN ROOF ACCESIBILITY	Inaccessible
PLANTS USED ON THE GREEN ROOFS	• Grass • Ground Concealer • Bushes • Shrubs
POTENTIAL ADVANTAGES	• It has reduced the amount of waste water in city. • It created less dusty environments. • It reduced the ambient noise. • It increased the thermal insulation of the roof. • Water Efficiency • It has provided for aesthetic aspects.
EXPLANATION	It has LEED certification (platinum). There can be walked on the green roof.
CLIMATE FEATURES	• It has the temperate climate features.

Table 7. The Residences at 900 Building ID card and Roof Garden Analysis

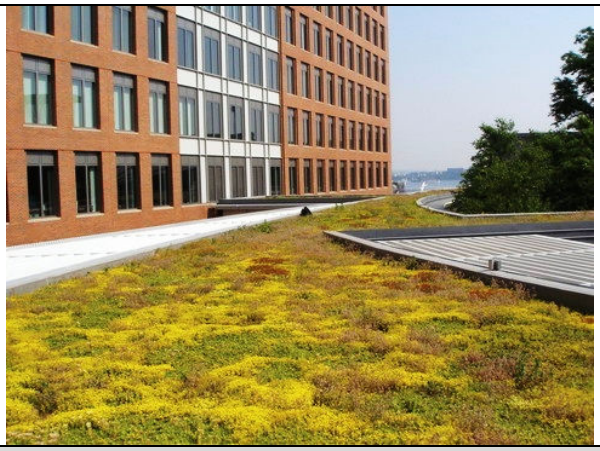
THE RESIDENCES AT 900 BUILDING ID CARD [13]	**Example 7**
PROJECT NAME	The Residences At 900
CONSTRUCTION YEAR	2007
OWNER	900 Tower, LLC, an affiliate of JMB Realty Company
LOCATION	Chicago, ABD
TECHNICAL TEAM OF THE PROJECT	
ARCHITECT	Booth Hansen
CIVIL ENGINEER	Structural Group Ltd.ec
LANDSCAPE ARCHITECT	Douglas Hoerr
FEATURES OF THE BUILDING	
BUILDING TYPE	Multi-Family Residential
BUILDING FLOORS	Unknown

ROOF GARDEN ANALYSIS	
ROOF TYPE	Green Roof
AREA COVERED BY GREEN ROOF	1300 m^2
GREEN ROOF FLOOR	On the roof-top
ROOF SLOPE	%1
GREEN ROOF TYPE	Intensive Planting
GREEN ROOF USABILITY	Custom
GREEN ROOF ACCESIBILITY	Accessible
PLANTS USED ON THE GREEN ROOFS	• Grass • Ground Concealer • Bushes
POTENTIAL ADVANTAGES	• It has reduced the amount of waste water in city. • It created less dusty environments. • It reduced the ambient noise. • It increased the thermal insulation of the roof.. • Water Efficiency • It has provided for aesthetic aspects.
CLIMATE FEATURES	• It has the terrestrial climate features.
EXPLANATION	It was awarded in the green roof house category.

Table 8. Boston World Trade Center Building ID card and Roof Garden Analysis

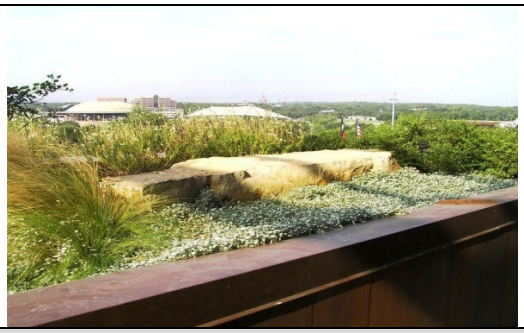
BUILDING OF BOSTON WORLD TRADE CENTER ID CARD [13]	**Example 8**
PROJECT NAME	West Podium Park of Boston World Trade Center
CONSTRUCTION YEAR	2003
OWNER	Boston World Trade Center
LOCATION	Boston, ABD
TECHNICAL TEAM OF THE PROJECT	
ARCHITECT	Kallmann McKinnel & Wood Architecture
CIVIL ENGINEER	Weidlinger Associates
LANDSCAPE ARCHITECT	Pressley Associates
FEATURES OF THE BUILDING	
BUILDING TYPE	Commercial
BUILDING FLOORS	3




ROOF GARDEN ANALYSIS	
ROOF TYPE	Green Roof
AREA COVERED BY GREEN ROOF	2700 m^2
GREEN ROOF FLOOR	On the roof-top
ROOF SLOPE	% 1.5
GREEN ROOF TYPE	Intensive Planting
GREEN ROOF USABILITY	Custom
GREEN ROOF ACCESIBILITY	Accessible
PLANTS USED ON THE GREEN ROOFS	• Grass • Ground Concealer • Bushes
POTENTIAL ADVANTAGES	• It has reduced the amount of waste water in city. • It created less dusty environments. • It reduced the ambient noise. • It increased the thermal insulation of the roof. • Water Efficiency • It has provided for aesthetic aspects.
CLIMATE FEATURES	• It has the terrestrial climate features.
EXPLANATION	It was awarded in the Green Roof Industrial / Commercial Building category.

