

ISTANBUL TECHNICAL UNIVERSITY ★ GRADUATE SCHOOL OF SCIENCE
ENGINEERING AND TECHNOLOGY

**AN INVESTIGATION OF
SURFACE PARKING LOTS AND DEVELOPING DESIGN STRATEGIES**

M.Sc. THESIS

Ouldouz HAJIMOHAMMADIPOUR

Department of Landscape Architecture

Landscape Architecture Program

DECEMBER 2015

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**Ouldouz HAJIMOHAMMADIPOUR
(502121609)**

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Thesis Advisor: Prof. Dr. Hayriye EŞBAH TUNÇAY

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**AÇIK OTOPARKLAR ÜZERİNE BİR İNCELEME
VE TASARIM STRATEJİLERİNİN GELİŞTİRİLMESİ**

YÜKSEK LİSANS TEZİ

**Ouldouz HAJIMOHAMMADIPOUR
(502121609)**

Peyzaj Mimarlığı Anabilim Dalı

Peyzaj Mimarlığı Programı

Tez Danışmanı: Prof. Dr. Hayriye EŞBAH TUNÇAY

ARALIK 2015

Ouldouz Hajimohammadipour, a **M.Sc.** student of ITU **Institute of Science and Technology** student ID **502121609**, successfully defended the **thesis/dissertation** entitled “**AN INVESTIGATION OF SURFACE PARKING LOTS AND DEVELOPING DESIGN STRATEGIES**” which she prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

Thesis Advisor : **Prof. Dr. Hayriye EŞBAH TUNÇAY**

Istanbul Technical University

Jury Members : **Doç. Dr. Yasin Cagatay SECKIN**

Istanbul Technical University

Prof. Dr. Adnan UZUN

Işık University

Date of Submission: 27 November 2015

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To my dear family,

FOREWORD

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Ouldouz HAJIMOHAMMADIPOUR
(Architect)

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ABBREVIATIONS

ASLA	: American Society of Landscape Architecture
EPA	: United States Environmental Protection Agency
LEED	: Leadership in Energy and Environmental Design
SMCWPPP	: The San Mateo Countywide Water Pollution Prevention Program
UHI	: Urban Heat Island
USGS	: United States Geological Survey

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AN INVESTIGATION OF SURFACE PARKING LOTS AND DEVELOPING DESIGN STRATEGIES

SUMMARY

Nowadays by increasing the population, demand for cars is increased also, the way of life in the most places around the world is dependent on the automobile, more and more natural lands are devoted to accommodating automobiles. Large amount of impervious surface areas and buildings, lack of vegetation in urban landscape, and especially mobility and car usage have negative impacts on the environment. By controlling the transportation system by motor vehicles Parking lots are inseparable sector of the most of the urban areas and these plots are mostly assumed as a place without beauty and aesthetic value. As long as cars exist in our society as a personal transportation system, environment will be faced with the parking lot issue and the designing problems that related to it. Sustainability concept has been arisen from these environmental concerns in order to find long-term solutions for environmental degradation. Sustainable design of parking lots is an important issue due to the way of design directly affects the way of peoples living and social health. Green design concept has assisted environmentally friendly designs in order to achieve sustainability. A considerable amount of attention has been devoted to examining the environmental impact of impervious surfaces. however, little attention has been paid to the transportation footprint portion of the impervious surface parking lots and their impacts on land use perspective has not been assessed on a large scale. This study explores how to design sustainable landscape and implement green design strategies in urban surface parking lots. In this study, firstly, the importance of the sustainable design in parking lots has been emphasized and the impact of the surface parking lots in various aspects has been researched in detail. At the next chapters, examples of the parking lots have explained in relation to the existence of green design initiatives and sustainable strategies in their design process. In the third chapter, a table of sustainable design criteria have been determined as a guideline based on the comprehensive research on proposed examples, guidelines and, literature that was mentioned in the previous chapters' in this study. Fourth chapter includes of a general analysis; which is conducted in various scale. Fatih district as recommended by Ispark was considered as case study for large scale analysis because of its historic and strategic situation in Istanbul. The high amount of impervious, or paved, surfaces in this area creates a large volume of water that flows directly and indirectly into city sewers and, eventually, into the Marmara Sea and Golden Horn, in addition impervious surfaces and lack of green coverage cause to increase the temperature in the mentioned area. In large-scale analysis, firstly Fatih district's existing parking lots and green spaces are Highlighted in different maps according to the 2014 satellites images and, furthermore additional maps are prepared to present the green areas and surface parking lot's coverage in the years 1966 and 1982, these maps are compared with existing green networks and parking lot coverages. By analysis and comparison of mapped data's this will be result that urbanization of the Fatih associated with the loss of natural green spaces and agricultural lands and increase in the paved surfaces in Fatih District. For site-scale

analysis five surface parking lots are selected as case studies. Site visit and survey was done for determining the feature of the sites then these lots are evaluated according to the mentioned sustainable criteria table for understanding the situation of the Istanbul's surface parking lots in relation to the existence of sustainable criteria in their design. In the final step, a plan was designed according to the sustainable design table for Sehit Ahmer property in Istanbul as case study, proposed plan was compared with the conventional site plan. By the way most of the conventional surface parking lots can be improved by implementing green design infrastructures while providing aesthetic and social benefits in public realm and without changes in the land use.

AAÇIK OTOFARKLAR ÜZERİNE BİR İNCELEME VE TASARIM STRATEJİLERİNİN GELİŐTİRİLMESİ

ÖZET

Günümüzde nüfus artışı ile ,araba kullanımında artmaktadır, bugünkü yaşam tarzı bir şekilde motorlu araçlara bağlıdır, bu araçların yerleşim için yeşil alanlar kullanılmaktadır. Sanayi Devrimi sonrası dünya nüfusunun hızla artmasıyla beraber artan ihtiyaçların karşılanması için endüstrileşme hız kazanmıştır. Yoğun nüfuslu ve yüksek yapıların sıklıkla görüldüğü kentsel alanların çevrelerine göre daha sıcak olmaları, kentlerin ısı adası etkisini oluşturur.

Büyük ölçekte binalar ve su geçirmez alanlar, kentsel peyzaj azlığı ve, özellikle araba kullanımı çevreye ölümsüz etkilemektedir. ulaşım sisteminin kontrolü motorlu taşıtlara bağlı olduğu için, açık otoparklar kentsel alanların ayrılmaz bir parçasıdır. genellikle açık otoparklar estetik açıdan zayıf kalmaktadır. Günümüzde arabalar ulaşım araçları olduğundan, kent içi otopark ve otoparkların Planlama ve tasarım problemleri ile karşılanmaktadır.

Çevreci hareketlerin gelişmesi ve çevreyle ilgili kaygıların artması sonucu birçok ülkelerde sürdürülebilirlik kavramı çevresel problemlerin uzun süreli çözümü için ortaya çıkmıştır. Son yıllarda dünyada yaşanan iklimsel ve çevreyle ilgili değişimlerin etkileri ve nedenleri birçok kavramla birlikte sürdürülebilirlik kavramının da görünürlüğünü arttırmıştır. Sürdürülebilirliğin sağlanabilmesi konusu farklı bilim dalları kapsamında birçok boyutuyla ele alınmaktadır. Gittikçe artan çevre problemleri, sağlık ve diğer problemleri meydana getirmektedir. Sürdürülebilirlik kavramı, ekonomik ve teknolojik gelişmelere paralel bir şekilde ortaya çıkan çevre sorunlarının önüne geçebilme ve ekosistemin korunması üzerine odaklanmıştır.

Kent deki açık otoparklar bireylerin günlük yaşamları üzerinde çok sayıda etkileri vardır. Tüm yukarıda belirtilen hususlar göz önünde tutulursa, açık otoparkların tasarımının ne derece önemli olduğu vurgulanabilir. Çevre problemleri, sürdürülebilir gelişmede önemli bir faktördür . Bu çalışmada özellikle peyzaj tasarımcı bakış açısı ile kent deki açık otoparkları önemi vurgulanmaya çalışılmıştır . Amaç kent içi otoparklarına toplumun geniş kesimlerinin dikkatini çekerek daha fazla sağlam, çevreye zararsız ve ekolojik desteklemek ve kullanımı etkinleştirmek için, uygun tasarım değerlendirme kriterleri keşfetmektir.

Bu amaçla, otoparkların etkilerini ve özelliklerini keşfetmek ve dünyada kentsel açık otoparkların, tarihini gözden geçirmek çok önemlidir. Gelecek kent açık otoparklarına dair arzu edilen ve tatmin edici bir tasarım sunmak için, bu çalışma, tasarımı derinden etkileyen temel özellikler ve değerlendirme kriterlerine hitap etmektedir. Bu nedenle, bu kriterler tezin sonraki bölümlerde incelenmiştir.

Açık otoparkların sürdürülebilir tasarımı, insanların yaşam tarzı ve sosyal hayatın sağlığın, direkt veya indirekt olarak etkilediğinden, önemi bir konudur. Yeşil tasarım

kavramı, sürdürülebilirlik desteklemektedir. Bu konunun önemi arttıkça, Su geçirmez malzemelerde önemi ortaya çıkmıştır.

Sürdürülebilirliğin önemi bilmesine rağmen, büyük ölçekteki açık otoparkların konunun önemi göz ardı edilmiştir.

Bu çalışmada, sürdürülebilir kentsel peyzaj tasarımı ve yeşil tasarım stratejileri ve uygulamaları üzerinde anlatılmıştır.

Metodoloji ve uygulanan prosedürler literatür kapsamlı inceleme ile başlamıştır. Çalışmanın temel araştırma sorusu “çevreye ve insan sağlığına zararsız ve daha sosyalleşmesi için açık otoparkların tasarımında hangi kriterler dikkate alınmalıdır? cevabı bulabilmek için ilk olarak, farklı kaynaklardan tasarım değerlendirme kriterleri incelenmiştir.

Birinci bölümde, ilgili ve geçmiş literatürlerden kapsamlı bir inceleme sunulmaktadır. sürdürülebilir tasarımın açık otoparklardaki önemi ve detaylı olarak açık otoparkların çeşitli boyutlarındaki etkisi, ele alınmıştır. İlk otoparkların başlangıç nedenleri ve kriterleri tarihi açıdan incelenmiştir.

İkinci bölümde ise, açık otoparkların çevresel etkileri bahsedilmiştir, otoparkla ilgili dünya'daki genel esaslar ve standartlar ve onların başlangıç noktaları ve nedenleri ele alınmıştır, mevcut otoparklı olay alrı örnekler verilmiştir.

Üçüncü bölümde, sürdürülebilir tasarım kriterleri çeşitli kaynak taraması ile elde edilmiştir. tasarımcıların açık otoparklarıdaki farklı tasarım değerlendirme kriterleri tartışılmıştır. Bu kriterler ele alarak, sürdürülebilir tasarım tablosu oluşturulmuştur. kriterler ve bileşenleri tek tek tartışılmıştır. Bu kriterler üç ana başlık olarak kategorize edilmiştir: sürdürülebilir ve ekolojik, estetik ve görsel kalite ve, sosyal ve insan sağlığı. Bu üç ana başlık, alt başlıklara bölünmüştür.

Çalışmanın dördüncü bölümünde, büyük ve küçük ölçeklerde, İstanbul'daki otoparkların analizi yapılmıştır. Fatih ilçesi tarihten beri İstanbul'un en önemli lokasyonlarından biridir. Fatih ilçesi ticari, tarihi ve turistik açısından önem taşıdığı için büyük ölçek analizi için İspark tarafından önerilmiştir. Fatih ilçesi yarım ada olduğundan, atıksu ve yağmur suları denize dökülmektedir. Bölgenin yoğunluğu nedeniyle, otopark olarak kullanılan yüzeyler artmaktadır. Bu yüzeylerin geneli su geçirmez alanlar oldukları için kentsel ısı adası teşkil etmektedir. Bu konu önem taşıdığından,

Fatih ilçesi otopark analizi edilmiş. 1966, 1982 ve, 2014 yıllarındaki açık otopark ve yeşil alanlar Türkiye haritası ve uydu görüntüleri üzerinden birbirine karşılaştırılmıştır. Zaman içinde yeşil alanlar ve tarım arazileri, motorlu araç kullanımının artışı ile otoparklara dönüşmüştür. ve 1982-2014 yılları arasında bu hız aşırı şekilde artmıştır.

Küçük ölçekteki analizde, konum, kapasite ve, boyut olarak beş farklı otopark analiz edilmiştir. Bu analizde, beş farklı otopark sınıflandırılmış tasarım değerlendirme kriterlerine göre: sürdürülebilir ve ekolojik, estetik ve görsel kalite ve, sosyal ve insan sağlığı karşılaştırılmıştır. Alan çalışmasında, konum, bölgenin genel bilgileri ve verileri ele alınmıştır. Ayrıca, tasarım değerlendirme kriterlerine göre alan çalışması gözlem ve görsel kayıtlar ile desteklenmiştir. Bu kıyaslamak bir tablo şeklinde göstermektedir.

Sonra ise son adım da Maltepe ilçesinde İsparka ait, Şehit Ahmet otoparkı, üçüncü bölümünde elde edilen tablodaki kriterler ele alınarak tasarlanmıştır. Bu tasarımları yapmak için ilk adım da genel olarak bu otopark analizi edilmiştir. Bu tasarım üç ana

başlık: sürdürülebilir ve ekolojik, estetik ve görsel kalite ve, sosyal ve insan sağlığı sağlamak üzere tasarlanmıştır.

Ardından sonuç olarak ,tasarlanmış otopark Isparkin tasardığı otoparkınan karşılaşmıştır ve yapılan uygun olan stratgiler baslık olarak soyleneştir.

Çalışmalar ve örnek çalışma sonucunda elde edilen sonuçlar, gelecek ve çağdaş kent otoparklarında daha çevresel ve ekolojik olarak anlamlı tasarımlar gerçekleşmesi açısından, yön verici olabilir.

1. INTRODUCTION

Urbanization is associated with the loss of open/green space (Ewing,1997; Johnson,2001), the loss and fragmentation of wildlife habitat (Radeloff et al., 2005), and an increase in impervious surfaces (Brabec et al., 2002).

The ongoing increase of the human population and at the same time increase in the demand for automobiles in daily life, cause manipulation of natural environments, the duration of human evolution has coincided with changing in environment, including drying, cooling, and climate swings, ozone depletion, loss of biodiversity over time. By passing the time, these changes have led to the emergence of large-scale environmental hazards to human health. Environmental degradation is a significant problem of present days as a consequences of human activities and the way of that they manipulate and misusing the nature and natural recourses. Parking lot is one of the inseparable aspects of the modern world, although the existing of the parking lot back into the existing of the chariots within Roman cities (Miller, 1988, p6). in the early times, automobiles parked alongside horses and wagons at the curbside, by increasing the number of the "horseless chariots "the need for storing and parking them had to be accommodated outside of the street space. municipalities to solve this ever-growing need started to offer off-street parking (Ben-Josef, 2012). By increasing the number of the cars on the road, need for more parking spaces are increase also. Parking lots can have detrimental effects for the environment for many reasons, so Parking has been a fundamental part of daily life.

Parking space is one of the most significant aspects of urban environment, as Paul Groth (1990) asserts parking lots present urban planners and designers an enormous opportunity to enhance the character and vibrancy of urban areas.

"The ancient Egyptians organized their life and their gods in reference to life-giving Nile. Colonial New Englanders organized their village life around the axis mundi of the meeting house, the place that manifested their connection to the cosmos. Although it happens just below the level of awareness, the parking space probably generates the most significant sense of personal and social place in the cosmos for today's urban Americans; it is their major axis mundi"(Groth, 1990, P130).

Most of the parking lots are large in area, with minimum of landscape and green areas. In most cases, parking lots are assumed as place for car storage without any aesthetic value and environmentally function . Impervious surfaces, such as parking lots, roadways, and roof tops, lead to more storm-water runoff and pollutant loads than any other type of land use (Rushton, 2001). allotting more spaces to parking lot construction, which means that more pavement has to be construct and more pavement means less green space and thereby reducing the number of tress and vegetation that serve as natural air cleaners. It also means less open soil that can collect rainwater, which helps to refilling natural aquifers. Asphalt and concrete is one of the common and known materials, which have been used in parking lots, these artificial covers due to the dark color and low moisture content accumulate extreme heat. Due to the high ratio of impervious surface, parking lots increase heat island effects, storm water pollution and runoff and air and light pollution and these are significant role in harming the ecosystems.

The way of parking lot planning, constructing, maintaining, demolishing and replacing has a huge impact on the environment, health, living conditions and the economy. Parking can have an even bigger impact by considering how it can be impact the urban areas by their designs method, enhance it, and reduce the environmental problems .

With new strategies in the design, parking lots can have the ability to transfer from an environmental problem to an independent working ecosystem. Sustainability concept emerged as result of ever-growing environmental concerns. Principles of sustainable design can be applied to the design of parking structures in order to minimize their impact on the environment, enhancing and protecting ecosystems and biodiversity. Environmentally friendly landscaping can improve water, air and soil quality, provide habitat for wildlife and protect biological diversity; reduces waste and conserves natural resources, there are also economic benefits as well, such as reducing the cost of parking for stormwater infrastructure and utility maintenance.

In this study, parking lots in Istanbul were analyzed in relation to the existence of sustainable design criteria in both small and large scales.

1.1 Aim of the Study

The purpose of this study is investigating sustainability strategies in parking lots and concentrate on how to design sustainable, environmentally friendly parking lot in order to minimize their impact on the environment and reduce the negative effects of common standard of parking lots. This study explores and assess the design strategies for surface parking lots, in terms of sustainability. In addition, create strategies for municipal governments, developers, business- owners, landowners, residents and community activists to vitalize parking lots as environmentally friendly places. It is my hope that there are practical strategies presented that can be used to promote more environmentally sound parking lots, thus improving our built landscapes and giving more purpose to our shared realm of the public environment.

1.2 Theoretical Framework

The method that used in this study were composed of various investigations on green design initiatives in parking lots for providing sustainable landscape by:

Review of literature regarding approaches to designing green parking lots and current knowledge about green parking lot,

Review of guidelines, memos and project documents,

Site visit to understand the layout and observe site conditions,

Meeting with ISPARK staff regarding green design practices, and the parking lot standards and maintenance (JUN 10, 2015).

Email exchanges and in-person discussions, including with Buck Abbey (Louisiana State University) and Anita Jeerage (LEED Specialist).

The study comprises of steps that include history of parking lot, environmental effects of surface parking lot and examples of green design in surface parking lots and then developing table for recommendation for case study. Green design has been used in parking areas for providing sustainability. This study explores the methods of green design from landscape design perspective.

The study consists of four steps including

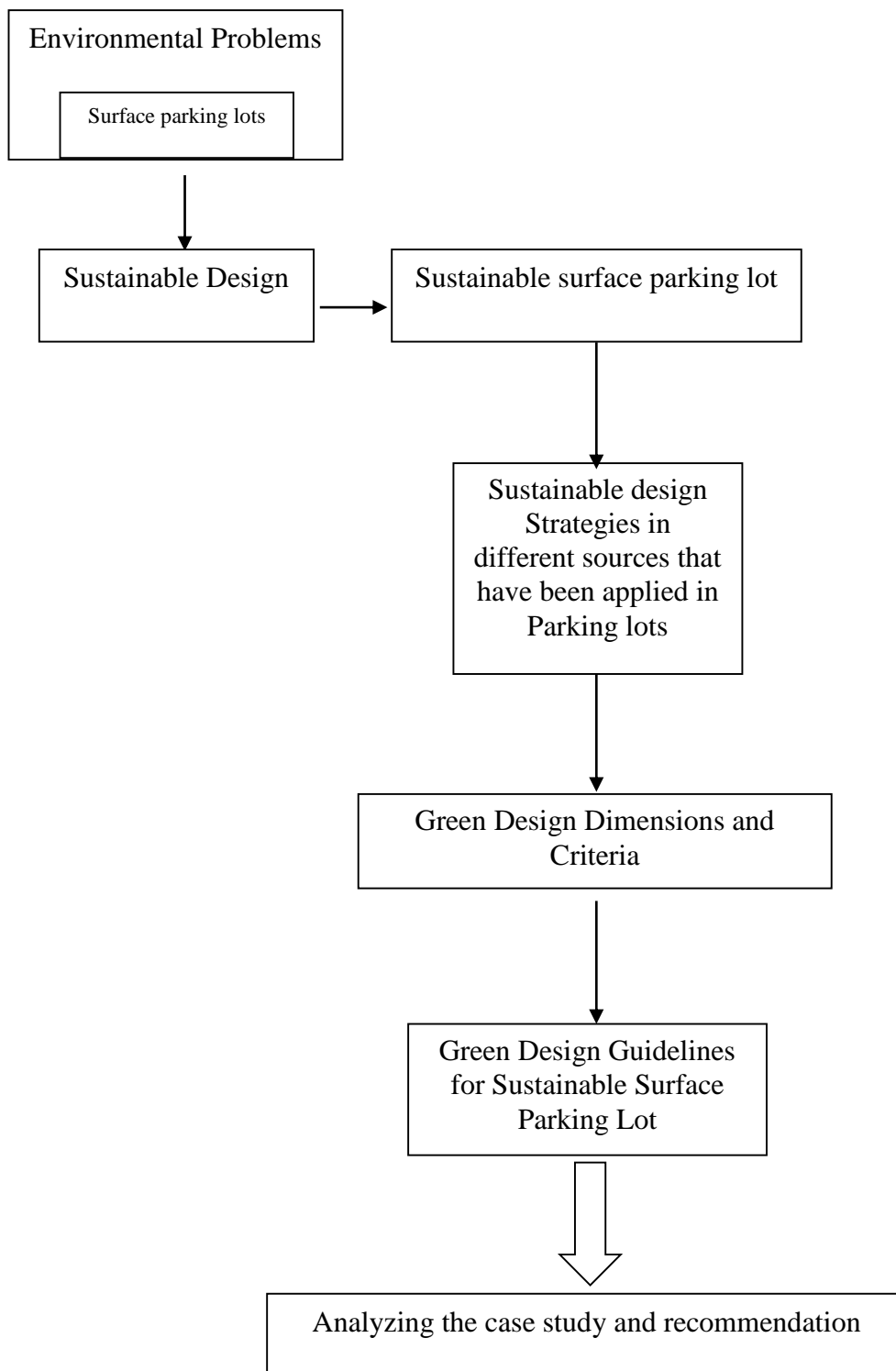
First chapter is introduction part that includes the purpose, objectives and structure of the research.

Second chapter, includes the review of the surface parking lot history: how it was formed and evolution process by the time, transforming historical policies and design from curb or street parking to off-streets lots. Expresses the related issues with surface parking lots and their urban morphology, focuses on the parking lot environmental impacts, aesthetics and social influences, explains the conditions that led to change in the design of parking areas, and asserts the initiatives and innovations strategies that create to response the environmental problems.