Table 9. Austin City Hall ID card and Roof Garden Analysis

AUSTİN CITY HALL ID CARD [13]	**Example 9**
PROJECT NAME	Austin City Hall Roof Garden
CONSTRUCTION YEAR	2007
OWNER	City of Austin
LOCATION	Austin, Texas, USA
TECHNICAL TEAM OF THE PROJECT	
ARCHITECT	Antoine Predock
CIVIL ENGINEER	Datum Engineering
LANDSCAPE ARCHITECT	McKinney Kelley
FEATURES OF THE BUILDING	
BUILDING TYPE	Municipality/Government
BUILDING FLOORS	Unknown

ROOF GARDEN ANALYSIS	
ROOF TYPE	Green Roof
AREA COVERED BY GREEN ROOF	1115 m^2
GREEN ROOF FLOOR	On the roof-top and other floors
ROOF SLOPE	1%
GREEN ROOF TYPE	Intensive Planting
GREEN ROOF USABILITY	Public
GREEN ROOF ACCESIBILITY	Accessible
PLANTS USED ON THE GREEN ROOFS	• Grass • Ground Concealer • Bushes • Shrubs
POTENTIAL ADVANTAGES	• It has reduced the amount of waste water in city. • It created less dusty environments. • It reduced the ambient noise. • It increased the thermal insulation of the roof. • Water Efficiency • It has provided for aesthetic aspects.
CLIMATE FEATURES	• It has hot and humid sub-tropical climate.
EXPLANATIONS	Project has also Austin's first LEED gold certification. It was awarded in the Green Roof Corporate Structure Category.

Table 10. California Academy of Science Museum Building ID card and Roof Garden Analysis

CALIFORNIA ACADEMY OF SCIENCE MUSEUM BUILDING ID CARD [13]	Example 10
PROJECT NAME	California Academy of Science Museum
CONSTRUCTION YEAR	2007
OWNER	California Academy of Science
LOCATION	San Francisco – ABD
TECHNICAL TEAM OF THE PROJECT	
ARCHITECT	Chong Partners Architecture, Renzo Piano
CIVIL ENGINEER	Arup Engineering
LANDSCAPE ARCHITECT	Rana Creek
FEATURES OF THE BUILDING	
BUILDING TYPE	Education
BUILDING FLOORS	4


ROOF GARDEN ANALYSIS	
ROOF TYPE	Green Roof
AREA COVERED BY GREEN ROOF	18302m^2
GREEN ROOF FLOOR	On the roof-top
ROOF SLOPE	5 %
GREEN ROOF TYPE	Intensive Planting – Testing / Research
GREEN ROOF USABILITY	Open to the Public
GREEN ROOF ACCESIBILITY	Inaccessible
PLANTS USED ON THE GREEN ROOFS	• Grass • Ground Concealer
POTENTIAL ADVANTAGES	• It has reduced the amount of waste water in city. • It created less dusty environments. • It reduced the ambient noise. • It increased the thermal insulation of the roof. • Water Efficiency • It has provided for aesthetic aspects.
EXPLANATIONS	• It is LEED certified. It has taken Silver Holcim Award.
CLIMATE FEATURES	• It has the terrestrial climate features.

4. RESULTS AND DISCUSION

The data obtained from analysis performed for the roof gardens in the samples have been placed on the following table in order to compare the samples in Turkey and other countries and determine the features of each roof garden. In this paper, there are 10 buildings for analyzing. But, there have been researched on 20 buildings in complete of the study. Therefore, Table 11 has contained data belonging to the 10 buildings.

Table 11. Analysis table of the roof gardens

Turkey	**1**	**2**	**3**	**4**	**5**	**Other Countries**	**6**	**7**	**8**	**9**	**10**
Roof type						Roof type					
Sloping roof garden			X	X		Sloping roof garden	X		X		X
Flat roof garden	X				X	Flat roof garden		X		X	
Area covered						Area covered					
0-5000 m^2 space	X	X		X		0-5000 m^2 space		X	X	X	
5000-10000 m^2					X	5000-10000 m^2					
10000-15000 m^2						10000-15000 m^2					
15000 m^2 and over			X			15000 m^2 and over					
Roof slope						Roof slope					
%1 - % 5	X	X			X	%1 - % 5 slope	X	X	X	X	
%5 -%10						%5 -%10 slope					
%10-%15			X	X		%10-%15					
%15 and over						%15 and over					X
Green Roof Type						Green Roof Type					
Sparse green roof				X		Sparse green roof					
Intense green roof		X				Intense green roof		X	X	X	X
Sparse – Intense Green Roof	X		X		X	Sparse – Intense Green Roof	X				
Usability						Usability					
Open to public	X	X	X		X	Open to public					X

Private				X		Private	X	X	X		
Public						Public				X	
Accessibility						Accessibility					
Accessible	X	X	X	X	X	Accessible		X	X	X	X
Inaccessible						Inaccessible	X				
Plant species used						Plant species used					
Trees		X				Trees	X			X	
Shrub		X	X		X	Shrub	X			X	
Bushes		X	X		X	Bushes	X	X	X	X	
Ground Concealer		X	X	X	X	Ground Concealer	X	X X	X	X	X
Grass	X	X	X	X	X	Grass	X	X	X	X	X
Climate Features						Climate Features					
Terrestrial Climate	X					Terrestrial Climate		X	X		X
Temperate Climate		X	X	X	X	Temperate Climate	X				
Blacksea Climate						Blacksea Climate					
Mediterranean Climate						Mediterranean Climate					
Tropical Climate						Tropical Climate				X	
Advantages						Advantages					
Water Efficiency	X	X	X	X	X	Water Efficiency	X	X	X	X	X
Heat Insulation	X	X	X	X	X	Heat Insulation	X	X	X	X	X
Sound Insulation	X	X	X	X	X	Sound Insulation	X	X	X	X	X
Recreation	X	X	X	X	X	Recreation	X	X	X	X	X
Energy efficiency	X	X	X	X	X	Energy efficiency	X	X	X	X	X
Awards and Certificates						Awards and Certificates					
Yes			X	X	X	Yes	X	X	X	X	X
No	X	X				No					

According to the data from Table 11, the roofs of 2 buildings in Turkey are sloping green roofs; the other 8 are flat green roofs. While the 4 of 10 buildings in other countries have sloping green roofs, other 6 have flat green roofs. The area of green roofs of 8 buildings examined in Turkey is between 0 – 5000 m^2, 1 of them is between 5000 – 10000 m^2 and other one is 15000m^2 and over. While the area of 7 green roofs in other countries is between 0 – 5000 m^2, other 3 are 15000 m^2 and over. The slopes of the 8 green roof samples in Turkey are between 1 – 5%, slopes of other 2 are 10 – 15%. The slopes of the 8 green roofs in other countries are 1 – 5%, slope of 1 is 10 – 15% and slope of other 1 is 15% and over.

The 3 of the samples in Turkey have sparse planting, 1 has intense planting and 6 have both sparse and intense planting. The 7 green roofs in other countries have intense one, 3 green roofs have both sparse and intense planting. The 4 of the samples in Turkey are open to the public, 6 are for private usage and the 2 of the samples in other countries are open to the public and only 1 is open to the public. The 9 of the green roofs in both Turkey and other countries are accessible, only 1 is inaccessible. All the green roof samples examined have contributed to the buildings in terms of heat insulation, sound insulation, water efficiency, recreation etc.

5. RESULTS

In recent years, the roof gardens that have almost become necessary in big cities are in very limited numbers. The roof gardens have become a part of human life because of the importance given to the environment in many countries including Germany.

Recently, the increase in the number of institutions or companies that realize the production and do researches make the issue of roof garden an area of expertise by separating this issue from the construction sector. The new materials emerging with the development of the new technology in the world reduce the difficulty of creating roof gardens to certain extend. These building materials are produced from recycled materials and thus contribute to the environment. While there were difficulties in the transportation of the materials such as gravel, sand etc. that is heavy and cumbersome to be laid out to the roof in ancient times, the preferability of the new materials because of the convenience in transportation and sprawl makes the roof gardens widespread. This type of new materials used in roof gardens will reduce the costs such as labor and freight and in addition to this, provide energy savings.

Therefore, when a weight comparison is made between the new and old systems, the new systems are almost two times lighter. The two time lighter roof garden system;

· They will bring fewer loads to the building and prevent the deterioration of the building's static balance.

· They will provide more functions together when creating roof garden and eliminate the restrictions in design.

· While planting, they will facilitate the selection of plants by allowing to bring bigger plants to the area.