Third chapter explains sustainable design in parking lots according to the different sources and examples of great lots from around the world as best practices and each project include the descriptions and explanations of its key innovative, and analyzed in relation to green design initiatives, and then a table has been created to showing different aspects of the sustainable parking lots and their components

last chapter of this thesis contain of three folds: general comparison of the Istanbul' s surface parking lots between the 2014,1982 and 1966 years'. analyzing of the surface parking lots in different location and sizes according to sustainable design table, and proposing a designed model according to the literature review and standards of the different communities, a table for sustainable design of parking lots were proposed by determining green design guidelines. (Table 1.2) shows the framework of the study.

Table 1.2 : Framework of the study.



1.3 Definitions and Historical Backgrounds of Parking Lots

In this section, the meanings of the parking lot will be summarized according to the dictionary and primary landscape architectures and the genesis of parking lots in western world and the consecutive evolution of the design process of surface parking lot. Moreover, the study will investigate the codes and regulations that shaped its form and classify the lot morphology.

1.3.1 Parking lot

For understanding Parking etymology, it is essential to mention the roots of the word Park. Its root is related to the post-classical Latin word "Parricus". The word "Park", According to the Oxford English Dictionary, first time used as a large enclosed area of lawn land or woodland where one keeps and raises animals for the hunt and recreation (1160–74). around end of the early of the 16 century this word was used as a place for gathering and keeping things in a place, and around 18 centuries the word was used as a place for collection of vehicles which an army makes use of. Finally, around 19 centuries widely used as a verb for a place to sorting vehicle temporary (URL1).

According to the 1800s documents, Prominent landscape architecture of the time, Frederick Law Olmsted (1871), had proposed the term "parking-system" for wide streets that design with the green, lush, and parklike medians in center. (Figure 1.1) shows the street parking concept. Olmsted, in his proposal, "parking" was applied in referring to greening the street, vegetated tree-lined strip along sidewalk, not just medians (Howard Brown, 1904).



Figure 1.1 : Street parking: greening the avenue (Ben-Joseph, 2012, 57).

Early in the 20th century, "park" word was used for a place and the action of parking cars (Figure 1.2). Based on the *New Orleans vs. Lenfant*, 126 La.455, 52 So.575 (1910) decision, which defined parking as "to bring together in a compact body, within a park or enclosure, objects not in actual service but held for use when required."(Lloyd, 1929).



Figure 1.2 : Washington DC, Arsenal Park of Artillery,1862. (Ben-Joseph, 2012, 54).

1.3.2 Historical evolution of parking lot planning

There were apparent changes in parking lot morphology and process of their formation and transformation during the time. The philosophy of existence of the parking lot refers even before the automobile coming to existence. It starts with the management of ancient vehicles and their accommodating surface design. (Ben-Joseph, 2012, 53).

Assyrian King Sennacherib, who governed from 705 to 681 BC, had signs posted along the main highway of his capital city to ensure the route was kept clear of parking carts. The markers read: "Royal Road- let no man decrease it." The king directed that any person whose property or possessions exceeded upon the 24-meter-wide roadway should be put to death and impaled upon a pole in front of his house. (Ingraham, 1954, 18). Before the automobile came into the world people traveled by horses and chariots, and during these times it was common to tie their horses to a post in front of the buildings (Miller, 1988). Most of the cities have post for Hitchings the horses and most of the streets were broad enough for angled parking for horses and wagons (Figure 1.3). late of the 18th century most of the streets in America and Europe were

insanitary due to the lack of drainage system and horses manure, to prevent of congestion and stink smell of horses in the curbing stations in the main roads, some places at the end of the main street was considered for clustering horses, later by emerging the motor vehicle as a way to enhance the mobility , health and physical condition and by replacing horses by automobiles, many of the these stables remain and become open parking lots and garages (Ben-Joseph, 2012, 62).



Figure 1.3 : Angled parking in front of the buildings (Ben-Joseph, 2012, 56).

The shift from horses to the automobile as a major mode of transport during the early 20th century allowed for the return curbside parking. Ben Josef in his book *Rethinking a Lot* stated that during the 1900 and 1920 years' curb parking become a prominent traffic control problem. Increase in the number of cars in the cities and, curb parking cause more terrific and disorder in the streets, by arise the terrific problems that related to the curb parking, rules and legislations for on-street parking started to be revealed. Different solutions were proposed to solve these problems, some municipalities inhibited the entrance of the cars to the city center, while other municipally banned on-street parking and allotted specific lots for storage of the cars, in fourth decade of the 20th by these decisions, urban surface parking lots became one of the prevailing characteristic of downtown America.

Eno in his publications "*The Storage of Dead Vehicles on Roadway*" cited that there were two words that applied for the stopping cars in the road near the curbs in United States: "to rank (ranking)" and "to park (parking)". The differences between the ranking and parking were in the occupancy of the space and the angle between the cars

and curbs (Figure 1.4). In the ranking vehicles stand one behind the other and parallel to the curb with little space in between and in the parking vehicles stand parallel to each other and with an angle to the curb. Enno writes: "when vehicles are ranked, no one of them can move out of the line independently of the others, unless considerable waste space is allowed for between them, whereas when they are parked, being parallel to one another, any of them can get away without causing any other one to move." (Enno, 1924, 169).

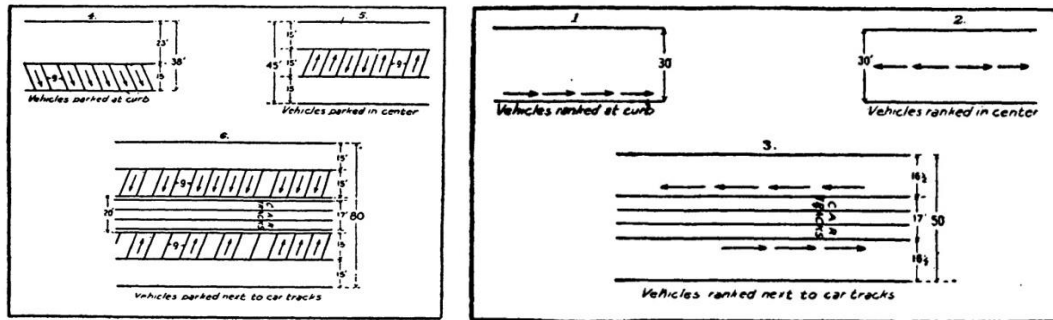


Figure 1.4 : To park and to rank (Enno, 1924, 169).

Most of the cars abandoned without passengers and driver in the streets and this was a major problem for cities. Enno divided the parked automobiles with "live" and "dead". A live car is one whose driver is present and can move vehicles and dead car is one whose driver is absent and unable to move the vehicle. Dead vehicles were seen as a problem for parallel to curb parking because cars need to move of the other cars for movement accordingly to obviate the inefficiency that related to ranking cars, legislators suggested two solutions: limit curb parking only for live vehicles and allot off-street spaces for dead vehicles. Moreover, he predicted the emergence of parking lots in the congested part of the cities or where a little far from the destination and people can leave their cars and proceed by streetcar, bus or taxi (Enno, 1924, 170).

One of the earliest urban surface parking lots was constructed in Los Angeles in the 1922, and then followed by Flint, Michigan, in 1924 and Chicago and Boston in 1930, most of the sundried and, some of the parking lots were constructed near the rail ways and shopping centers, the goal was to providing facility movement from cars to rail (Ben-Joseph, 2012, 68-73).

In the 1950s there was a correlation with lot design and urban forms, there has been a major change in urban dynamic and expansion of the countryside, city core has declined and most of the business districts were moved toward the suburban. during

the 1920 and 1930 parking lots play important role as a financial income, because of constant income with minimal investment, there was little or no need for site reconstruction, maintenance or operating fees in the Parking lots (Ingraham, 1954, 226).



Figure 1.5 : Chicago, 1930s. off- street parking lot (Ben-Joseph, 2012, 68).

Simultaneously most of the old buildings in down town were cleaned as a process of cleansing unpleasant uses from city center (Figure1.6), parking lots were the best short- term solution for vacant lands. Surface lots were interim placeholders with little or no enterprise as land owners awaited the opportunity to build. These “temporary” placeholders became widely accepted as the default program to implant within vacant lots, the process of increasing of suburbs changed the dynamic of downtowns and spurred the decline of Central Business Districts and also lead to the reduction of tax revenues. Zoning for surface parking at the center of the city was seen as a method to remedy this condition and to prevent with the decentralization. parking requirements were authorized and government through the use of condemnation and eminent domain imposed landowner to provide off-street parking when a change occurred to the existing use of their lands , some of the municipalities established municipal parking authorities, the aim was to offering low-cost, convenient parking's in the city centers and evoking the downtown from decline and backing into the commerce and

business, it was only in the late of 1900s that municipalities realized the parking lots as a potential source of revenue to replenish reserves . Thus, city centers promoted the tearing-down of vacant buildings and replacement with surface lots, in hopes of attracting suburbanites back into the city centers with easy parking. nowadays as Eno predicted these placeholders are still dominating city centers (Ben-Joseph, 2012, 76).



Figure 1.6 : Denver, 1950. Depleted land as a parking lot (Ben-Joseph, 2012, 75).

Extensive expanse of parking lots and their ugliness and unattractive visuals led to disguise their impacts, thus in the 1950s, aesthetic aspects became considerable subject among traffic and road engineers. Many of these considerations accompanied with the zoning ordinances. But most of these aesthetic considerations have not been put into practice and a preference for quantity over quality, was affected the parking lot visual impacts. Ben Josef pointed out that "aesthetic considerations replaced by desire for excessive supply and ease of movement. The result has been an overwhelmed landscape filled with unattractive, harsh and unpleasant seas of asphalt parking". In the 1930s, rapidly changing in the transportation issues led to formation of professions such as transportation engineering to study and improvement of the traffic issues. Later contractors and transportation associations started to enter the Standard- setting to centralize in the parking design standers. Most of the standards have been concerned with dimensions of stalls, parking angles, location of exit and entry points, the outcome lots are oversized and paved with harsh materials. with little or no attention to

ecological impacts, even when a code related to be aesthetical issues, the code was deficient and vague. After the mid-1970s, along with the improvements in the social and civil rights planning and accessibility criteria started to gain attraction and lack of standers to disable people started to appear, and during these years' environmental organizations were established and renewed looks at the way reigns and neighborhood design were designed, started to appear (Ben-Joseph, 2012, 92).

The parking network (including lots, garages, etc.) covers 6% to 40% of the land in American cities (Childs, 1999, xix). Figure 1.7 shows aerial images of downtown Austin, Dallas, Houston, Jacksonville, Little Rock and, Tulsa these maps show how parking occupies a huge land area in these cities, right next to their central business districts.

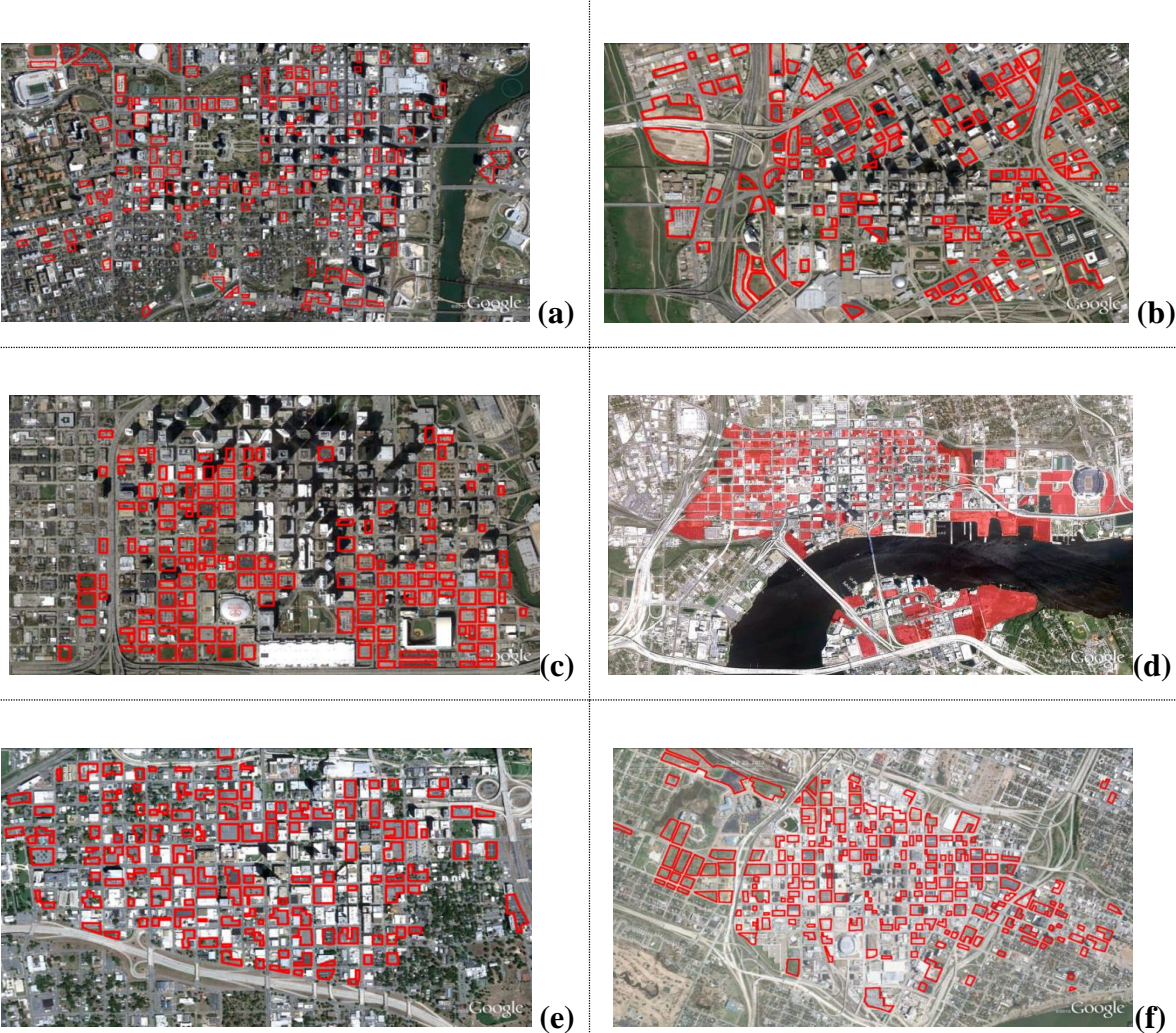


Figure 1.7 : Parking Lots as Voids. Red represents parking lots and vacant lots. (a) Austin, (b)Dallas, (c)Houston, (d)Jacksonville Red XL, (e)Little Rock, (f)Tulsa L. (Metro Jacksonville, 2011).

2. DESIGNING OF PARKING LOT AND SUSTAINABILITY

Surface parking lots are inexpensive to construct, according to the Victoria Transport Policy Institute analysis in “2008 the average per-space cost of surface parking was \$4000, versus \$20000 in an above-grade parking structure, and \$30000-\$40000 in an underground garage” (Victoria Transport Policy Institute, 2006).

Most of the time Surface parking lots are neglected during the design process because most of the designers underestimate the effect of parking lots on lifestyle and environment conditions. Sustainable/Green design of parking lot is an approach that promotes and protects ecosystems and habitat. It also ameliorates quality of water and air, lessens waste and maintains natural resources. There are also economic benefits as well, such as decreasing the cost of parking lot for construction and operation, enhancing asset value and profits, and optimizing life-cycle economic efficiency.

2.1 Environmental Impact of Parking Lot

Environmental impacts of parking lots become increasingly apparent, as they become a dominant feature of urban landscape. Most parking lots are made of combination of asphalt concrete with base course of sand, gravel, or crushed stone. Large surface parking lots can contribute to drainage and flooding problems, increase urban heat islands, become visual eyesores, and encourage people to abandon mass transit, thereby accentuating air quality problems and increasing the energy consumption and costs (McPherson, 2001, 353-369). With increasing of impervious surfaces, stormwater volume and speed increase. A one –acre parking lot produces almost 16 times the volume of runoff as that from a similarly sized meadow; it not only increase water volume runoff but also prevents recharge of aquifer (Ben-Joseph, 2012). These impervious pavements caused to raising stormwater speed on its surface and do not allow it to filter into the soil and interdicting the natural water cycle, materials used to construct parking lots have a variety of impacts on water, air and biodiversity throughout their life cycle. Traditionally in parking lots for collecting water bodies as

quickly as possible piped drainage systems and gutters have been used as primary method of channeling storm water that these ways lead to a danger to the supply of potable water. As runoff, that is contaminated with many types of petroleum remnant, fertilizers, pesticides, and other pollutants from parking surfaces, enters streams and waterways at an unnaturally high rate and volume, consequently, decrease in oxygen levels and increase in nitrogen and negatively impacting the surrounding ecosystem, Impervious surfaces including rooftops, roads, parking lots, sidewalks, patios, and compacted soil are increased by the growth of developed areas. Runoff from the construction of buildings, roads, and sidewalks; emissions generated by travel; and the use of chemicals for landscaping all negatively impact water quality. In addition, type of materials that used for parking lot covering have strong impacts on air quality and wildlife cycle (EPA, 2001, 9).

Parking lots can be considering a part of an ever-changing cycle of use and function and parking areas can integrate natural and absorbent elements to filter contamination. Changing the use of contaminated sited and convert it to a parking lot can remediate and the site and changes in environmental or use conditions.

Ben-Joseph in the third part of his book ,”Rethinking a lot”, asserts that some plant species can remove lead from contaminated areas moreover, parking lots that are used in special times such as those adjacent to large sports stadiums, could be designed with a repairable vegetated surface to decrease adverse environmental impacts. Parking lots by having this abilities can be integrate in both transportation systems and environmental ones (p119).

Studies of global warming in U.S. began in the early 1900s. Most of the cities in the word recode all-time high temperatures in the summer, experts ascribe this phenomenon to a combination of global climate change and the Urban Heat Island (UHI). dark roofing, paving materials and lack of vegetating cover in urban areas are the most significant factors of increasing temperature near the ground. "Air in the canopy layer including below the tops of trees and buildings, is warmer approximately 10°F than the air in rural areas and air in the boundary layer, from rooftop level extending up to about 6,500 feet above the earth’s surface, also becomes warmer, and can cause temperature inversions that trap warm surface air (Figure2.1). Summer inversions can increase human health problems and escalate energy bills"(Wolf, 2004)

Paving materials absorb much of solar radiation because they have Low reflectivity and Albedo, absorbed solar radiating heat up the materials and cause to reradiate the heat in the surrounding environments and increasing the ambient air temperatures (Calkins, 2012, 391).

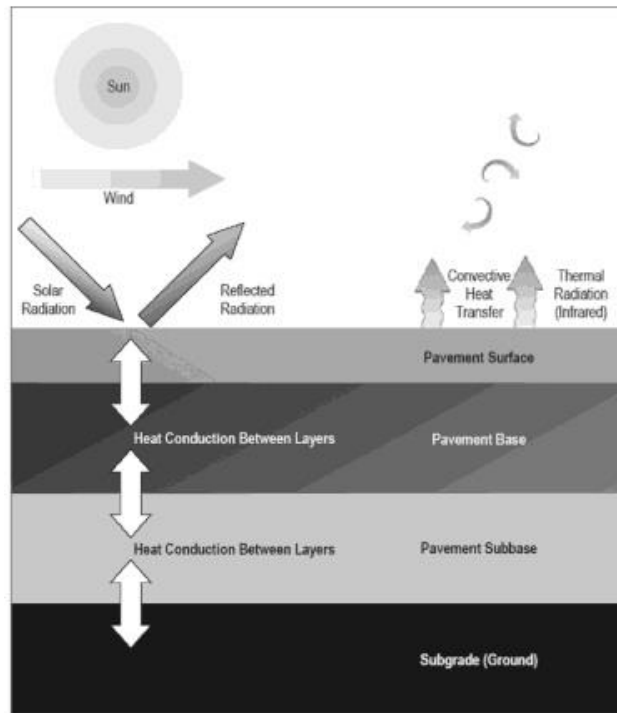


Figure 2.1 : Schematic Pavement Section-Contribution of the Pavement to the Urban Heat Island (Calkins, 2012, 392).

Choosing of pavement materials as one of the urban landscape design steps, can have enormous impact on the mitigation of intensification of the urban heat island effect. Asphalt pavement and other dark surfaces as a one of the common pavement materials in surface parking lots have a primary effect on the UHI. Black asphalt as a conventional pavement absorbs rather than reflects the sun's radiation and causes the increasing the pavement surfaces and surrounding air temperature (Pomerantz et al, 1998, 51). Two features of the dark material causes for contributing in Urban Heat Island effect first feature is "excessive accumulation of heat" and second is level of "moisture content"(Wolf, 2004).

In 1994, NASA (2003) used an airborne scanner to establish data at the Madison Square Mall in Huntsville, Alabama, according this examination, surface temperatures in a spot in the middle of the parking lot reach about 120°F. (Table2.1) However, the temperature of a tree island or a small planter containing a couple of trees, in the

parking lot read at only 89°F. Temperatures decreased by 31°F, even with a small area of tree shade surrounded by a very hot parking lot (NASA, 2003).

Table 2.1 : Vegetation Cooling Effect (Maco &McPherson 2003, McPherson 1998).

Vegetation Condition	Compared to:	Air Temperatures
Tree groves	Open tertian	9°F cooler
Irrigated agricultural fields	Bare ground	6°F cooler
Suburb with trees	No suburb, no trees	4 to 6°F cooler
Grass sport field	Parking lot	2 to 4 F°cooler

2.2 Parking Codes and Ordinances

Legal code, ordinances and regulations are significant tools that communities can use to encourage, require and enforce sustainable practices (Wolf, 2004, 2). regulations that related to the parking lots are 2 fold: fist is landscape regulations and second is the traffic regulations.

Rapid growth in the number of vehicles in urban areas cause, directly, indirectly and cumulatively to environmental problems and lead to appearing New trend in writing new codes in landscape design to solving these harmful effects. This new trend of landscape ordinances moving toward sustainability based design for solving and diminishing adverse effect of the vehicles in the environment. In the viewpoint of the public, Landscape codes have always been looked as a beautification approach, not a way to solving ecological problems. Expanse of cheap asphalt and a net of white lines is a one of the typical designs of the surface parking lots. This land is often unsafe and from the aesthetic view is ugly and unpopulated, the aim of the primly design standards were to just accommodating and storing the automobiles, but when drivers step from their vehicles and become a pedestrian the lot become an unfavorable place. (Childs,1999, xxi).

Most of the Contemporary landscapes codes back to the late 1950’s as a response to the unsightly appearance of surface lots, and most of these primary codes were applied in the private multifamily developments parking lots (Craw, 1947, 11). Developer, Charles E. Fraser, stated these codes but landscape architect Hideo Sasaki emended

and refined the codes (Abbey, 2011, 2). Regulatory purpose of the landscape ordinances in parking lots related to the Beautifications and visual quality. In addition, perimeter planting was the most common requirements. Recently code aims and goals have become more comprehensive and explicitly address the environmental benefits of having nature and ecosystems in cities.

Until 1900, there was not any serious attempt to apply mandatory traffic regulations in United States. (Figure 2.2) shows the Chicago in 1929. In 1939, the number of vehicle reached to 23 million across the United States, and city centers such as downtown Chicago, had already become auto-centric areas with streets covered in moving and parked vehicles. Court cases and regulations that related to vehicle and roads had been emerged; Al Jackle and Sculle, geographer and historian, in their book: *Lots of Parking: Land Use in a Car Culture* inferred the prime regulation of parking as a solution to mass car ownership with chaotic parking habits. Court cases started to appear and have dealt with behavior of drivers and pedestrians on the street, parking definition, speed limit of the automobiles on the road and matters such as on which side of roads automobiles should pass (Ben-Joseph, 2012, 55).



Figure 2.2 : Chicago, Illinois 1929 (Ben-Joseph, 2012, p64).

After various traffic laws were applied, it became obviously clear that laws and regulations needed to be created ameliorate the roads condition and from chaos—to created order of cars parked along the streets. Ben-Joseph points out that in the early

1900s, traffic legislators, such as William P. Eno, predicted the emergence of parking lots in 1909, William Phelps Eno was one of the forerunner creators of traffic safety rules in United States and Europe, his "rules of the road" was first city traffic plan and accepted by New York City. He suggested the accomplishment of speed limits, taxi stands, pedestrian safety, turn signals and enhanced the adoption of the rules as laws in New York City and also in 1921 he constituted the Eno Foundation for Highway Traffic Regulation. (Url-13) in the 1924 with the collaboration of the Bureau of Public Roads of United States and Eno Foundation, the traffic and vehicle codes and standards revised and reclaimed for implemented across United States (Ben-Joseph, 2012, p55). "in August 1923, The first reported ordinance for off-street parking was in Columbus, Ohio, where, requirements were composed which prescribed that off-street parking spaces be provided in connection with multiple-family dwellings"(Craw, 1947, p14).

In the 1930s, the transportation engineering profession founded through the Institute of Transportation Engineers(ITE) and a specialized education program at Yale University to the enhance and improve the traffic impacts and road networks and terminals as well as, achieve efficient and free and rapid traffic's flow. In the 1941s, this program published a handbook due to the federal government request to providing traffic engineering guidelines and standards. Only 9 pages of the 320 pages were about parking lots and only 3.5 pages concentrating about off-street, and there was little information about parking lot design, most of the sections devoted to the demand and supply and stalls geometry (Ben-Joseph, 2012, p84).

In 1946, *Parking Manual: How to Solve Community Parking Problems* published by the American Automobile Association. This was one of the earliest parking design standards. Another standard setting association was the *Parking and Highway Improvement Contractors Association* established in 1960. And another one was *Los Angeles Parking Standards Design Association* founded in the 1970 (Ben-Joseph, 2012, p85).

Later in 1947 a study fulfilled by the Eno Foundation throughout a whole nation and Foundation gathered data from 586 municipalities on what types of requirements they had and the outcome shows that only 12% of the municipalities had parking regulations. (Ben-Joseph, 2012, p76). National Parking Association had been formed by 1951 and, nearly 200 cities had adopted minimum off-street parking requirements in their zoning (Jackle,2004, p77). Landscape regulations have become a major and

standard part of American zoning laws over the decades. Zoning ordinances and land development regulation ordinances contain these regulations as part of zoning law; they fall under the community's police power to adjust the use of land and the way it is expanded (Abbey, 2011, p2).

2.3 Changing in the Design and Planning Spaces for Car

Jackle, John and Keith A. Sculle (2004) asserted in their book "Lots of Parking: Land Use in a Car Culture" that "Parking lots were parking lots. For the most part they existed not so much from building something new as by demolishing something old. Beyond signage, few of the accoutrements of place-product-packaging readily applied. Parking did not involve architecture (p 160)." For the decades parking lots was not considered as a designable part of cities, but by increasing the number of the automobile in the urban areas, Motor Vehicles and consequently parking lots become an increasingly dominant feature of the city centers. According to Ben-Joseph, 500 million surface parking spaces exist in the United States and are set to increase. These 500 million parking spaces if consolidated into a single location, they would occupy an area equaling 9.300 square kilometers. This area is the equivalent of the size of Puerto Rico (p 13). Most of surface parking lots were underdesigned and poorly maintained because owner refused to investment on their lots and anticipated to change the usage of lands, this drastic situation leads to setting some standers for design and investment. Ben-Joseph asserted that in the 1930 primary regulations for off-street parking lots started to appear and applied in building construction and added into zoning regulations. One study accomplished by Eno foundation about the existence of the provision on parking lots in the municipality regulations and the result lead to increase in legislation requiring a critical mass of surface parking lots (Ben-Joseph, 2012, 76). However, these regulations did not address the design quality of lots and most of the related to multifamily dwellings and distance between parking and building.

2.3.1 Emerging sustainability and green design concepts in parking lots

In the mid of 19th century, public notifications about environmental hazards had risen when detrimental and apparent consequences of the mechanized world on nature augmented. Despite the fact that the most important steps in the environmental

planning is mainly dated to the late 1960s and early 1970s, there were earlier visions that impressed the field of environmental planning, as mentioned before Frederick Law Olmsted's plan and ideas in the design of Washington, DC, he had proposed the term "Parkway –system " for the layout of broad streets with green, lush, parklike medians in the center. His idea demonstrated the significance of the cities environment in human life; Olmsted for the reclamation and rehabilitation of damaged environments in the cities that created unhealthy situations for the individuals used parks and parkways as a tool. (Olmsted, 1870). After Olmsted in the late of 1890s book of "Garden Cities of To-morrow: A Peaceful Path to Real Reform " published by Ebenezer Howard, his book suggested a vision of towns free of slums and enjoying the benefits of both towns such as opportunity, entertainment and high wages and country such as elegance, fresh air and low rents, his viewpoint place extra emphasis on environmental planning field in Europe and later in the U.S. (Erbil, 2005, 23).

Regional Planning Association of America in New York, USA had been influenced by Ebenezer Howard's Garden City idea and Patrick Geddes's Regional Planning idea. In addition, a new type of thinking and approach to environmental planning was presented by Kevin Lynch in the 1960s. He claimed that the environment is a subject to be interpreted and perceived by individuals. This perception is not uniform since humans' values and backgrounds are not uniform (Lynch, 1960).

In 1962, Rachel Clacson in "Silent Spring" book attracted the views for the environmental issue: use and abuse of detrimental new chemicals in agriculture and pest control, she pointed out in her book that: environment and nature could have meanings other than production and aesthetics since its components can be affected by human actions in a way that can cause deaths or pathologic illnesses. Ian Mchargs in his book (1969) in "Design with Nature" redefine the more scientific side of the landscape architecture, urban and regional planning, and ecological design. It has also left a permanent mark on the ongoing discussion of mankind's place in nature and nature's place in mankind within the physical sciences and humanisms. He asserted some basic and important principles of nature that had been ignored in the industrialized world. (Erbil, 2005, 25). These books were the first steps toward ecological and environmental problems and influenced governmental agencies and organizations mainly in the U.S. and European countries, in addition led to fundamental changes in thinking and in ways of operating and protected the

environment with new policies, and tried to find scientific approaches to assess the present condition of the environment in order to protect its equilibrium such as United States Environmental Protection Agency (EPA) born in the wake of elevated concern about environmental pollution especially air pollution, EPA was established on December 2, 1970 to consolidate in one agency a variety of federal research, monitoring, standard-setting and enforcement activities to ensure environmental protection. In 1973 for diminishing the adverse impacts of vehicular emissions, and for the dismissing the air pollution EPA assumed parking impact as an important pollution sources and presented a traffic control strategy (Ben Josef, 2012, 93). For three decades, EPA concentrated on parking lot management practices and pollutions control techniques.

In the 1993, formation of The United States Green Building Council (USGBC) changed the way of the community was designed. The members of the USGBC quickly understand the need for a system to define and measure of "green buildings". Less than a year after formation, a committee established to focus on this topic later the first LEED (Leadership in Energy and Environmental Design) Pilot Project Program, also referred to as LEED Version 1.0, was launched at the USGBC Membership Summit in August 1998 (Url-14). However, LEED consists of essential standards for parking lot design but this program does not address parking lot design from a landscape design point of view (Abbey, 2011). In the late 1990 and the early 2000s, that EPA starts to present new parking design techniques. *Parking Spaces / Community Places: Finding the Balance through the Smart Growth Solutions* and, *Green Parking Lot Resource Guide* published by EPA in 2006 and 2008, in these publications explains specific design techniques especially about stormwater management.

2.3.2 Green parking lot experiments

In 1977, Environmental Protection Agency (EPA) constructed a porous asphalt parking prototype at the University of Delaware in Newark, the purpose was to develop low-impact paved surface next to a sensitive environment. After 27 years, the parking lot was sealed and still in good shape without no especial maintenance (Ben-Josef, 2012, 95).

Another experiment has done by EPA in 2009, about 43,000-square-foot parking lot area, at agency's Edison, N.J. facility, replaced with three different pavement

materials, including interlocking concrete paver blocks, porous concrete, and porous asphalt. In this study for evaluating the efficacy of pavement types and the rain gardens in removing pollutants from stormwater and the ability of rain gardens to allow the ground to better penetrate and filter stormwater, which alleviate maximum flows, EPA installed permeable pavements and created several raingardens with various type of vegetation (Figure2.3). This study by using different designs and material types will help to develop strategies to diminish the adverse impacts of surface parking lots and ameliorate environment conditions for been more sustainable (Url-11). Below the permeable pavements, an impermeable liner was installed. This water that sinks into to below-grade tanks, use for collection, measurement, and sampling. This allows the researchers to examine each material’s reaction to a variety of contaminants that exist in water. To recognize origins of pollutants, infiltrate samples are compared to rainwater samples and stormwater runoff samples taken from the conventional asphalt regions that canalization into the rain gardens on the southern-part of the parking lot (Url-12).

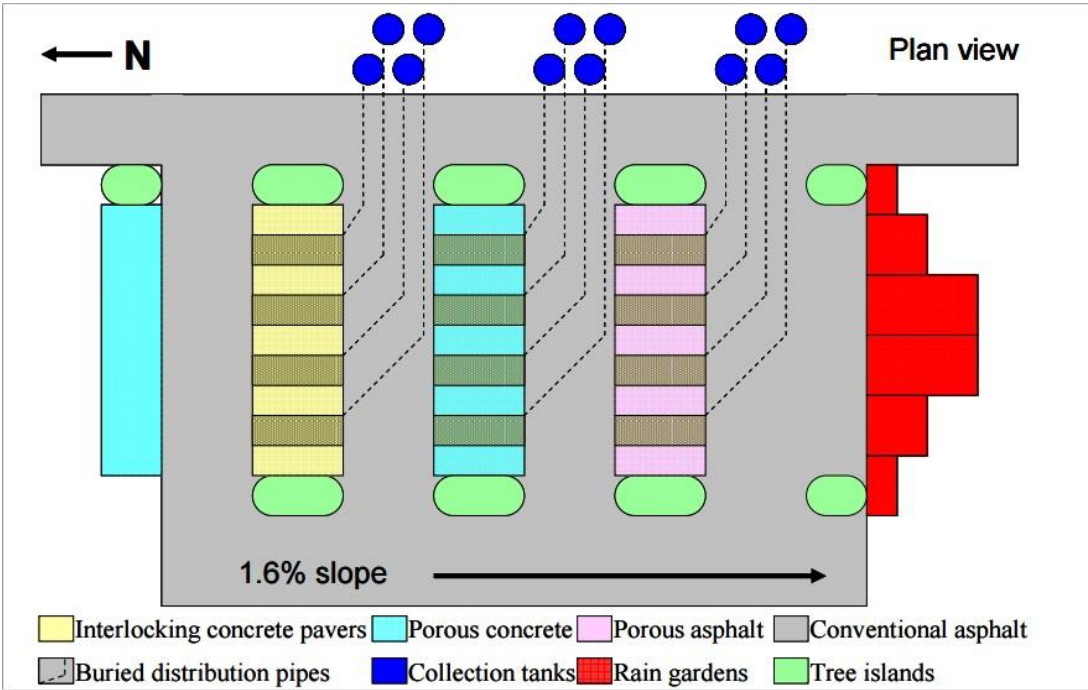


Figure 2.3 : Plan of the parking lot at the Edison Environmental Center (Url-11).

Over the next decade, EPA researchers will evaluate the effectiveness of each pavement type and the rain gardens in removing pollutants from stormwater. They will also measure how each type of permeable pavement helps water filter back into the ground.

2.4 Parking Lot Events

vast amounts of land in urbanized areas are occupied by Surface parking lots and surface parking lots are relatively free of structural facilities. They are as close to a blank slate, physically, as can be found in urbanized areas. As Childs claims: "Design [of parking lots] should not simply allow public use, but should facilitate public use and reflect the fundamental dignity of civic space" Access to public space is a quality of life issue; parking lots have the potential to provide greater amenity for surrounding areas. There are several activities and events that related to the parking lots, these activities are mostly to emphasizes on the parking and car culture roles in our daily life.

2.4.1 Parking lot day

PARK(ing) Day is an annual, worldwide event that started in 2005 by San Francisco-based art and design to protest the lack of the green spaces in the city, and this movement inspires city dwellers to rent metered curbside parking spaces and afterwards transform metered parking spots into temporary parks for the public good such as temporary urban farms, open free bike repair shops., build art installations and etc., Figure 2.4 shows parking day activities in different communities. parking day events have quickly spread around the globe. In 2009,700 installations were performed in 21 countries and 140 cities (Ben-Joseph,2012,117).



Figure 2.4 : parking Day Activities in different cities (Url-18)

Parking Day focuses on curb parking areas, according to the writer, it can easily be spread through the parking lots and transform it.

2.4.2 Walkmobile

in 1975, an Austrian civil engineer Hermann Knoflach developed the Walkmobile, he compared the amount of space that one person takes by a motorist to one person walking.



Figure 2.5 : Walkmobilitie (Ben-Joseph,20120 15).

For protesting against the priority given to automobiles in the city, or just taking a walk in traffic and excessive land consumption(Ben-Joseph,2012,13).

3. DESIGN EVALUATION CRITERIA FOR URBAN PARKING LOTS IN DIFFERENT SOURCES

This chapter will demonstrate viewpoints about the urban parking lots and green strategies in parking lots, and the key factors and techniques that improve the quality of the parking lots and mitigate negative impacts of parking lot on the environments. There are Landscape Architects and agencies that focus on the parking lot design.

There are different sources that has been defined Sustainability and sustainable development, however, Bruntland Commission Report of 1987 definition is one of the most accepted definition. According to the Bruntland Commission Report, sustainable development is “the ability to meet the needs of the present without compromising the ability of future generations to meet their needs”. The first and significant goal of the sustainable parking lot study is to find out a way to linking and filling the gap between sustainable development/sustainability and parking lot design and implementation. Parking lots throughout the world have followed a design that is inconsistent with the path of sustainable practices have become prevalent in today’s lifestyle and green initiatives.

Expanse of cheap asphalt and a net of white lines is a one of the typical designs of the surface parking lots. This land is often unsafe and from the aesthetic view is ugly and unpopulated, the aim of the primly design standards were to just accommodating and storing the automobiles, but when drivers step from their vehicles and become a pedestrian the lot become an unfavorable place. (Childs,1999, xxi)

Beautification and Visual Quality of parking lots was one of the first and primary reasons of emerging the parking landscape ordinances. amenity and beautification concerns are the historic foundation of green law in the most communities. for instance, San Francisco Green Landscaping Ordinances' purpose was to achieve the environmental and aesthetical goals such as:

A. Healthier and more plentiful plantings through screening, parking lot, and street tree controls;

- B. Increased permeability through front yard and parking lot controls;
- C. Encourage responsible water use through increasing “climate appropriate” plantings; a
- D. Improved screening by creating an ornamental fencing requirement and requiring screening for newly defined “vehicle use areas.”

There are landscape architects and urban designers who focus on different aspects of the surface parking lots, Mark Childs (1999), urban and regional designer in the *Parking Spaces* book presents guidelines for analyzing parking lot form environmentally concerns, safety, convenience and location.

Toshihiro Katamaya (1997), Robert Irwin (2003), specialized their designed parking lots projects by composition of the parking areas with interior and exterior spaces. they believe Integration with inside and outside spaces is one of the physical and prime feature of the surface parking lots. And parking lots have to be conceded as part of the overall design scheme. Most of the attention has gone into determining the proper geometries of the spaces themselves than to the overall design of the lot and how it relates to its surroundings.

One of the features of surface parking lot that was mentioned by various landscape architect in their designs is considering the parking lot as a place for installation permanent or temporary artistic or cultural statement. Since early as the 1950s artists have recognized the lots potential for ephemeral installations.

additional to current and previous books and researches about designing of surface parking lots there are some guidelines for greening of the parking lots, stormwater management of the parking lots.

Landscape architects and organizations who care about nature and environmental hazards changed the design approaches and started to help and bringing roots of green design in parking lots by preparing codes and standards. United States Environmental protection Agency(EPA) is an organization of the U.S Federal Government which was created to protect human health and the environment by writing and enforcing regulations based on laws passed by Congress. EPA considered parking lot impacts as significant pollution source and presented new approaches in the designing of parking lot. This organization has accomplished experimental projects in different communities, they used permeable pavement and rain gardens to demonstrate and

document the performance and capabilities of the material and rain gardens which was used in the experiment. according to the EPA’s definition Integration of permeable pavement, bioswales, and rain gardens into parking lots allows property owners to manage stormwater on site. Such features also help mitigate urban heat islands and can create more pedestrian-accessible communities. EPA has recognized specific elements of sustainable parking lot approaches including planning and design approaches, sustainable stormwater management techniques, alternatives to asphalt parking surfaces and water efficient landscaping and irrigation (2008).

Another source reviewed in this study is the guidebook of the various communities such as “San Mateo County Sustainable Green Streets and Parking Lots Design Guidebook (2009)”. This guidebook is one of the most innovative and comprehensive guidance documents on Green Street design, that produced by the San Mateo Countywide Water Pollution Prevention Program (SMCWPPP) initiated measures to address the adverse impacts of stormwater runoff from transportation developments on County waters. Figure 3.1 shows the component of the sustainable stoemwater design.



Figure 3.1 : Components of the sustainable stormwater design (San Mateo County,2009).

The site-scale stormwater management strategies described in the guidebook. Design strategies for green streets and parking lots that was mentioned in this guidebook were: site layout strategies such as Provide Efficient Site Design, Balance Parking Spaces with Landscape Spaces, Utilize Surface Conveyance of Stormwater, Add Significant Tree Canopy, Provide Alternative Transportation Options and, stormwater facility

strategies including Pervious Paving, Vegetated Swales, Infiltration/Flow-Through Planters, Rain Gardens, Stormwater Curb Extensions, Green Gutters. (Figure 3.1) is the composited model of sustainable developments components. According to the San Mateo guideline, a balance of economy, ecology, and society will provide sustainable stormwater for the parking lots.

Landscape architect, Stuart Echols, In *Artful Rainwater Design in the Urban Landscape* (2007) discusses about stormwater management approaches and considers parking lots as flexible place in layout design that have the high potential in applying stormwater managements strategies, moreover these strategies can turn parking lots into well designed places that act as hydrological- ecological systems while further being attractive(Echols,2007).

Another Landscape architect, Buck Abbey, in his recent publication dealing with landscape codes for parking lots. According to his definition “Green Parking means parking areas that do environmental work, reduce energy and are healthy for humans. Green parking does environmental work by incorporating energy efficiency, water conservation, on-site storm water management, waste minimization, pollution prevention and the use and recycling of resource efficient materials and outdoor environmental quality in respect to air, water, soils, wildlife and visual quality.” (Abbey, 2011) as he asserts in his article (2009) “Notes on Parking Lot Design”, green parking design is one of the key design strategies for on-site stormwater management. Abbey (2009) indicates that the essential components of a green lot design comprise 7 folds:

1-porous pavement 2-slotted curbs 3-interior planting spaces 4-pedestrian walkways 5-car sorted parking places 6-the use of recycled or repurposed materials and 7-stormwater management facilities such as wet ponds, parking lot retentions bioswales, as well as parking lot screening and parking lot shading are all associated with green parking lot design and construction.

Kevin Lynch (1996) emphasize on the flexibility of the surface parking and in “the openness of Open Space” he describes the advantage of the flexible open spaces. surface parking lots have the ability of accommodating the public and containing the both formal and informal uses. Shared street is one of the example of flexible space that both pedestrian and cars integrated with each other.

On the other hand, Ben Joseph (2012), in his book "Rethinking A Lot" argues "that a successful parking lot is one that integrates its site conditions and context, takes measures to mitigate its impacts on the environment, and gives consideration to aesthetics" (p136). Ben Joseph also emphasizes on the social aspect of parking lot in urban areas. parking can be used for something other than car storage, parking lots be placing in urban areas could be significant public places and contribute to communities such as parks, plazas and boulevards.

According to the Ben-Joseph factors and considerations below will change and improve the traditional parking lot conditions:

A forest of solar canopies to “produce energy while lowering heat”, Porous asphalt to stop stormwater runoff and trees “planted in rows like an apple orchard, so [the park] could sequester carbon and clean contaminated runoff.” The Fiat Lingotto factory in Turin, Italy, has such a lot, minus islands and bumper-busting curbs and with “rows of trees in a dense grid, creating an open, level space under a soft canopy of foliage that welcomes pedestrians as naturally as it does cars.” And, Regular activities, including farmer’s markets, games of street hockey, tailgate parties, and the aforementioned concerts and film screenings. Sustainable landscape model was presented in the Figure 3.2. Sustainable Sites Handbook is one of the important sources that have been reviewed in this study. this book has been created to suggest comprehensive and detailed information on strategies, technologies, tools, and best practices for sustainable site design.

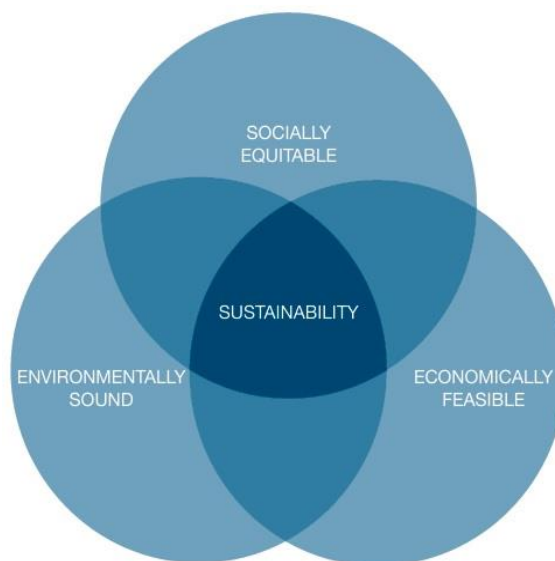
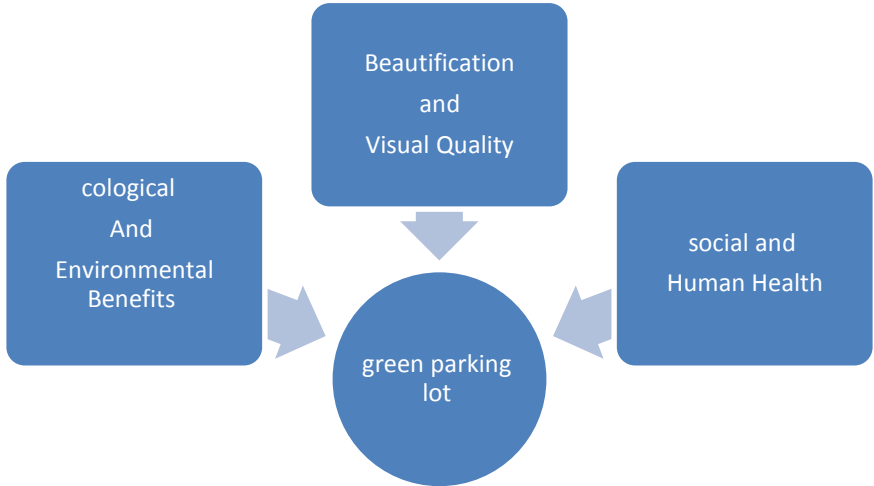


Figure 3.2 : Presented model by site for sustainable landscape (SITES, 2009).