· They will facilitate in the implementation stage of the roof garden.

In terms of the samples examined, roof gardens are made in many different ways and using different materials.

Some of these roof gardens have been created in standard building construction techniques. In some of them, some layer thought as absolutely necessary has been omitted, in others, one or two new materials have been added to standard techniques. The most important one among the layers that omitted is the root protection layer. It's likely that the roots harm the waterproofing in roof gardens, especially the ones that do not contain root protection layer and the ones that contain bigger plants. In due course, as a result of the leaks, it will be very costly to repair the water insulation and re-establish it in the same area by removing a large part of the garden. In addition, it is obvious that the gardens which new materials have been used in have eases in terms of both their construction time and application.

The important thing here is when necessary; the old and new systems are combined in accordance with purpose and utilize the advantages of both systems. While the roof garden is created, the selection of the structural layers and lower layers (drainage, water insulation etc.) from new materials and the bringing soil layer as habitat like in the classical systems provides good results.

The formation of the roof gardens in structures such as skyscraper or shopping center and the abandoning of traditional systems can be interpreted as an attempt to development. Also, in the future, the emergence of some new buildings or sites with roof gardens, thought to be built in İstanbul, is an encouraging development for the future of the roof gardens in our country. As a result of increase in the construction of roof gardens by preserving the existing green areas, it will be possible that the areas that people can breathe can be created and the city will able to gain an aesthetic appearance.

REFERENCES

[1] Beyhan F., Erbaş M., "An Analysis Of Green Roof Being Of Effective Elements Of Energy-Efficient Building Design Over The World and Our Country", Master's thesis, ***Karadeniz Technical University Gradute School of Natural and Applied Sciences***, (2011).

[2] Breuning J., Yanders, A. , Edition of the Green Roofing Guideline, "Introduction to the FLL Guidelines for the Planning, Construction and Maintenance of Green Roofing", (2008).

[3] Werthmann Ch. , "Green Roof – A Case Study", ***Princeton Architectural Press***, (2007).

[4] Yang J, Yu Q, Gong P., "Quantifying air pollution removal by green roofs in Chicago", ***Atmos Environ*** 42:7266–7273, (2008).

[5] Van der Steen P, Howe C , "Managing water in the city of the future; strategic planning and science" ***Rev Environ Sci Biotechnol*** 8:115–120, (2009).

[6] Oberndorfer E, Lundholm J, Bass B, Coffman RR, Doshi H, Dunnett N, Gaffin S, Kohler M, Liu KKY, Rowe DB. , "Green roofs as urban ecosystems: ecological structures, functions, and services". ***Bioscience*** 57:823–833, (2007).

[7] Adam J. Bates, Rae Mackay, Richard B. Greswell, Jon P. Sadler, "SWITCH in Birmingham, UK: experimental investigation of the ecological and hydrological performance of extensive green roofs", ***Rev Environ Sci Biotechnol***, 8:295–300, (2009).

[8] Dawson, National Geographic News., (2002).

[9] Dawson, National Geographic News., (2004).

[10] Weiler, S., Scholz-Barth, K., "Green Roof Systems – A Guide to the Planning, Design and Construction of Building Over Structure", (2009).

[11] Weiler, S., Scholz-Barth, K., "Green Roof Systems – A Guide to the Planning, Design and Construction of Landscapes over Structure", New Jersey: ***John Wiley & Sons***, (2006).

[12] Dunnett, N., Kingsbury, N., "Planting Green Roofs and Living Walls", Portland, Oregon: ***Timber Press Inc***., (2008).

[13] Altun, M.C., "Stratification of vegetated roofs: 1.Heat-Sound-Water Insulation" Proceeding Books of Symposium and Exhibition , 132-136.,İstanbul, (1995).

[14] Scholz-Barth Katrin, "Starmwater Management Management From the Top Down", http://www.edcmag.com/CDA/ArticleInformation/features/BNP, 15 October (2009).

[15] Esin, T. ve Yüksek, İ., "Environmentally friendly Eco-buildings, 5th International Symposium on Advanced Technologies" (IATS'09), 13-15 May 2009, Karabük, Turkey, (2009).

[16] http://www.raf.com.tr., 14 November (2009).

[17] http://www.meydanumraniye.com.tr/servlet/PB/menu/1029933_l8_yno/1292350911022.html, 10 October (2009).

[18] http://arkiv.arkitera.com/p9135.,18 June (2009).

[19] Ekşi, M., "The use of construction materials in roof and terrace gardens and the new dimensions" , Master's thesis, ***İstanbul University Institute of Science and Technology***, (2006).

[20] http://www.greenroof.se/index.htm., November (2010).