According to the Sites definitions any site in any location can be designed and managed to foster healthy ecosystems, and promote ecosystem services and sustainable human systems. Sustainable design as defined by SITES is “design, construction, operations and maintenance practices that meet the needs of the present without compromising the ability of future generations to meet their own needs” (SITES 2009a).

To designing the truly sustainable development, environmental conservation, socially equity and economical feasible must be considered. According to the SITE, Grayfield sites such as surface parking lots offer the opportunity to sustainably redevelop large tracts of land within existing communities. They are commonly available in many established areas, typically near public transit, and have the potential to be used for a variety of retail and residential uses.

A model for parking lot design can be seen in Figure 3.3, By taking, all above-mentioned discussion into consideration following conclusion can be drawn about the issue. Before the 1990 and early 2000 landscape architects and urban designers’ focuses on the physical planning of a parking lot and although since 1920-1940 planting trees within parking lots have been started but they are more for decoration than environmental purposes.



Sustainable Parking Lot

Figure 3.3 : Model for parking lot design.

Since 2000, EPA considered parking lot impacts as significant pollution source and started to present new parking design techniques. This movement changes the design

of the parking lots, parking lots are assuming as a void in urban fabric without any social activity then social and human well-being aspects are added to parking lot design table for offsetting this impacts in social life. base on the analysis and review of the all sources; design evaluation criteria for green parking lot have been categorized into three main headings in this study. These headings and their components are listed below and they will be discussed in detail in the next section.

Table 3.1 : Sustainable design criteria table.

Criteria	Ecological and Environmental			Aesthetic	visual quality	Social and Human health			
Strategies	On –site Stormwatre facilities	surface material	Cost and Energy conservation	landscaping	Site layout strategies	Pedestrian and vehicles safety and accessibility	Flexibility and social connection	Educational and cultural statement	Economic activates
Applications	Vegetated bioswales.	Minimizing hard cover	Well-designed lighting systems and solar panels	Internal landscaping	Balance Parking Spaces with Landscape Space	Continuous Pedestrian network system	ADA Parking stalls and signs	temporary or permanent social and cultural installations	small commercial shops
	Rain gardens and	Pervious pavements	Storage and collection of recycled materials	Perimeter landscaping	Alternative Transportation Options	Adequate lighting system	Provide Mingling area	multiple languages description	Provide spaces for vendors
	Curb cut and Conveying Water	Light color pavements	Stainable irrigation systems.	Ornamental planting	Provide Efficient Site Design	Site accessibility	On-site events		Swap or sale
	Green roof		Local material	Tree canopy		Control cameras	Provide access to public		
	overflow system		Provide space for electric cars and bikes	Preserving existing trees					

3.1 Design Evaluation Criteria for Parking Lots

3.1.1 Ecological and environmental benefits

On-site Stormwater facilities, surface material, Cost and Energy conservation, are the components, which will be explained in this section.

For reduction the negative impacts to aquatic ecosystems implement strategies to decrease the precipitation runoff volumes, peak flows and, pollutant discharges.

And in addition implement strategies to increase evapotranspiration, filtration and, infiltration and mitigating the temperature of the overflow water.

According to the SITE RATING SYSTEM (2009), minimizing impervious surface, specify permeable materials for hard surfaces, including permeable concrete, asphalt, and pavers; using infiltration opportunities in the landscape area such as bioswales, raingardens, constructed wetlands and tree canopies; runoff conveyance systems and vegetated channels are the strategies that can be used in design process for manage precipitation on site (p 27).

3.1.1.1 On-Site stormwater management

Modification of water quality and quantity is One if the hydrological effect of surface parking. Water cannot penetrate in ground in paved areas, and there is not enough ground cover in these areas, constructed surfaces produce 2 to 6 times more runoff than a natural surface (USGS, 2003). In addition, vehicles remnants and residues such as oils, gasoline, heavy metals and suspended solids are washed off by rainfall in parking lots. Exacerbation in Water flows cause to flood increasing, erosion, sedimentation, water pollution, stream channel instability and loss of both in-stream and streamside habitat.

Drainage system, are built as a common approach for collecting the rainfall runoff over impervious surface, design philosophy of this "out of sight" and "out of mind" approach lead to considering rainfall runoff as a redundant (Dusenbury, 2009). Stormwater runoff grows as more and more impervious surface is created. Impervious surfaces such as roads, parking lots, and roofs are directly connected to the drainage system, in the heavy rains, impervious areas will shed large portion of rainfall and will

produce the first runoff in inlet and outfall of drain system because their path times are the quickest (EPA, 2008, 7).

Residues, and pollutants that urban surface parking lots produce sediment on the surface of parking lots and streets and then in the rainy days they are washed directly into pipes with the rainwater, afterward discharged to creeks, the Bays (Figure3.1).

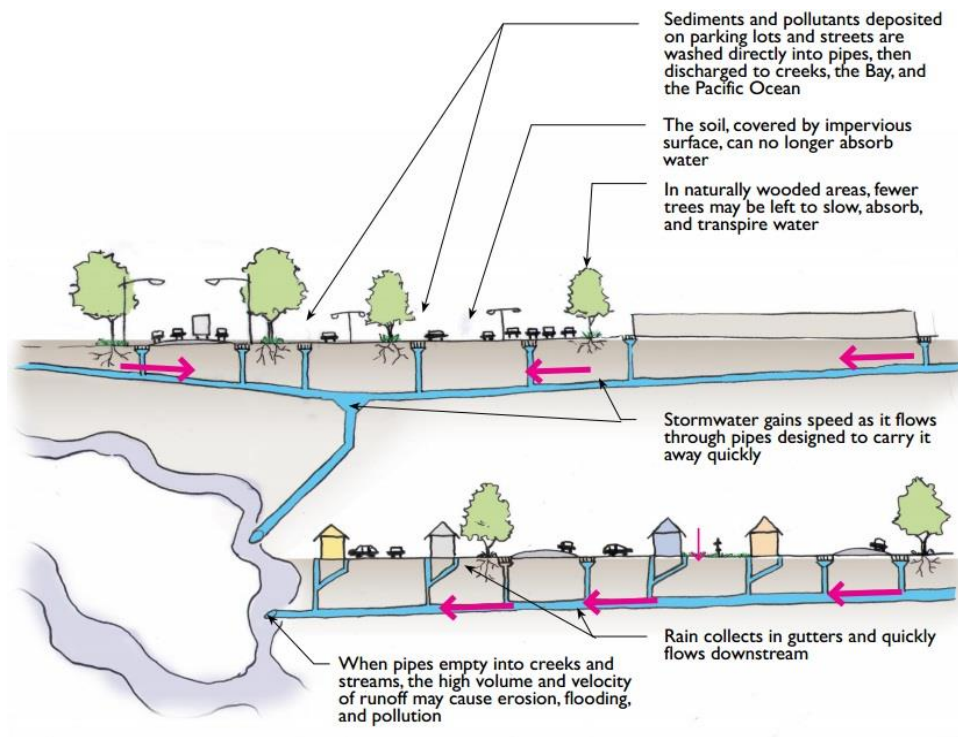


Figure 3.4 : Adverse effect of runoff (Nevuengan associates, 2009).

Green parking lots provide stormwater reduction and increase the quality of runoff before these waters discharging to local creeks.

There are techniques to reduce adverse impacts of stormwater runoff, Sustainable stormwater design preserve natural hydrological functions, in addition sustainable stormwater design attains various goals such as being cost effective, improving water quality, and addressing community concerns (Dusenbury, 2009).

In The conventional approach of stormwater management, rainfall runoff treating as a waste, while in sustainable approach rainfall runoff assume as a source and bringing it to a healthy hydrological process. (Figure 3.5)

Water is one of the precious resources, surface parking lots have potential to improve, treat, and conserve it. Ben joseph (2012) in his book Rethinking a Lot claims that

“during a typical one-inch storm event more than 27000 gallons of water are washed away from a one-acre paved parking lots.

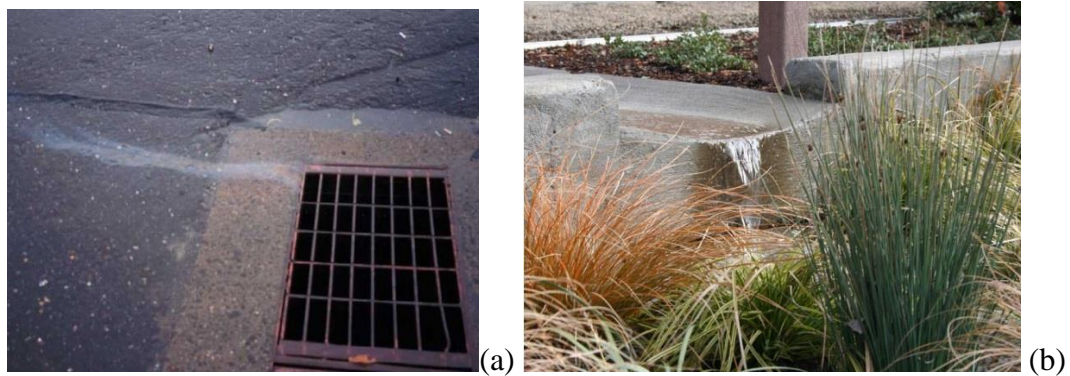


Figure 3.5 : Stormwater management: (a) conventional stormwater management. (b) Sustainable stormwater management. (Nevuengan associates,2009).

Control stormwater by infiltrating it where it falls is a simple and significant way to capture and conserve run off water. This paradigm changes the conventional conveyance systems which typically have used curb, gutters inlet and outlet, piping systems, and convert it to a nonstructural conveyor that mimic natural hydrological cycles (ben joseph, 2012, p 127).

simple and cost-effective On-site stormwater facility strategies should be applied through the site plan. These facilities can contribute both in function and aesthetic features. Enhancing water quality and reduction the velocity and volume of runoff are the goals of sustainable stormwater design. Pollutant and sediments are removed by stormwater facilities, in additions water quality improvement due to the physical and chemical processes that occurs when water interacts with natural elements.

Vegetated swales:

Vegetated swales are shallow landscaped areas designed to capture, transport, and potentially infiltrate stormwater runoff as it moves downstream. over the surface of the ground to a point of disposal that may be a catch basin, ditch that will filter, infiltrate, evaporate and clean the water of, solid waste and other pollutants. Swales low-cost, simple to construct, swales collect the water from areas that must be drained and move it to some other location. Swales are often used along property lines, public streets and around buildings (Abbey,2009). Vegetated swales (figure3.6) can be planted in a variety of wetland plant species that ranging from mown grass to a diverse

palette of grasses, sedges, rushes, shrubs, groundcovers and trees and can be designed to be an attractive feature to any landscape.



Figure 3.6 : A residential area with a vegetated bio-swale (san Mateo guideline,2009,37).

Vegetation coverage helps to reduce erosion potential. A minimum of seven (7) species of plants shall be included in the design with at least two of those species being evergreen during the winter month, and also different heights plants must be included in the design. Figure 3.7 shows a bioswale in a parking lot.



Figure 3.7 : Bioswale in parking lot (San Mateo guideline,2009,37).

Bio-swales have different dimension and slope but shallow slopes allow the plants to have more time to influence the water. check dams or terraces should be designed to

slowing the flow of water for swales above a 2% slope. According to the Abbey “A permeable filter media and under drain system may be provided in locations of heavy clay soils.”

In brief parking lots by having long and continuous space have the potential for installation of bioswales. perimeter of existing parking lot landscaping is One of the best places to incorporate vegetated swales. leftover and extra space might be possible to redesign into vegetated swales.

Rain gardens:

According to the Zolna Russel (2000) “Rain gardens are small-scale stormwater infiltration devices that may replace these detention basins while providing the benefits of groundwater recharge, beauty, and wildlife habitat(p24).”

Rain gardens are planted with a variety of native or ornamental water loving plants that can treat run off to improve water quality. rain gardens Filter grease and oil from driveways, pesticides and fertilizers from lawns, and other pollutants before they reach groundwater or the storm drain and eventually streams, wetlands, lakes, and marine waters. They decrease flooding speed in areas, overflows in sewers, and erosion and increase the amount of water that soils into the ground. and also Enhance the landscaping and appearance of the surrounding area (San Mateo guideline,2009,44).

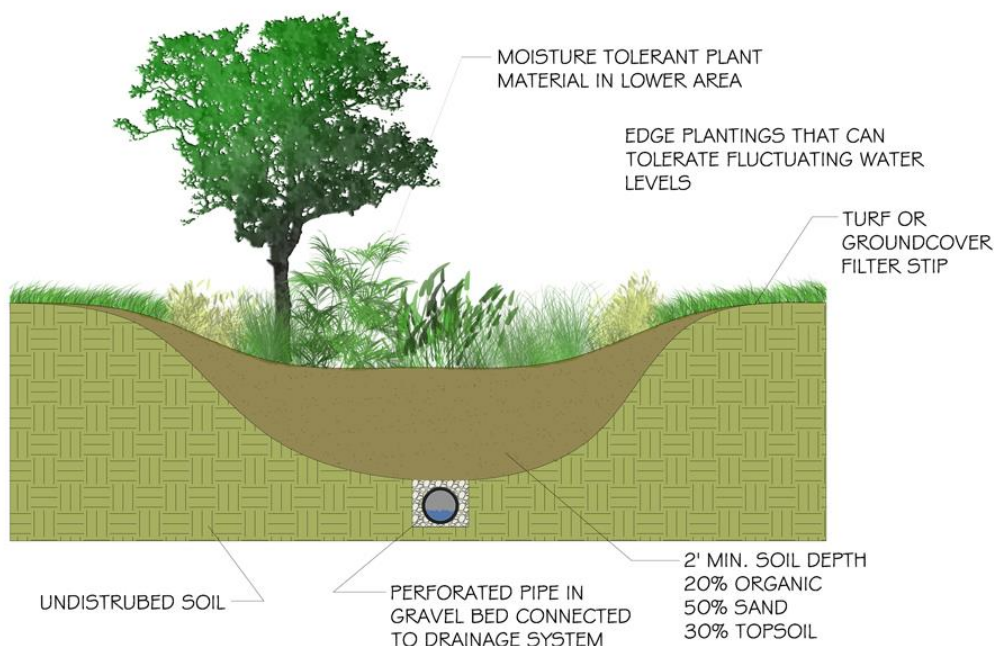


Figure 3.8 : Section of a Rain Garden(Abbey,2009).

Abbey (2009) in his article Notes on Parking Lot Design These explains rain gardens as a” small micro-retentions areas that are often small circular depression less than twenty (20) feet in diameter and not more than twelve (12) inches deep. In many rain gardens they are only six (6) to eight (8) inches deep. They include of different parts consisting a grass buffer strip, a ponding area, a rich thick organic mulch layer and a prepared sub base with improved drainage media”. an improved soil structure is needed in the subsurface to encourage rapid infiltration.

Curb cuts:

“Curb cuts is One of the primary considerations for designing stormwater facilities associated with streets and parking lots, determining how the runoff enters a stormwater facility. slotted curbs direct stormwater to enter a stormwater facility at specific points along a raised curb, thus concentrating runoff both in velocity and volume(Figure 3.9).

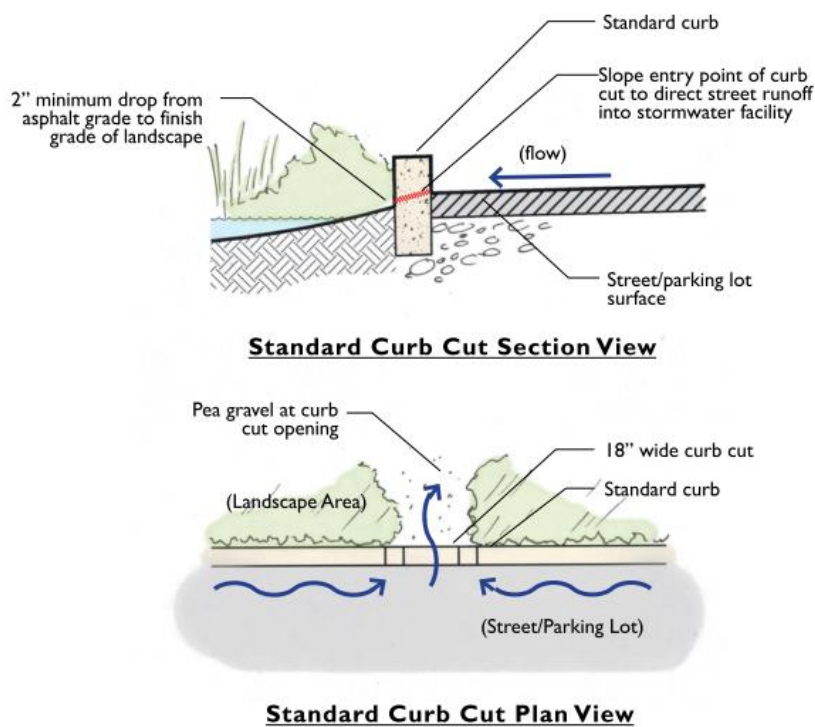


Figure 3.9 : Curb cut section and plan view (San mateo,2009, p130).

This approach channelizes water flow and should be spaced frequently along the length of the curb to distribute the water flow as evenly as possible within the stormwater facility. Curb cuts along stormwater facilities should be as wide as possible to accept flow from along the street or parking lot edge.” (San mateo,2009, p130).

Conveying Water with Trench Drains:

“Conveying stormwater runoff on or near the surface can be accomplished with a number of techniques. Using trench drains and small- scale speed bumps are good ways to efficiently direct runoff to landscape areas without using underground pipes.

Figure 3.10 shows a trench drain system which are designed to convey stormwater runoff within a shallow channel while maintaining unimpeded pedestrian or vehicular access(Figure3.10). Trench drain grates can vary considerably in size and shape, as well as material choice and patterns. Trench drain channels, to which a grate is affixed or mounted to, can be designed with a variety of profiles and depths"(San mateo,2009, p137).



Figure 3.10 : Trench drain (San mateo,2009, p137).

Green roof:

green roofs can have an enormous effect on stormwater runoff and urban heat island effect Although they are not actually a treatment of the parking lots, Normally, all water that falls on the roof of a building is collected in gutters and is drained down to ground level, frequently to a paved surface., a tremendous amount of water can accumulate and transport a significant quantity of pollutants and it is Depending on the size of the building, type of roof, and condition of mechanical systems. Additionally, rooftops can reach temperatures of over 180 ° Fahrenheit (Scholtz-Barth,2001, p 87), which can result in a great deal of hot polluted water. However, an extensive green roof creates little or no runoff (less than 25%, which is treated post storm, by the roof's vegetation). all water that falls on the roof is effectively removed from stormwater runoff calculations (Kinkade,2004, p 60). There are other advantages

as well. “Not only aesthetically pleasing, the rood garden is expected to lower the roof’s temperature, provide thermal and acoustic insulation, control stormwater, convert carbon dioxide to oxygen, and reduce smog, as well as last longer than a traditional rooftop, pay for itself over a period of years, and even attract birds and butterflies...a 22,000 square foot green roof is expected to save between \$3,000 and \$4,000 a year in heating and cooling costs.and extend the life expectancy of the roofing system by 2 to 3 times (Scholtz-Barth,2001, p 87).” Figure 3.11 shows the section of green roof.

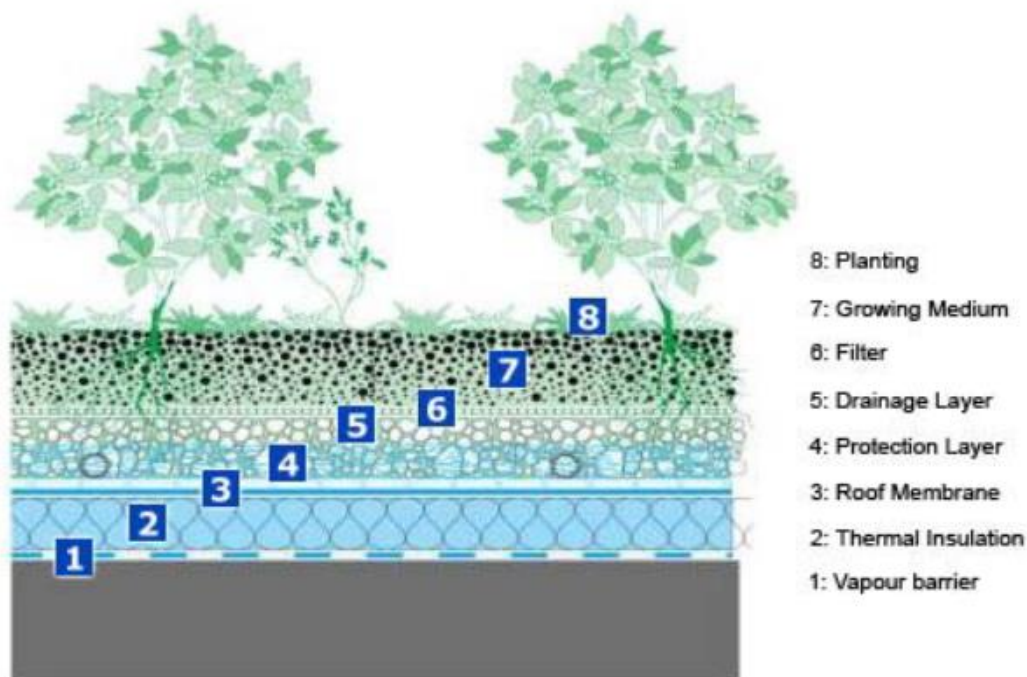


Figure 3.11 : Green roof section (Scholtz-Barth,2001, p 87).

Overflow system:

“Overflow within rain gardens can be managed in several ways depending on what type of stormwater infrastructure is already available. Try whenever possible to have a viable surface overflow as the primary overflow and the piped system as a secondary overflow (Figure 3.12). In retrofit conditions, simply allowing water to overflow from the stormwater facility through a curb cut and exit back into the street or parking lot where it can eventually be captured by an existing storm drain inlet is the most cost-effective and least intensive option. Another option for handling overflow is to

construct a new storm drain inlet located either within the stormwater facility or immediately adjacent to an exit curb cut (San Mateo, 2009, p139)”.



Figure 3.12 : Overflow system in bio retention areas (San Mateo, 2009, p139).

3.1.1.2 Surface materials

The selection on what kind of plant material should be installed within a green parking lot project is an important one. this selection can be influence the parking lot function in various aspects such as stormwater runoff, heat island effect, aesthetical and safety. Selection of surface martials consist of two fold first is plant selection and the second one is pavement selection.

Plant selection:

Hence, there are essentially two primary considerations in choosing plants for a particular stormwater project: 1) general aesthetics; and 2) choosing plants that can survive in both “wet” and “dry” conditions. A more detailed discussion of each design issues is presented below.

Using native plant communities, and other aquatic organisms that are appropriate for local conditions will enhance both aesthetical and environmental aspects in the site plan figure 3.13 shows the planting of a bioswale. (rating system,2009, p 34).

Installing appropriate plants for site conditions, climate and, design intent will Improve landscape efficiency and alleviate resource use (rating system,2009, p 42).

Select plants that require minimal maintenance or can be maintained with hand tools

And Convert turf areas to ground cover or shrubs in areas that adjoin walks and curbs.

Large lawn areas can be converted to meadows or naturalized into restored habitats (rating system,2009, p 112).

If you are planting in a parking lot, broad canopies are most effective as their shade covers the larger areas, it is also important to choose species with leaves, berries and blossoms that do not drip and stain. When you are planning the planting design, try to create islands of trees, rather than planting individual trees across the area. Trees clumped together share soil, help keep each other cool, and create a broader shade shape than do isolated trees. Such islands need to be curbed to protect the trees from bumper damage, soil compaction, and oil runoff.

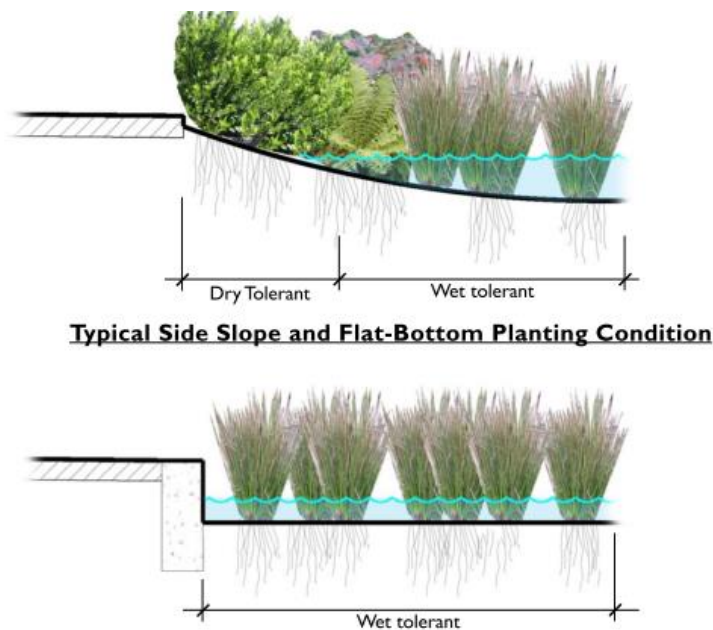


Figure 3.13 : Bioswales planting (San Mateo,2009).

pavement selection:

Pavement materials also contribute to air-quality problems, impervious material lead to negative impact in the surface parking lots, replacing these materials by the permeable new materials lead to reducing these effects. With this in mind, a number of surface paving materials have been developed to reduce these environmental impacts. These pavers including types of permeable and semi permeable pavers such

as gravel, cobble, concrete, wood mulch, brick, open jointed pavers filled with turf or aggregate, turf blocks, natural stone, and pervious concrete (EPA, 2008).

Permeable alternative pavers should not be used for the aisles and main (primary) vehicle travel areas in high traffic lots because they are not strong enough to withstand constant weight and use, however in most cases they would be ideal for use in parking stalls, crosswalks, or overflow (i.e. secondary) parking areas.

However, in many cases, the aisles and driveways can be constructed using conventional pavement, while alternative pavers can be used in parking stalls, crosswalks, and overflow lots.

Alternative pavers slow the flow of runoff, allowing it to filter into the soil, sustaining an area's natural hydrological cycle, and in some cases, allowing microbes to break down contaminants before entering the soil layer. Different type of surface pavement can be seen in figure 3.14.

Opportunities for materials recycling exist in the management and construction of parking lots. For example, the use of recycled asphalt in parking lot construction is not only environmentally beneficial, but can make economic sense. Other environmentally preferable materials, such as recycled rubberized asphalt, may also be used in parking lot construction. Recycling materials can be more economical for developers than incurring the rising costs in some states for disposal of construction, demolition, and clearing debris in landfills. (san mateo,2009).



Figure 3.14 : Type of surface pavement.

Light-colored permeable pavers:

Light-colored permeable pavers further mitigate the heat island effect, since it increases the albedo, or spread reflectivity, of the paved area(Figure3.15).

Along with transpiration cooling, tree shade can help cool the local environment by reducing the solar heating of some below-canopy artificial surfaces (e.g., buildings, parking lots). Together these effects can reduce air temperatures by as much as 5°C (Akbari et al., 1992).



Figure 3.15 : light-colored permeable pavements (Nevuengan associates,2009).

3.1.1.3 Cost and energy conservation

Parking lot would to provide opportunities for decreasing the cost and energy consumption. One way to reduce costs is to minimize the impact to the existing storm drain infrastructure as much as possible and maintain existing storm drain inlet locations. well-designed lighting system and using solar panel is one of the energy conservation approaches. Position photovoltaic cells to providing shade for impervious surfaces materials (rating system,2009, p 50).

Well-designed Lighting system:

poor engineering in lighting design is one of the common problems in surface parking lot. Figure3.16 shows light pollutant in a parking lot. Most of the parking lots lights tends to wash out the darkness low in the sky and trespass onto adjacent properties this badly design lead both creating lighting pollutants and also increase in the costs (benjoseph,2013, p33).



Figure 3.16 : Light pollution.

Solar panels:

“Solar parking lots are highly visible evidence of a company’s commitment to the environment” Donald Shoup asserts (2012) in his article Solar Parking Requirements and also he explains that “each solar canopy has an electric-vehicle charging station at its base, the solar parking requirement will help to distribute charging stations throughout the city. In California, one solar-covered parking space can generate about 5 kilowatt-hours of electricity a day, which is enough to drive an electric vehicle for about 20 miles. With only a slight change to the parking requirements in their zoning ordinances, cities can lead the way toward a future powered by renewable energy. Solar canopies produce power and also decrease the demand for it. Shading parked cars will reduce the use of air conditioning by motorists when they leave the solar parking lots on sunny days, resulting in better fuel efficiency and reduced tailpipe emissions. The canopies can also reduce the heat island effects of parking lots around buildings, and thus reduce air conditioning demand in the buildings”. In addition, this solar panels can provide electric power for nearby buildings and a solar power parking lot with charging connections could be attractive for plug-in drivers for electric vehicles.

In addition, solar panels can be used as power producer device for irrigation of the vegetated area.

Storage and collection of recycled materials:

Facilitate recycling and reduce waste generation and disposal in landfills by providing space for recyclable materials collection in outdoor areas (rating system,2009, p 104). Collect excess vegetation generated during site maintenance to divert to a composting facility on or off site. Consider using a mulching mower when trimming grass and leaving plant materials in site.

Sustainable irrigation system:

By using stormwater management practices and implementing the strategies during the site design process rainwater runoff will be captured and treat

This water could be use as source for the irrigation of the site plan also solar panel would be used as a source for producing power for pumping the water form cistern to the planting zones.

Local materials:

providing employment opportunities and purchasing local materials and services would Provide economic and social benefits to the local community (rating system,2009, p 84).

Bicycle and eco electric cars:

CALGreen (California Green Building Standers code) become one of the nation’s first statewide energy-efficient and environmentally conscientious set of enforceable regulations. The code stipulates the allocation of parking spaces for eco-electric cars and bicycles (ben joseph, 2012, p 119).

3.1.2 Aesthetical and visual quality

Aesthetical and visual quality in parking lots are one of the primary features that most parking standards and regulation.

These standards including the parking lot plantations both perimeter and inside of the parking lots. Appropriate landscaping can increase water infiltration and purification, reduce heat island effect and improve overall aesthetic. “Also, landscaping with evergreen trees can shade western and southern exposure to mitigate solar heating of water. Figure 3.17 shows landscaping in a parking lot. Deciduous trees should be kept

back from the ponds [retention and smart] to avoid excessive accumulation of leaf litter.” (stormwater ponds,2000, p54).

Parking lot islands should be sunken to allow for infiltration, and trees and vegetation should be planted so that root systems do not disturb paved surfaces or compromise visibility.



Figure 3.17 : Landscaping of the parking area.

Preserving existing habitat:

according to the SITE V2 Rating SYSTEM, minimizing disruption in existing habitat and species connectivity should be considered in design process (rating system,2009, p10). Conserve existing plants and minimize damage to existing healthy native plant communities that are appropriate for site conditions and provide opportunities for wildlife habitat, where possible (rating system,2009, p43).

Site layout strategies and Efficient site design:

One of the primary steps, according to the Childs (1999), and San Mateo County Sustainable Green Streets and Parking Lots Guidebook (2009), by considering site layout strategies, it is better to minimize the impervious area that devoted to the parking lots and maximizing landscape area. Many of the parking lots are oversized or inefficiently used, by site layout strategies site can be design more effectively. Implementing appropriate landscape design through the site plan for providing the

natural hydrologic processes, minimizing underground piped infrastructure, increasing landscape area, decreasing impervious surface, preserving existed vegetation and trees and adding appropriate tree canopies. Afterward this step, for enhancing the process Efficient site layout is one of the simplest ways to provide sustainable/green design of parking lot. Evaluating the parking lot demand can help to reduce land use for parking lot and materials uses and energy consumption and it also reduces initial cost. It helps to prepare the required size of stalls and aisles of parking lot as well as possible while maintaining a good level of function.

"Site design is a process of intervention involving the sensitive integration of circulation, structures and utilities within natural and cultural environments."(guideline,1993)

According to the San Mateo County guidebook and Site design strategies explain the ways that a site can be design more efficiency in order to create sustainable landscape, these strategies can be applying for enhancing the site plan layout and dimension of parking stalls, balancing between the parking spaces and landscape spaces, pedestrian and automobile access and circulation.

Multi transportation networks:

Support for bicycle riders, access to bicycle racks and, enclosed parking lockers
Reduce emissions and promote a healthy lifestyle by encouraging and supporting efficient and adaptable modes of transportation (rating system,2009, p 82).

3.1.3 Social and human health

"If given a choice between walking on a deserted or a lively street, most people in most situations will choose the lively street" (Jan Gehl).

According to the Kathleen Kane Ziegenfuss, "a parking lots should be reconsidered as a new type of space, a flexible space which supports both active and passive activities, and that they should be transformed into places for people to be outside and recreate, could encourage more active lifestyles. Having more publicly available space is a goal touted by many open space and recreation departments and advocacy groups. In cities where open space is scarce, using parking lots as recreation spaces could increase the inventory of open space to help reach national standards (P 66).”providing visual and physical connections to nature, economic and social benefits, optimum site

accessibility, safety, and wayfinding, protecting and maintaining significant historic buildings, structures, and objects, supporting physical activity, providing on-site food production, reducing light pollution, encouraging fuel efficient and multi-modal transportation, minimizing exposure to environmental tobacco smoke positively effects mental health and facilitates social connections.

ADA Parking:

After the mid-1970s, with the rise of social and civil rights planning issues, accessibility criteria as a design solutions started to gain traction. As part of these efforts the lack of existing standards to accommodate the disabled people in developments was started to show.

After 20 years US Congress enacted the law American with Disabilities at (ADA) of 1990. handicapped parking spaces is one of the successful accommodations of the ADA (ben joseph,2012, p91)

Site accessibility:

incorporating elements of accessibility, safety, and wayfinding into the site design will improve site users' ability to understand and access outdoor spaces (rating system,2009, p 71).

This elements including:

adequate lighting levels, site design elements, Clear entrances and gateways, Hierarchy of pedestrian and vehicular circulation, landmarks

safety:

continuous pedestrian network in the site would provide safety for pedestrians. considering site lighting criteria maintains safe light levels while avoiding off-site lighting and night sky pollution. Control the direction and spread of light by choosing the correct type of light fixture and reducing light trespass on site increases nighttime visibility (rating system,2009, p 81).

Social and physical connection:

Parking lots due to their designs create physical and mental gaps, Social and physical connections is one of the factors of social and human health aspect in parking lot design. access to the public through the site provides social connection, in this case pedestrian level lighting as part of the design should be considered.

offer seating and mingling location at key nodes of activity is another way to enhancing the site (rating system,2009, p 75).

Flexibility:

“Shared street” is one of the accepted concepts in European cities, this concept is one of the example of flexible space. In the 1963, Ministry of Transport in England published a report for mitigating the traffic impacts through the residential areas. This strategy authored by Colin Buchanan and the approaches that mentioned in the report were removing boundaries and blurring distinctions between the uses. This strategy allow pedestrians and automobiles negotiate the right of way and lead to converting the streets into a pedestrian dominated places and automatically reduce the speed of the cars. shared spaces achieve flexibility by regulation less with signs and markings and by calling upon the self-adaptability of people and drivers.

urban planners of the Europe were inspired by this theoretical idea. Niek De Boer, urban planner in the city of Emmen in the Netherlands trying to overcome the conflicts between the children playing and car uses, he designed the streets like a garden so motorist had to take into consideration the other street users. He renamed this type of street Woonerf or “residential yard”.

a fresh design was constructed to integrate sidewalk and roadways into one shared surface and creating more space for pedestrian and Childs. afterward the “shared street” concept evolved into a “shared space” concept that not limited to only the streets but also contained all public spaces. (Ben Joseph,2012,106).

Cultural and educational statements:

Open parking lots have potential for installation temporary and permanent social and cultural installations. artist have realized parking potential since early of 1950s (ben joseph,2012, p109).

Promote understanding of sustainability in ways that positively influence user behavior by interpreting on-site features and processes

providing interpretative descriptions in multiple languages to meet a broader audience based on visitor and population demographics.

Incorporate interactive elements that encourage site users and visitors to integrate understanding of on-site examples of sustainability practices with experiences and behaviors that extend beyond the site (rating system,2009, p 115).

Economical:

eating, drinking, mingling, and socializing in parking lot have also created an opportunity for economic development (benjoseph,2013, p28). on-site events, facilities, amenities, or programming will enhance the economic and social features of the site (rating system,2009, p 72). Food trucks generates revenue to those vendors and to the other local businesses through increased food traffic caused by the event.

3.2 Example of Parking Lots in the World

In this section, examples of the prominent surface parking lots around the world, will be introduced and investigated. The mentioned examples have been selected from different parts of the world such as Italy, United Kingdom, France, and USA. All of these examples have different approach. Moreover, characteristic features of these urban parking lots in different parts of the world reflect the parameters which were classified and discussed in the study.

3.2.1 Ghost parking lot, Hamden, USA ,1977

Twenty junk automobiles were buried under asphalt at various graduated levels, at the street edge of the shopping center's parking lot. This project designed with SITE architecture firm and showed the people connection with the shopping center and the fetishism of American car culture.



Figure 3.18 : ghost Parking lot by Site firm ,1977(Url-15).

3.2.2 Parking lot showroom, Houston& TX & Los Angeles, USA, 1976

This parking lot is one of the Best Products that designed from SITE. The Parking Lot Showroom was the only one that not built. SITE took an unconventional approach of joining interior and exterior. This project shows the importance of parking lot and suggesting that it is an integral part of a shopping center, have to put on display and not to be hidden. In this project parking lot rolling over the building.

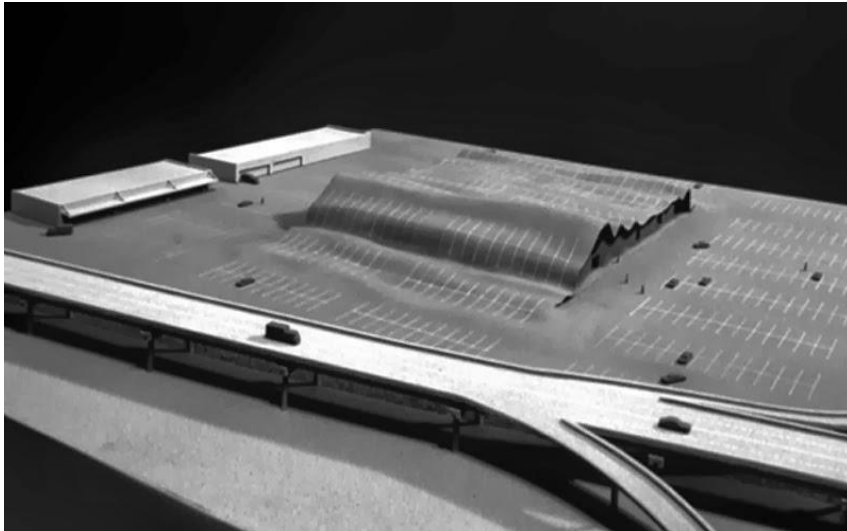


Figure 3.19 : Parking Lot Showroom by SITE Architecture, 1976 (Url-16).

3.2.3 Parking lot showroom by SITE architecture, 1976

This tram station and car park form part of a new scheme to combat and reduce the increasing congestion and pollution in Strasbourg's city Centre. Architect Zaha Hadid was designed the new station and parking lot for 800 cars, she used the random geometry of the site as a starting point. In bird view parking lot and building appear as a one and single composition and building and parking merged together.



Figure 3.20 : Park and Ride Tram Station (Url-17).

Although parking lot is a bare and without vegetation cover ,strasboirg’s tram station parking lot is a great example of integrated form and function, tram station and the car park create a synthesis between floor, light and space.(Ben-Jodef,2012,113) By articulating the moments of transition between open landscape space and public interior space, it is hoped that a new notion of an ‘artificial nature’ is offered, one that blurs the boundaries between natural and the artificial environments towards the improving of civic life (Url-17) .

3.3 Example of Parking Lots in The World Based on the Criteria and Green Design Strategies

3.3.1 3.3.1 12000 Factory workers meet ecology in the parking lot, Canton, GA

Since 1990 only one parking lot design has won an award from the American Society of Landscape Architectures (Ben-Josef, 2012). The project titled: "12000 Factory Workers Meet Ecology in the Parking Lot, Canton, GA," by Michael Van Valkenburg Associates, Inc., figure 3.21 shows plan and section of the project.

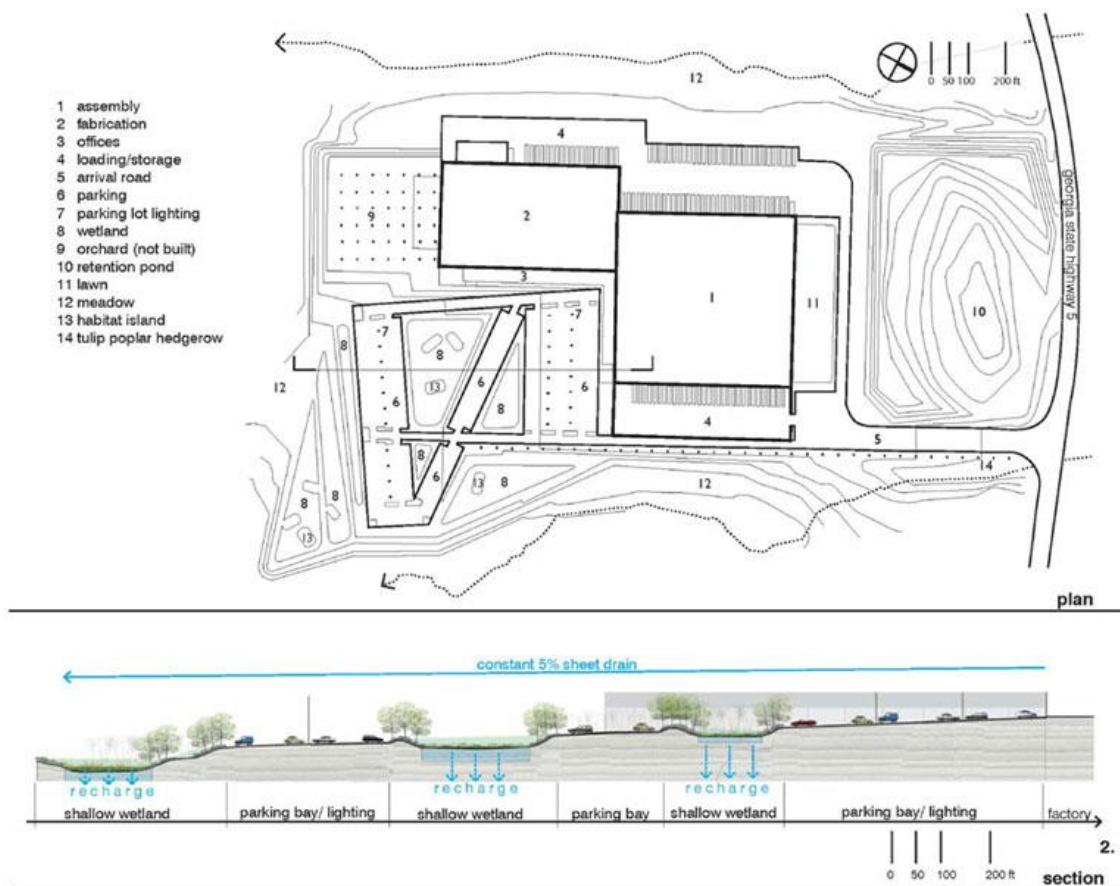


Figure 3.21 : Plan and section (Url-4).

Landscape architect by grading the entire site into 5percent and linking effective hydrological techniques with the industrial operation of the adjacent manufacturing facility and using recycle telephone poles as lighting, creates a new model for low-cost, low-maintenance, environmentally sound factory landscapes (Figure3.22).



Figure 3.22 : Hydrologic context diagram (Url-4).

Parking became part of a thriving ecological system that neutralizes the impacts of runoff, provides habitat for wildlife, and offers a compelling arrival and departure experience to the three-shift factory’s employees. According to the figure3.23 Runoff in the parking bays is mitigated by limited impermeable surface area and buffering hedgerows.

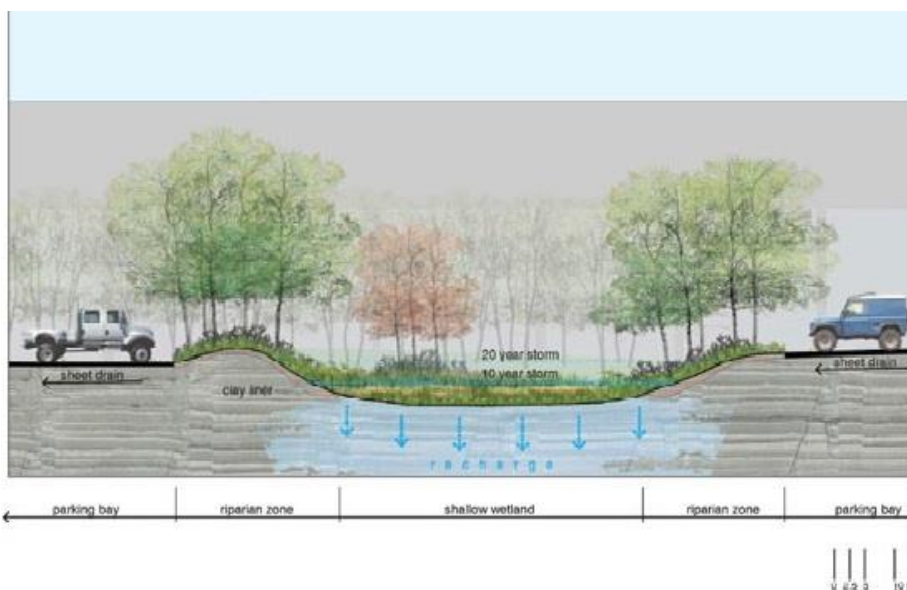


Figure 3.23 : Detail section of retention basin and constructed wetland (Url-4).

Constructing curbs in riparian zones of densely planted, small caliper floodplain trees, between parking bays and shallow wetlands, parking lot runoff flows through riparian zones before settling in shallow wetland trays, where it is filtered and returned to the hydrologic system at large. By constructing shallow wetlands, parking areas was divided into tree bays that steadily and consistently absorb runoff water, minimizing and governing the amount of runoff that enters the sensitive regional watershed. (Url-4).

Landscape element such as telephone poles, hedgerow, and paved surface, distinct and rhythmically arranged, together forms a visually diverse and multi-layered landscape (Figure3.24). Tulip Poplars trees as hedgerow, along the entry drive mirrors the building façade, maintain the balanced relationship between factory and landscape. Recycled telephone poles are set within the space to provide lighting as well as a visual connection between the surrounding woods and the industrial building (Url-4).



Figure 3.24 : landscape elements (Url-4).

According to analysis above, it can be declared that the factors that making this parking lot as a prominent sustainable parking lot, are its self-contained working ecosystem. Sustainable strategies that are applied in parking lot are stormwater management, creative use of recycled materials, dividing the land in smaller portions, grading the lands that devoted to the parking lots toward constructed wetland, mimicking the natural hydrological system and using various kind of plantation like trees and shrubs for conservation of the biodiversity. Managing the stormwater in best way lead to preserve the surrounding areas from the adverse impacts of parking lot runoff and keep the balance of the area.

3.3.2 Carscape competition: transforming a parking lot in a park

In the mid-1980s, a competition held to design a municipal parking lot for about 300 cars, the winning Eric R. Kuhne & Associates inspired by the European urban plazas,

transform the parking lot into a park, and create plaza under a canopy of trees. (Ben-Joseph, 2012).

The goal of competition that organizers stated is " The amount of creativity, energy, and planning that goes into the design of parking places, especially compared to other elements of the built environment, is miniscule, et. in terms of their VISUAL IMPACT, their land usage, or any other measure, there is almost no other place of the public environment that people experience more in their daily lives" (Ben-Josef, 2012).

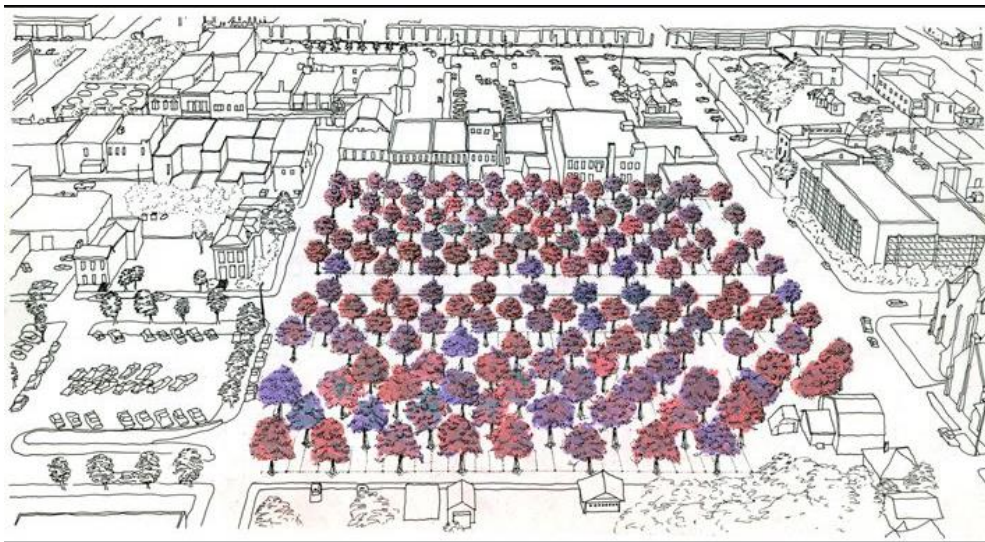


Figure 3.25 : parking lot as plaza (Url-5).

Outcomes of the competition entries published in carscape: A Parking Handbook by the Irwin-Sweeney-Miller Foundation.

Approaches used by Participants in the competition:

1. Circulation of the cars and pedestrians must be easy and direct
2. Connection with the urban life
3. Electric lighting must be as an essential part of the parking lot
4. Multi-function parking lots
5. Landscape design
6. Repetitive patterns are the basic design tools (Ben-Josef, 2012).

In sum up in this project landscape architect by providing multiple activities such as car parking, cultural activities, and marketplaces in a single space, enhance the social aspect of the parking lot.

3.3.3 Masdar City parking lot

Masdar city in Abu Dhabi, in the United Arab Emirates, was designed as a sustainable mixed-use development designed to be very friendly to pedestrians and cyclists(Figure3.26). This city designed by Foster (2007) and this is emerging global hub for renewable energy and clean technologies in Middle East (Tabb, 2013).



Figure 3.26 : Masdar City's master plan (Url-6).

Figure 3.27 shows using Photovoltaic Parking Shade Structure is one of the well-designed multipurpose solutions for providing environmentally friendly parking lot. Protecting cars from the sun, while creating carbon free, clean energy is a great way to showcase one's commitment to sustainability (Url-7).



Figure 3.27 : Photovoltaic Parking Shade Structure (Url-7)

Features: water collection system, easily expandable, providing shade, collecting solar energy.

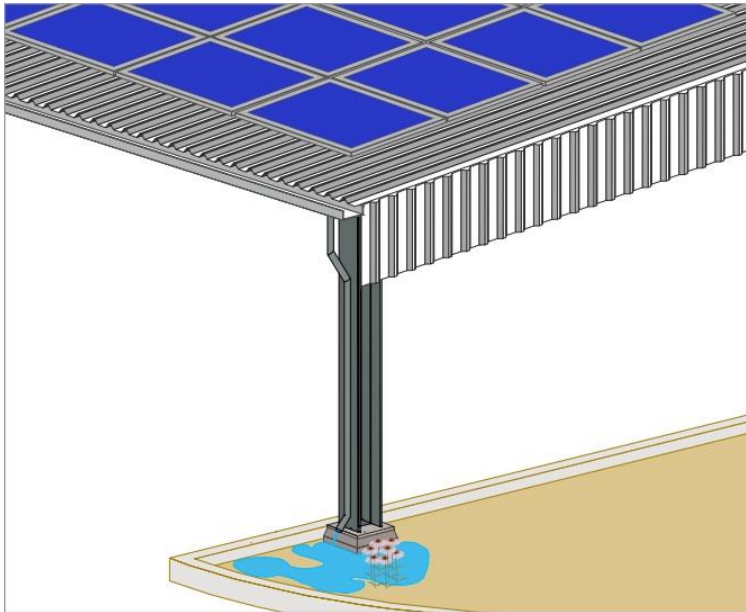


Figure 3.28 : irrigation of the plants under the structure by recycled water which system collected (Url-7).

3.3.4 Heifer International

The Heifer International American headquarters non- profit sustainable community development located in Little Rock, Arkansas was part of a series of first models that was sponsored by the Environmental Protection Agency's (EPA) office of Solid Waste and Emergency Response (OSWER). the aid of conducting this project was to understanding how environmental improvements affect public health. This environmentally friendly parking lot was designed to match the green building which was located of a former brownfield site at the Heifer International(Figure3.29).



Figure 3.29 : Green parking lot in Heifer International (Letzeiser, 2012).

Green parking lot techniques that were implemented in Heifer's parking plaza including: using three types of paving materials that provide environmental benefits over asphalt, Native turf seeding, Bioswales and rain garden, Wheel Stops, 23 Trees used per acre, using 100% recycled and local materials,

The most important contributions that the Heifer International case study had on this thesis was the method approach to designing of the green parking lot and type of materials that were used in this project and there is also financial analysis.

4. CASE STUDY RESULTS: SURFACE PARKING LOTS IN ISTANBUL AND GREEN DESIGN STRATEGIES

4.1 Surface Urban Parking Lot Regulations and Standards in Istanbul

Istanbul city, which is located in the western part of Turkey, has been developed as the capital city.

Municipal governments are responsible for applying national programs for health and social support, public works, education, and are authorized to carry out Organization and management of mass transportation systems, passenger and freight terminals and vehicle parking spots on motorways, roads, avenues, streets, squares and similar places(IBB,2013,15).

Since 2005 , Istanbul metropolitan municipality established ISPARK to modernize car parks of Istanbul by controlling them centrally through a system that is operated by the municipality.

ISPARK projects are supposed to reduction in high traffic density furthermore have authority to Constructing, managing and having constructed any kind of outdoor, indoor, underground and above ground parking lots, multi-story car parks at home and abroad.

In accordance with Municipality Council no. 349 dated 18/02/2005 as per article 26 of Metropolitan Municipality Law No. 5216, ISPARK Co. Inc. was commissioned with the operation of the car parks located on real estate's under the sovereignty and disposition of the municipality upon approval of Municipality Approval no. 7613 dated 26/10/2005. Currently, ISPARK Co. Inc. operates parking areas with a total capacity of 68,638 vehicles on 532 locations in 29 of Istanbul's 39 districts (IBB, 2013, 153S).

Most of the Turkey's municipalities standards were written base on the Eno's reports and Urban Traffic Control Engineering of England regulations.According to the ICS91.090 turkey standards," Otopark" is a place that is devoted for parking of

automobiles and it is usable for everyone to park their own cars, these places can be located near the curbside in the street or special areas anywhere but on the streets.

Parking in the Istanbul has two types like the other countries, on -street parking and off-street parking.

4.1.1 On-street parking:

Automobiles are parked on or along the curb of streets, this area are divided from the walkway and street, on-street parking have two type some of the on –street parking is limited to the time and some of them are free time. The time limits control by police or park meter.

4.1.2 Off-street parking:

These are usually parking facilities like garages and lots that located in the anywhere but on the streets. Off-street parking can be both indoors and outdoors. Off-street parking also includes private or public lots, garages and driveways. These can be open to the both public or private but is privately owned.

Off-street parking lots including of: parking lots, underground parking, multi-story parking and elevated parking,

Voids and vacant lands near the business districts, underground stories and spots that are close to the airports, mass transportations stations can be choose as off-street parking location.

Type and location of the off-street parking determine by the causes and changes in traffic flow and intensify during peak hours, capacity and type of other nearby parking, minimum parking requirements and percentage of parking that is utilized in peak hours.

Distances between the parking areas and destination should not be more than 250 m in the cities with 250000 populations and 500m in the bigger cities. If the distance were more than 750 m, mass transportation stations should be located along this distance.

Location of the parking lots, surroundings condition, site layout and planning, topography, drainage system, surface pavement, continent ingress or egress points, parking lot light, security, pedestrian circulation, landscape conditions have to be considered.

4.1.3 Ingress and egress points in off-street parking

Entrance and exit points of parking areas should be separated from each other and placed in the secondary streets and with the minimum 30 m distances from intersections. Below there is a figure that demonstrates preferred dimensions in Turkey regulations. Figure 4.1 shows dimension of the entrance and exit points in parking lots

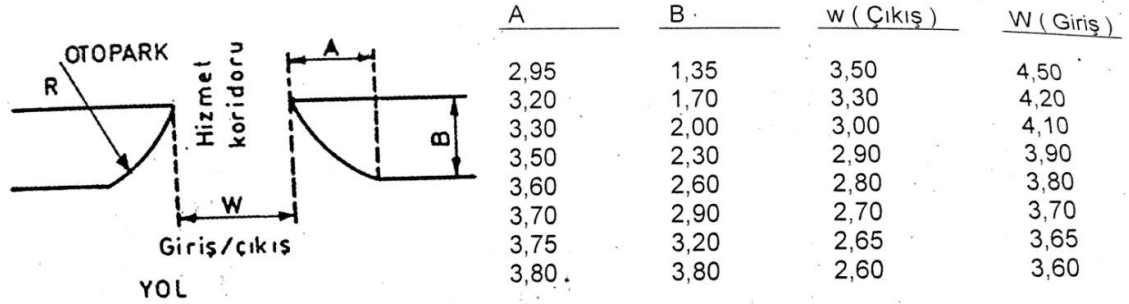


Figure 4.1 : dimension of entrance and exit points (Turk Standard, 1992).

it is better to consider a extra spaces between the main street and ingress and exgress point for vehichals movement because lack of these spaces may block the traffic flow.

4.1.4 Aisles and stalls dimation

Different types of parking dimensions, which are used in turkey regulations, are shown in the figures below.

it is better to consider a extra spaces between the main street and ingress and exgress point for vehichals movement because lack of these spaces may block the traffic flow. According to the regulations of turkey, the minimum size of one-way aisles is 3 m. and it is better to use of one-way aisles for convenient parking. different parking aisles and stalls layouts can be seen in figure 4.2.

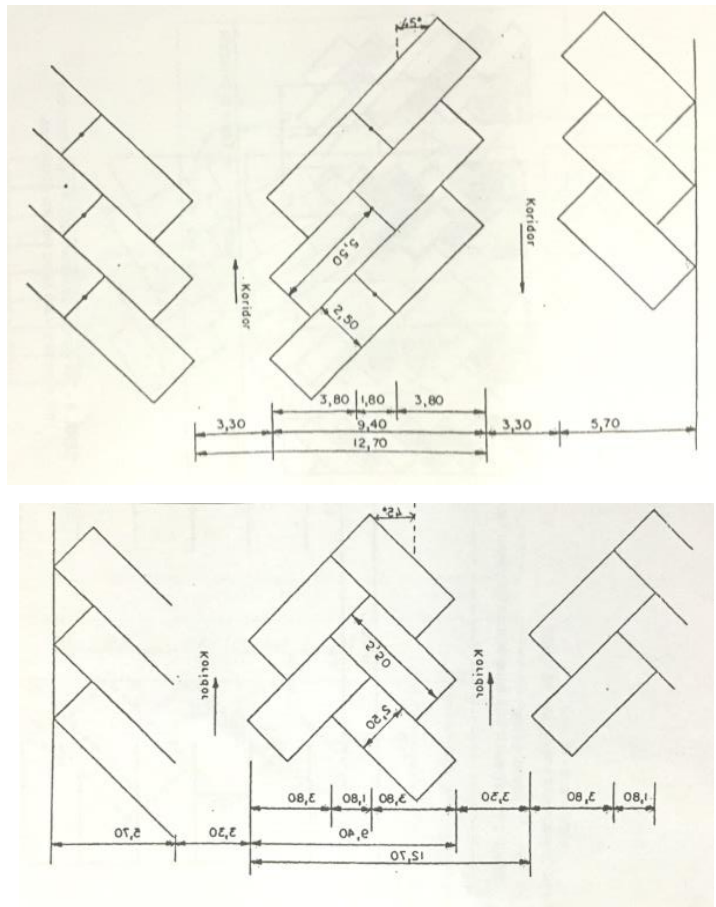
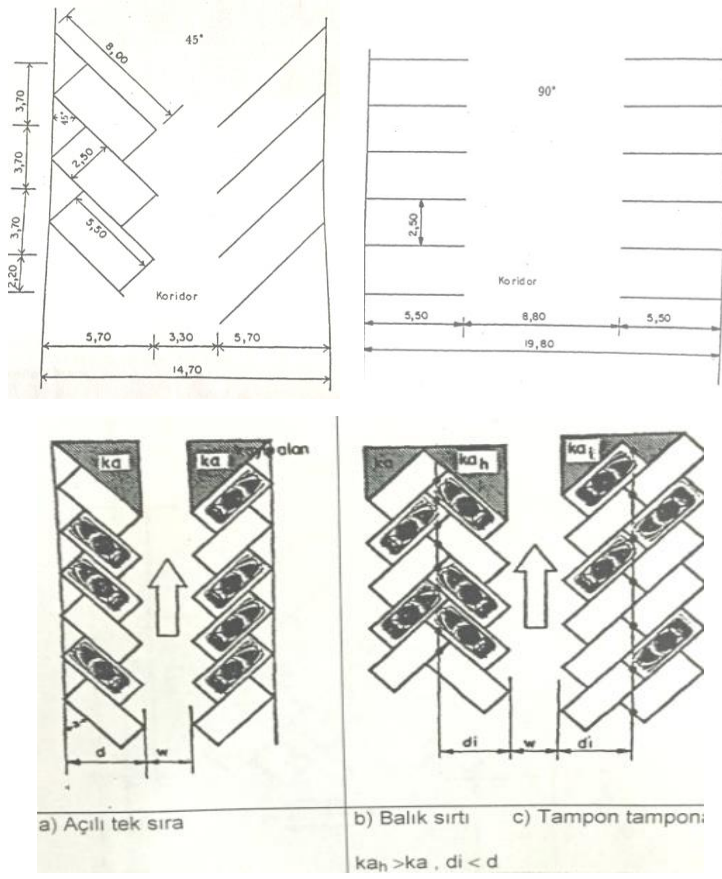


Figure 4.2 : Parking aisles and stalls layouts (Turk Standardlari,1992).

4.2 Surface Parking Lot Analysis

This part of the thesis consists three folds. first one starts with the comprehensive analysis and demonstration of the transition process of green lands to surface parking lots for indicating the importance of the parking lots. a coverage comparison was done in large scale such as district-scale. These analysis illustrates the growing speed of the parking lot by the time. Next fold consists of the site-scale analysis, different parking lots was chosen with various location and site sizes, these lots was evaluated according to the design criteria table. In the last fold a designed model was proposed for Sehit Ahmet parking according to the sustainable design criteria table.

4.2.1 Typical Urban Surface Parking Lots' Coverage in the Faith District as case study

Faith district selected as the area of investigation of this thesis. Figure 4.4 shows location of the Fatih district in Istanbul. Firth is a municipality and district in Istanbul and located in the European part of the Istanbul. Fatih is located in the area of Byzantine city walls "City Walls". Faith borders are the Eyup District on the north, the Golden Horn on the northeast, the Sea of Marmara on the south, Zeytunburni on the west and Bayrampasa District on the northwest, this district includes of 57 quarters. The acreage of the Faith peninsula according to the 2008 Address-based population registration system, is 15.6 km² and its population is 443955 (Faith Bel, 2013). Faith is a district with a rich multifaceted history including impressive architecture from various time periods. This historic peninsula is including the remnants of Classical, Roman, Byzantine, Ottoman, and Republic eras. This site was chosen for study as recommended by ISPARK's specialists. Faith district is located in the major historical, touristic and commercial region of Istanbul. Faith is a district with a rich multifaceted history including impressive architecture from various time periods. Location of Faith District in Istanbul can be seen in Figure 4.3.



Figure 4.3 : Location of Faith District in Istanbul.

The name of Faith originates from the Ottoman Emperor who conquered Istanbul in the year 1453. Excavations under Sultan Ahmet square and archeological findings demonstrates that the area has been a point of settlement for 8500 years. The Golden horn, the Marmara Sea, and Historic City Walls defines the borders of Faith District (figure 4.4).

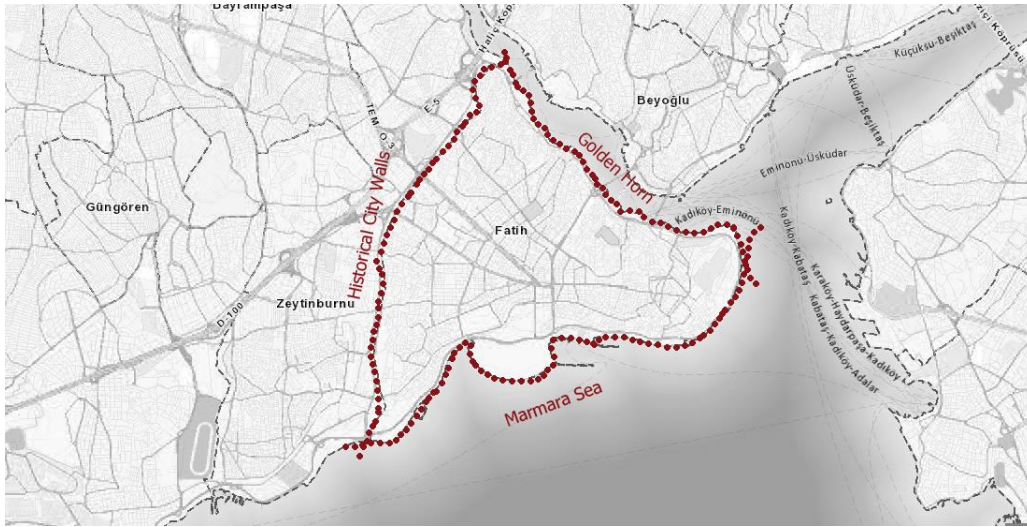


Figure 4.4 : Faith District borders.

In this chapter urban analysis are examined in the Faith District in the several last decades from 1966 and 1982(via Sehirhatitasi maps) and compared them to the current fabric (2014) for understanding of the expansion of surface parking lots in this district and comparing the growth speed of these voids through the time. Figure 4.5_4.10 show the analysis of the parking lot and green areas coverage in different years.



Figure 4.5 : 1966 studies: green coverage of the Faith District.



Figure 4.6 : 1966 studies: surface parking lot coverage of Faith District.



Figure 4.7 : 1982 studies: green coverage of the Faith District.



Figure 4.8 : 1982 studies: surface parking lot coverage of the Faith District.

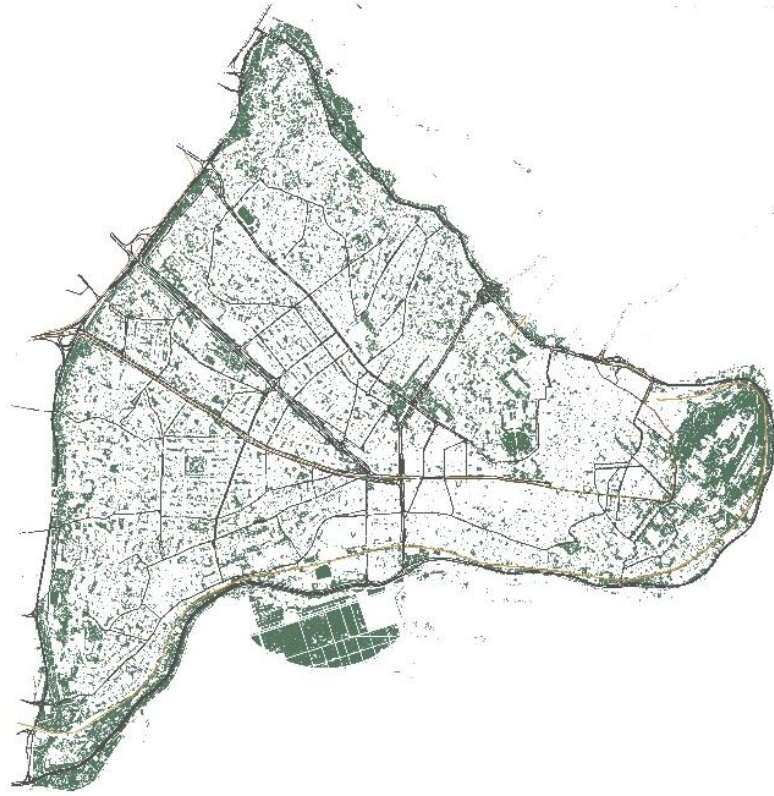


Figure 4.9 : 2014 studies: green coverage of the Fatih District.

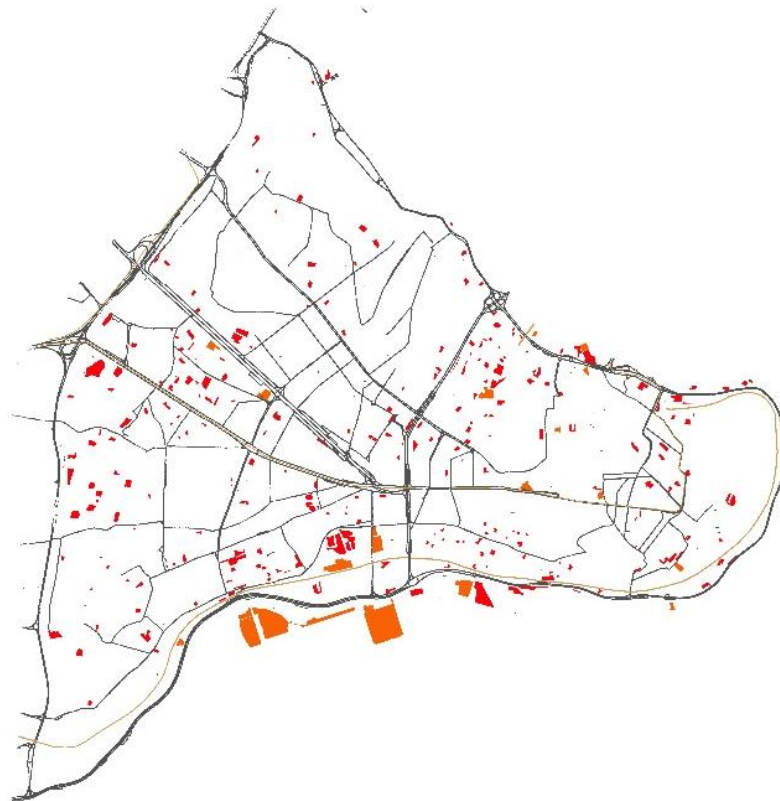


Figure 4.10 : 2014 studies: surface parking lot coverage of the Fatih District. Red: private surface parking lots Orange: sparks' surface parking lots.

In figure 4.10. red shows the surface parking lot coverage, orange shows the surface parking lots that owned by Ispark since 2005. Quantifying what proportion of urban areas are occupied by parking lots, will provide a measure to assess environmental and social impact of surface parking lots. During the fifty years' period 1966-2014 the growth of urban surface parking lots is obviously apparent, in the 1966 the total area that was occupied by surface parking lots is 40148 m², by increase in the population and formation of roads this area reached 58307 m² in 1982 and finally in 2014 this number by 1340% increase reached to 538249 m². The transition process of green lands to surface parking lots in Fatih district was shown in figure 4.11.



Figure 4.11 : The transition process of green lands to surface parking lots.

The study's results can be viewed in table 4.1.

Table 4.1 : Percentage of surface parking space coverage in Fatih district.

year	1966	1982	2014
Surface parking lot Area (square meter)	40148	58307	538249
percentage	0.25	0.37	3.45

The process of formation of surface parking lots is associated with the loss of open/green spaces and farmlands especially in Yeni Kapi neighborhood.

Figure 4.12 shows the transition of the green land and converting it to asphalt surfaces during the 1966-2014

By formation of roads and enhancing transportation system and giving access through the lands most of the natural lands and farmland transfer to the hard surface areas.

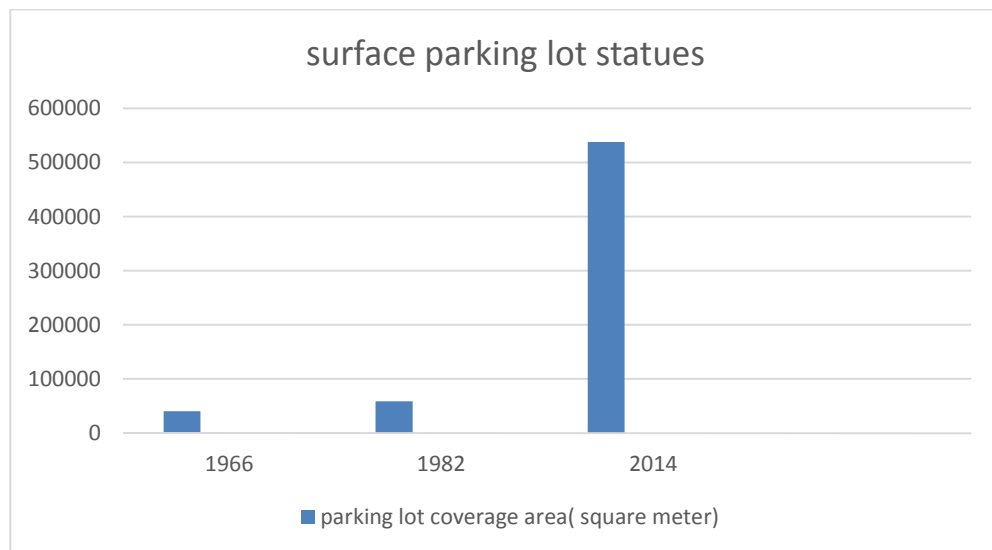


Figure 4.12 : Surface parking lot coverage chart.

4.2.2 Surface parking lots condition in Istanbul

In this part, a number of urban surface parking lot have been selected, afterwards these case studies have been evaluated by site observation and survey according to the classified design evaluation criteria of this study. In the previous chapter, it was pointed that the design evaluation criteria for green urban parking lot were categorize

under three main headings: ecological & environmental, aesthetical and visual quality, social and human health.

4.2.2.1 Case study No. 1 - Sabiha Gokcen parking lot

Location: Istanbul, near the Sabiha Gokcen Airport

Size: 29230

Car Capacity: 1000

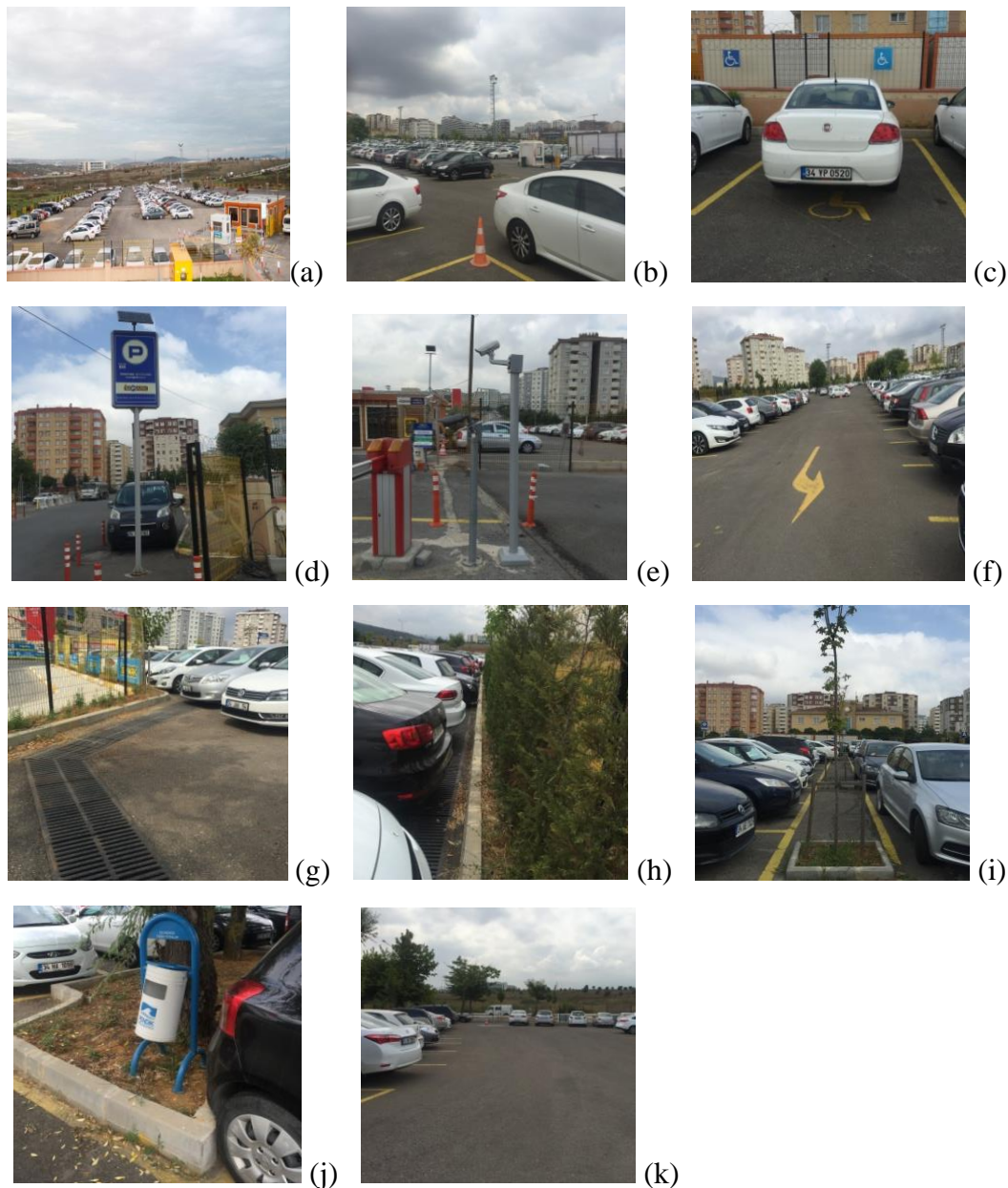


Figure 4.13 : Photographs of sabiha gokcen parking lot (personal archive)

The rectangular shaped open surface parking lot with painted parking stalls is located near the Sabiha Gokcen Airport and due specific location is always occupied by

motorists and there is a ring services to the airport every 10 minutes. the site is owned and maintained by Ispark. While there is not much vegetation to improve the environmental quality of this example but as figure (i) and (h) show there are some landscape features in both interior and perimeter areas. preserving existing trees is one of the features of this parking lot. this parking lot is one of the landscaped parking lots of the Istanbul. Conventional drainage system was used in this parking lot (g). Additionally, existing handicapped parking lots with blue sings is in accordance with ADA standards. using security camera, solar panels and, trash bins are another features of this site.

4.2.2.2 Case study No. 2 – Mercan parking lot

Location: Fatih District

Size: 1341

Car Capacity: 138



Figure 4.14 : Mercan Parking Lot (personal archive)

In a historic district in Faith, a parking facility shown in figure 4.4. this lot owned by Ispark. Two elevated parking was located both side of the parking lot (a). there is not any landscaped consideration in this parking, the only feature is solar panel.

additionally, there is huge multi-story parking lot front of this lot for increasing the car parking capacity.

4.2.2.3 Case study No. 3 – Maltepe recreation arena’s parking lot

Location: Istanbul, Maltepe

Size: 205465

Car Capacity: 2750



Figure 4.15 : Maltepe Parking Lot (personal archive)

This area is one of the designed surface parking lots and is part of the Maltepe Exhibition Arena. Raised walkways with the lighter color was seen all over the parking system and give safe accessibility for the pedestrian through the site. Using various kind of vegetation cover and interior landscaping features are the features of this parking lot and highlighted it form the others. Handicapped parking stalls are highlighted with different color. Bumpers and curbs in parking stalls give enough space for automobiles and preserving the trees and vegetation form cars.

4.2.2.4 Case study No. 4 – Alibeykoy Terminal’s Parking Lot



Figure 4.16 : Alibeykoy Parking lot (personal Archieve)

This terminal consists of building in the middle of the parking and facilities like children playground, ATMs, Coffee terries in corners, both side of the parking have vegetation for screening the parking area (b). Motorcycle parking was considered in this parking(e), and been close to public transportation is one of the features of this parking lot(g). shelters and places for passengers was considered in this lot for providing safer and convenient place. like other lots this parking also use conventional drainage system but slides were used near the catch basins to direct water flow (c).

4.2.2.5 Case study No. 5 – Yeni Kapi exhibition arena’s parking lot

Location: Istanbul, Fatih District

Size: 50825

Car Capacity: 5000



Figure 4.17 : Yenikapi Parking lot (personal Archieve)

This development like Maltepe recreation arena is a new designed one by filling the sea. Mentioned area has two parking spot in both side, one of them divided in two part. one of these parts considered as green parking lot. Rainwater infiltrates the porous surface, but accumulates on some parts because of extended curbs and bad inefficient drainage system (a).

considering all above, Table 4.2 was formed to comparing the typical condition of the surface parking lots in different location of the Istanbul based on the sustainable design evaluation criteria. According to the analysis it can be seen that all of the parking lots are using conventional drainage system. Asphalt was used as primary surface coating in the most cases except Yeni Kapi parking lot. These projects are designed poorly in

landscaped areas exclude Maltepe parking lot. Between the parking lots Alibey Koy parking lot has a social connectivity due to the existence of the shopping kiosks, ATM, children playground, shelter for pedestrian, rest of the analyzed parking lot are as void in urban areas.

Table 4.2 : Comparison table of surface parking lots

Criteria	Ecological and Environmental			Aesthetic	visual quality	Social and Human health			
	Parking lot Location	On –site Stormwatre facilities	surface material	Cost and Energy conservation	landscaping	Site layout strategies	Pedestrian /car safety/ accessibility	Flexibility / social connection	Educational / cultural statement
Sabiha gokcen parking lot	Conventional drainage and slop	Asphalt and Lawn	Inefficient solar panels in entrance,	Internal and Perimeter landscaping, Preserving existing trees	Alternative Transportation Options (shuttle service)	Control cameras signs	ADA Parking stalls and signs	-	-
Mercan parking lot	Conventional drainage	asphalt	Inefficient solar panels in entrance	-	Lift parking	-	--	-	-
Maltepe parking lot	Conventional drainage	asphalt	Bike parking, Inefficient solar panels in entrance,	Internal and Perimeter landscaping /Ornamental planting/ shade canopy	Small parking stalls	Pedestrian network	ADA Parking stalls and signs	Description about the site plan	-
Alibeykoy parking lot	Conventional drainage	asphalt	Bike parking, Inefficient solar panels in entrance,	Perimeter landscaping and screening	Alternative Transportation Options and bike parking	Control cameras and Shading panels	public, service area, ATMs and playground	-	small commercial shops
Yeni kapi arena parking lot	Conventional drainage	Asphalt and grass paver	Inefficient solar panels in entrance,	Internal landscaping	Balance between parking and landscape	Control cameras	ADA Parking stalls and signs	-	-

4.2.3 Implementing design strategies in Sehit Ahmet parking lot

Sehit Pilot Ahmet Altas parking lot was suggested by Ispark Architect as a case study for suggesting and implementing the design strategies. this land is one of the ongoing projects in Ispark and this space will be designed to provide a new paking lot system that will work in a sustainable way. The land is located in the Maltepe District in Asian side of Istanbul(Figure4.18).



Figure 4.18 : The existing land at the Sehit Pilot Ahmet Altas Cad.

Sehit Pilot Ahmet parking lot encompass 12900 m² of land and it has approximately 290 Meter distance from Maltepe Exhibition Arena.

according to the “SITE RATING SYSTEM for Sustainable Land Design and Development”, Site assessment is one of the important and primary steps before design begins. A comprehensive assessment must be done for understanding the existing physical, biological, and cultural conditions of the site also data-gathering will help to explore options for sustainable outcomes.

prerequisite 1.1 “limit development on farmland” explains that “locate project on a site that does not contain soils as prime farmland, unique farmland, or farmland of statewide or local importance.”

According to the satellite images and by comparing the 1982 and 2006 images this will be conduct that this land and shoreline was formatted by filling the sea as a residential and recreation area and does not contain the farmlands (figure4.19).



Figure 4.19 : Satellite images of the 1982 (left) and 2006 (right).

A general analysis was done for understanding the potential of existing condition of the land.

This property is an abandoned land with specific construction planning in a while and will convert to a surface parking lot. Residential areas are located in the north side of the land and south side runs along Turgut Ozel highway and have access to the green areas and coastline. Figure 4.20_4.22 show the analysis of the lot.

A good portion of the property is grass and also different tree species are existing in the edge of the lot. There is 4 catch basin in the land. a bus and minibus terminal are located besides and front of the site plan.



Figure 4.20 : Access to the property.



Figure 4.21 : Existing vegetation.



Figure 4.22 : Transportation nodes.

4.2.3.1 Concept design

In the designing of the green parking lot First step is site layout strategies according to the site features and analysis. analysis of movement and access patterns can inform the best location for new access points and road crossings, making the site and neighborhood easier to move around on foot or cycle

In this case, reinforce existing movement patterns, such as pedestrian desire lines and direct and convenient vehicle routes is one of the primary intents, for enhancing the accessibility of the site and social connections. according to the site plan analysis, property located between residential and public green park and also a minibus terminal is located in the left side of the lot.

Pedestrian network was designed for giving access to residential area and public park and in addition another access was designed to providing access to minibus terminal. Figure 4.23 shows the Vehicle access for parking lot which was given from secondary street for safety and avoid of traffic congestion.

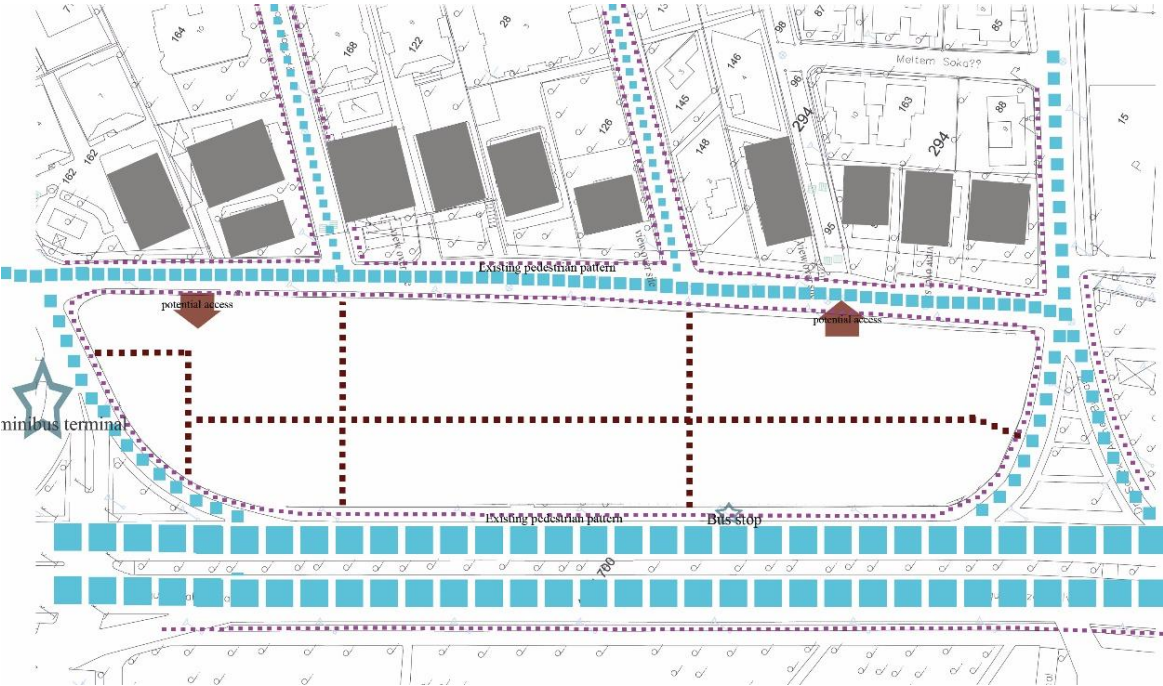


Figure 4.23 : Pedestrian and vehicles access.

by design the pedestrian and car access site plan divide to parcels, for improving the both visually and functionally aspects larger parking areas are divide into smaller parking courts. Figure 4.24 shows the parking islands and pedestrian network system.

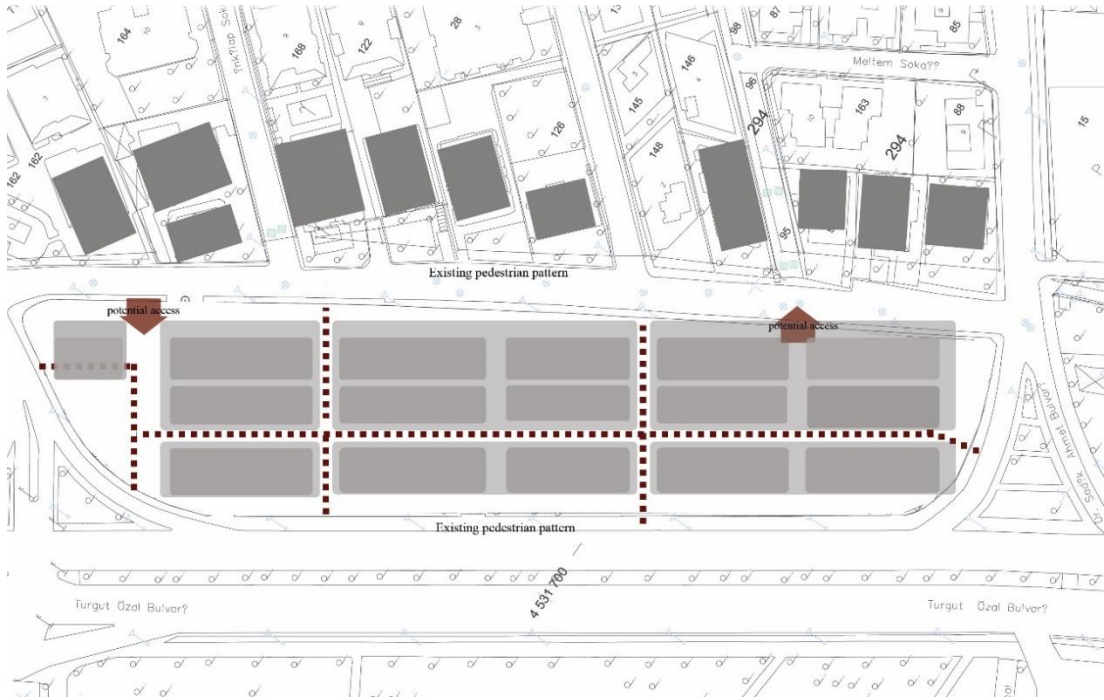


Figure 4.24 : Parking islands.

The design and layout of the development should protect and enhances the ecology and habitat of the natural environment, by analyzing the green network of the surrounding community, this will identify key aspects of the natural environment that should be protected and enhanced. Figure 4.25 shows the green network of the surrounding area.



Figure 4.25 : Green network.

New parking lot will bring change in the environment area, but this change should not lead to a permanent loss or damage of ecological system. And new development should Improve the ecology and habitat of the site as an integrated part of the development mature trees or other vegetation, should be Protected, and use them as features of the development. This is an effective way of integrating new development into an existing environment. The parking lot is located front of the residential area and to minimize negative visual impacts of the development a screening vegetated buffer with 3-meter width was designed between pedestrian network and property line these vegetated place has potential of the implementing of the bio retention facilities and although provide visual and aesthetical quality to the site. both side of the parking have potential for implementing raingarden as bio retention facility because of acute angle of the site in these places(figure4.26).

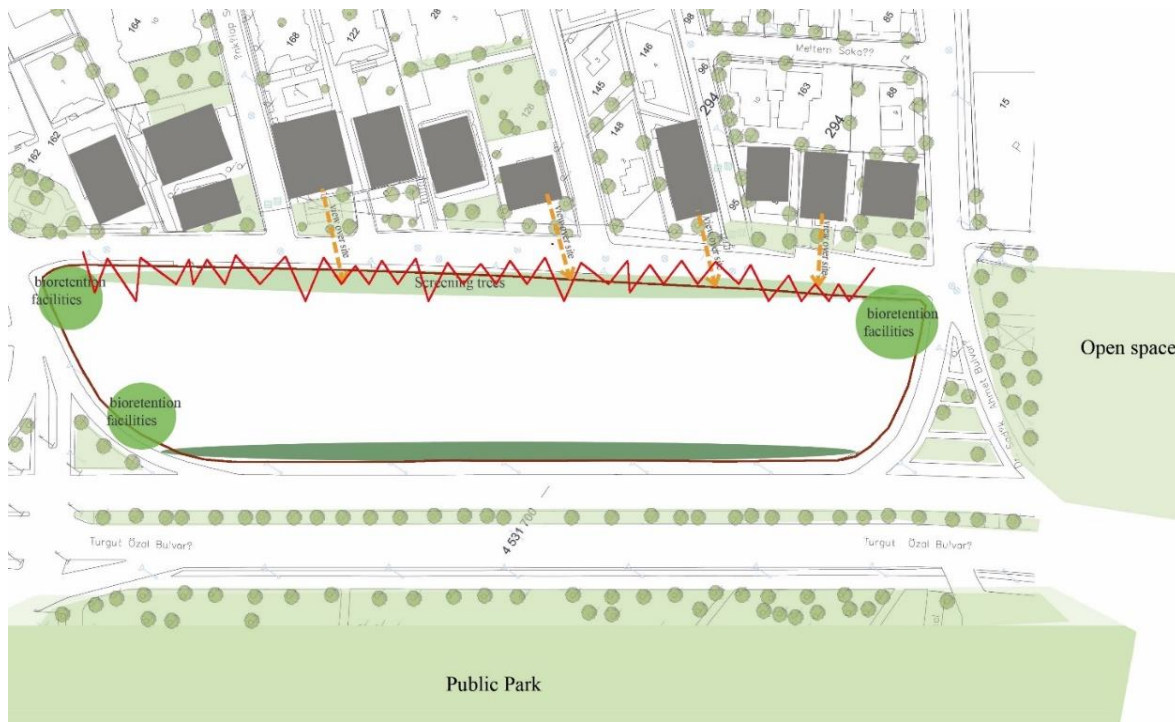


Figure 4.26 : Bio retention areas.

In the next step of the site layout, right side of the parking lot was allocated to the service area due to the existence of the TRAFO this place cannot be efficiently used for parking stalls. This service area consists of permanent waterless restroom facility and small shopping boxes that gives opportunities to vendors for sale, picnic tables, trash containers, compost area, and interpretive panels. And in the final step extensive green roof and solar panel added to the site, solar panels provide shading for

automobiles and pedestrians also by producing power can be use as charging plug in for electric cars, power source for irrigation pumping and finally can provide electric power for the neighborhood in the emergency situation. increase in the dedicated portion of land to green areas lead to decrease in the vehicle capacity, for offsetting this effect, lift parking was considered as a solution, stalls along the vegetated screening is appropriate place for installation of lift parking, dense screening in this part will cover the lifts from sight. Figure 4.27 shows the design elements of the parking lot.

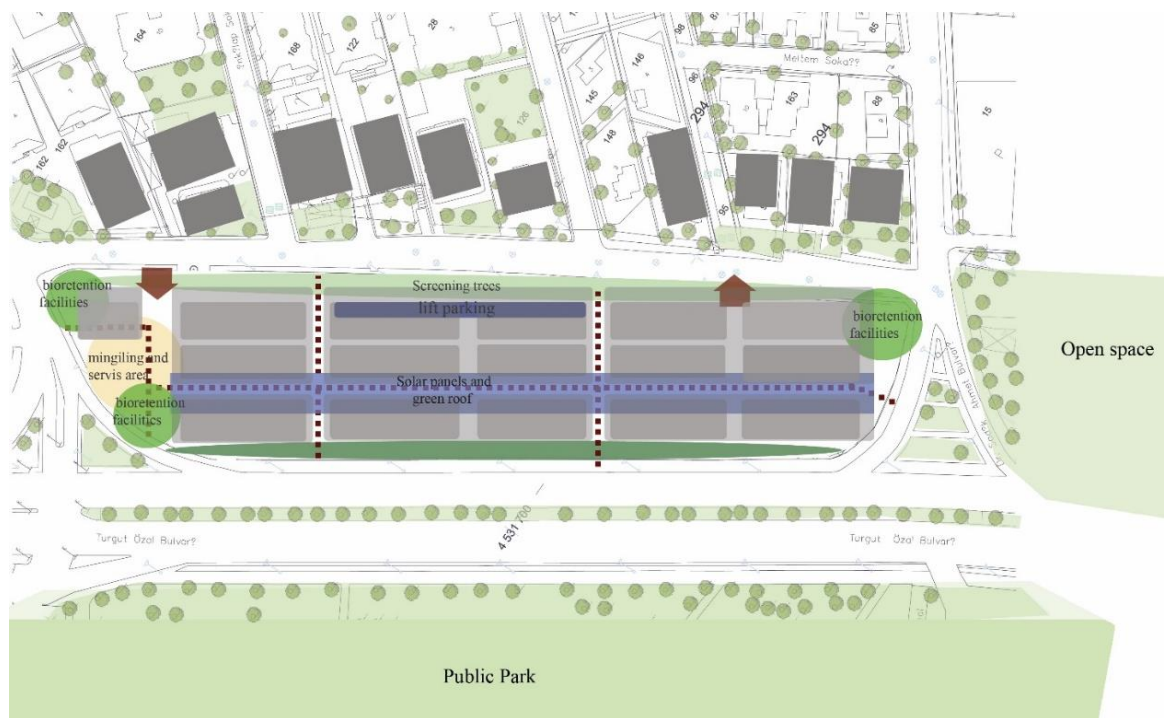


Figure 4.27 : Design elements according to the design criteria

4.2.3.2 Environmental and ecological concept

Providing ecological benefits is essential basis for nature conservation, Increases in stormwater runoff volumes associated with land development can put significant stressors on environments. In order to avoid potential adverse effects, concept designs for a site should seek to direct stormwater flows through a series of mitigation practices, in the first step, contamination source must be recognizing.

According to the site analysis, the property located between residential area and highway, Residential developments commonly contribute fine sediments, nutrients, pathogens and general organics to stormwater runoff. Landscape areas also contribute pesticides, herbicides and organic debris such as displaced mulch and grass clippings

(Kennedy & Sutherland, 2008). The contaminant load from streets and highways is impacted by automobile behavior (stopping and turning), and this increases with vehicle counts (Shaver, 2010).

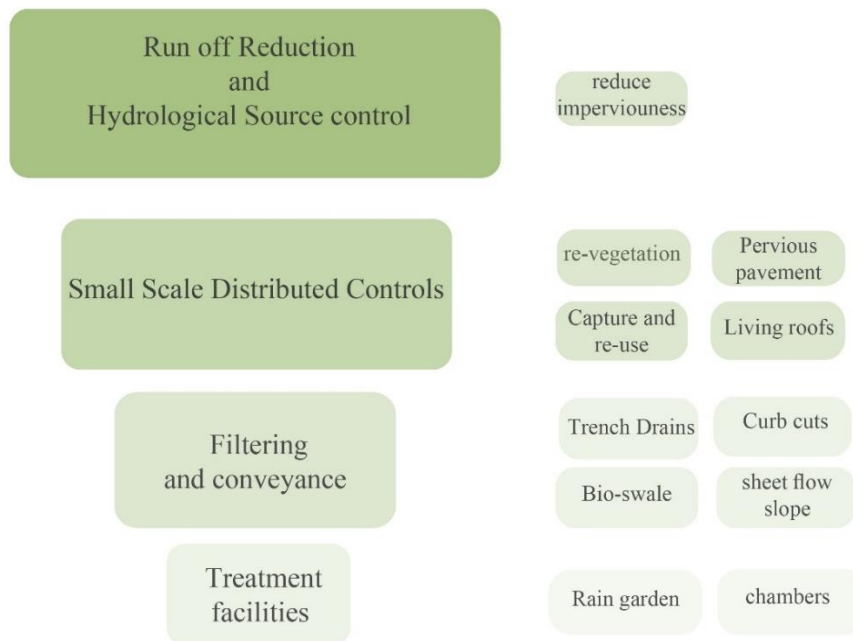


Figure 4.28 : Stormwater design diagram

Stormwater runoff direct from residential and highway toward the site. Run off direction through the parking lot can be seen in figure 4.28.

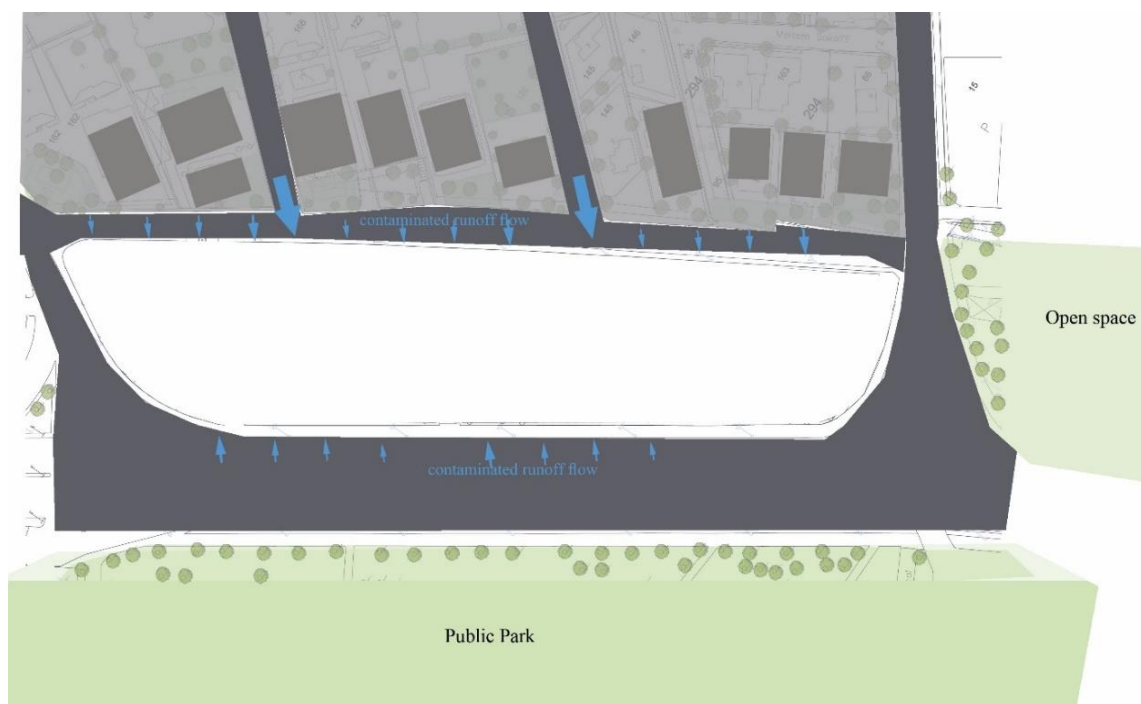


Figure 4.29 : Runoff direction

1-First step in the process of selection design strategies is considering opportunities for Run off Reduction and Hydrological Source control. these strategies are designed to eliminate or reduce stormwater runoff at the source by enhancing direct infiltration to the subsurface or reuse of the water.

Porous pavements for hard surface. Reducing impervious surfaces will increase opportunities for rainfall to be attenuated within vegetation and soils. This will moderate stormwater volumes and reduce the capacity. Reduced imperviousness is also likely to reduce the contaminant load, since there is less surface area for deposition of contaminants and more vegetated areas to capture and transform contaminants

2-Small Scale Distributed Controls in landscaped areas throughout the site opportunities are strategies that consider after opportunities for reducing runoff at the source. These strategies enhance and maximize the natural infiltration and storage capacity of the site where feasible.

Re-vegetation reduces stormwater runoff in catchments through the interception of rainfall in the canopy, infiltration through root systems, and transpiration. These re-vegetated areas can also function as filter strips to treat contaminants, slow overland flows, and attenuate stormwater quantities. There is a suite of environmental services provided by vegetation within a catchment, including enhancing biodiversity and ecosystem values, landscape amenity, dust interception, and temperature moderation. Trees in particular have several advantages over other vegetation in improving water quality.

Capture and re-use Stormwater from rooftops can be captured for use in buildings and landscape areas, reducing the requirements for mains water supply. Runoff from ground level surfaces can also be captured, and often contain entrained nutrients which can be beneficial for irrigation of landscape areas.

Between the solar panels and green roof, a panel was designed which can collect the rainwater and convey it to the surface chambers, this captured water can be used for irrigation.

Living roofs: living roofs have a significant potential role to play in stormwater management (Dunnett & Clayden, 2007). Extensive living roofs have lightweight layers of free-draining media to support low-growing drought resistant vegetation. The vegetation and media on living roofs capture atmospheric deposition of contaminants,

promotes evapotranspiration, cools stormwater runoff, and slows down rainfall response times, thereby reducing peak flow rates and runoff volumes. Green roof was considered in the internal part of the site for providing shade and also ecological benefits for the environment.

Pervious pavements can be designed as standalone water quantity treatment practices by providing below-ground storage for the water quality volume within base course layers. This reduces peak flows and total volumes, and improves water quality through filtration and sedimentation. In this project porous concrete was considered for both drive aisles and parking stalls but with difference in color. Pervious joint concrete paver was chosen for continuous walkway's material

3- conveyance: Both filter strips and swales achieve treatment of stormwater runoff while conveying it through the catchment. Specific mechanisms include:

Trench Drains: Using trench drains are good way to efficiently direct runoff to landscape areas without using underground pipes. Trench drain systems are designed to convey stormwater runoff within a shallow channel while maintaining unimpeded pedestrian or vehicular access. trench drain was used for directing the rainwater into to vegetated facilities from both residential area and high way,

Curb cuts: a simple cost-effective curb cut allows water to move freely into a stormwater facility without detracting from the aesthetics of the project. Curb cuts was considering in the curbs. different water penetration areas were shown in figure4.29.

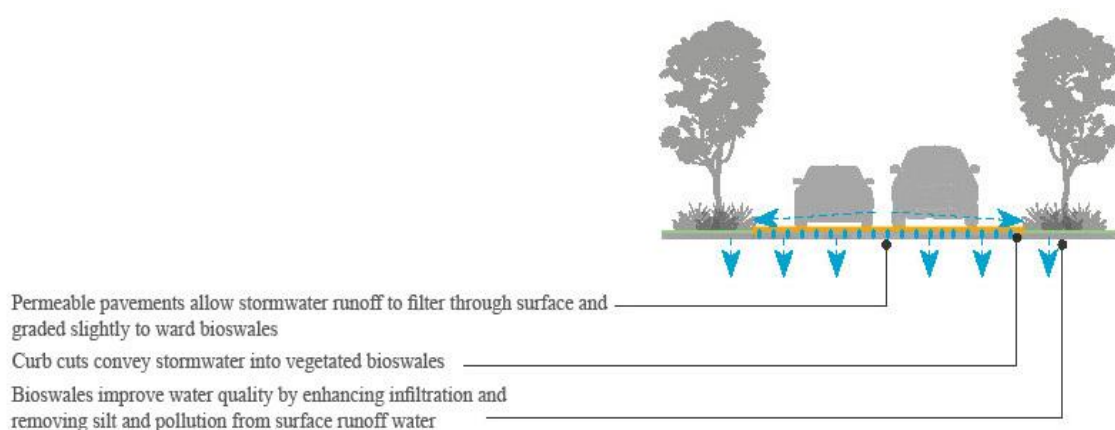


Figure 4.30 : Water penetration diagram.

sheet flow slope: by grading slightly (2%) water flow drain to the retention facilities when there is too much water to filter through the paving

bioswales: collect and treat runoff before heading into the waterbody's. It is sloped at 2% for continuous movement and also allows percolation into the soil and The swale is planted with native deep-rooted vegetation to filtrate the run off. The linear nature of swales makes them suitable for defining boundaries of the parking lot.

4-next step is centralized treatment facilities, these facilities should be selected and sized for the remaining water quality. Centralized facilities typically collect runoff from larger drainage areas and are therefore larger in size.

Rain gardens: In locations where conventional landscape areas would occur, raingardens can be used instead. 3 parts of the parking lot was designed as raingarden facility.

Chambers:

Three underground cistern, applied in the site for harvesting the overflow water from the biofiltration areas. overflow water capture by the Underground storm water chambers that are manufactured to be effective long-term storm water management systems. Figure 4.30 demonstrate plan and section of the underground chambers. These chambers located on junction with a site irrigation system that will sprinkle the collected water on to lawns and landscape beds. And also using above cisterns for the collection of the water from water harvesting systems.

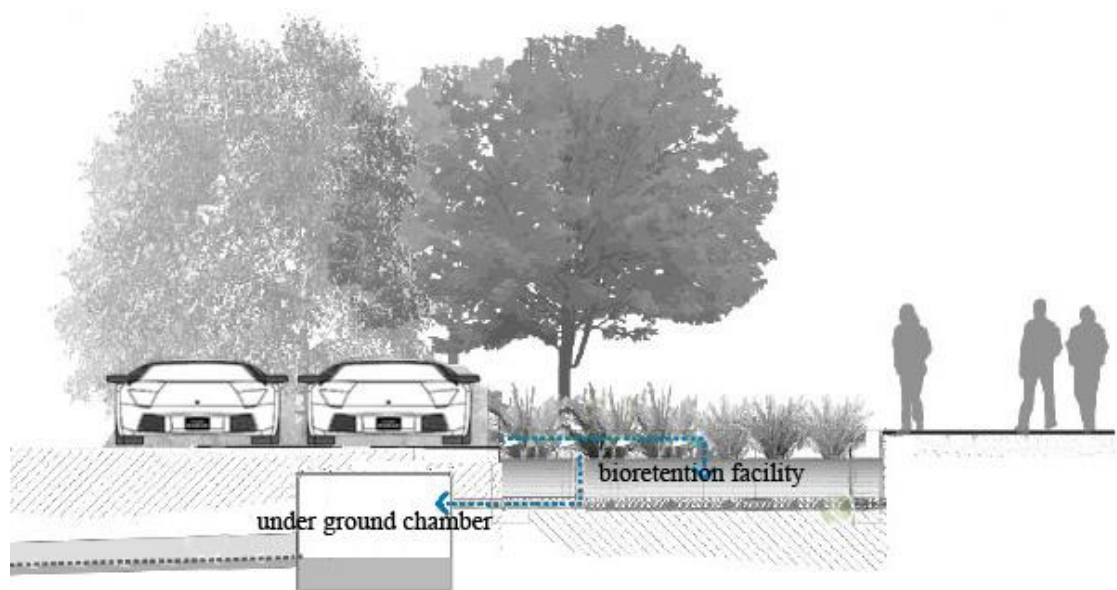


Figure 4.31 : Section of the underground chamber

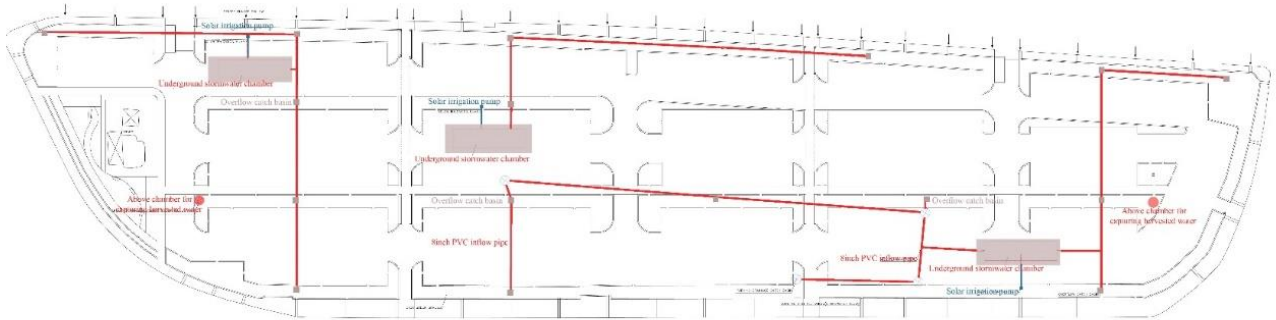


Figure 4.32 : Plan of the chambers

4.2.3.3 Social and human health:

For providing social and human health feature site was designed accessible for the public and continuous pedestrian network enhance this feature.

1-Left part of the site was designed to accommodate the area that boost the social continuous and also help in the education aspect by providing Interpretive panels in the picnic/restroom area which will educate people the history and importance of the site, and also how it is sustainable

2-The waterless public restroom is located in picnic area for easy access for the visitors.

3-wooden picnic tables are centralized in the parking lot under the shade and next to service room.

4-13 ADA parking facilities according to the design application one space for every 25 space is devoted to ADA parking lots.



Figure 4.33 : Handicapped parking stalls dimensions.

5-Trash and recycling containers and compost area are placed around the picnic area and at every pedestrian entrance to discourage littering on the property

6-a welcoming sign at the front entrance will help visitors identify the area. a “one way” and “wrong way” sign at the traffic split in the parking lot will help direct traffic. park rules at every pedestrian entry will inform visitors on what is and is not allowed

7- pedestrian scaled lightings provide safety and also reduce the light pollutants. Figure 4.33 shows the comparison of traditional and perfect lighting design in parking lots

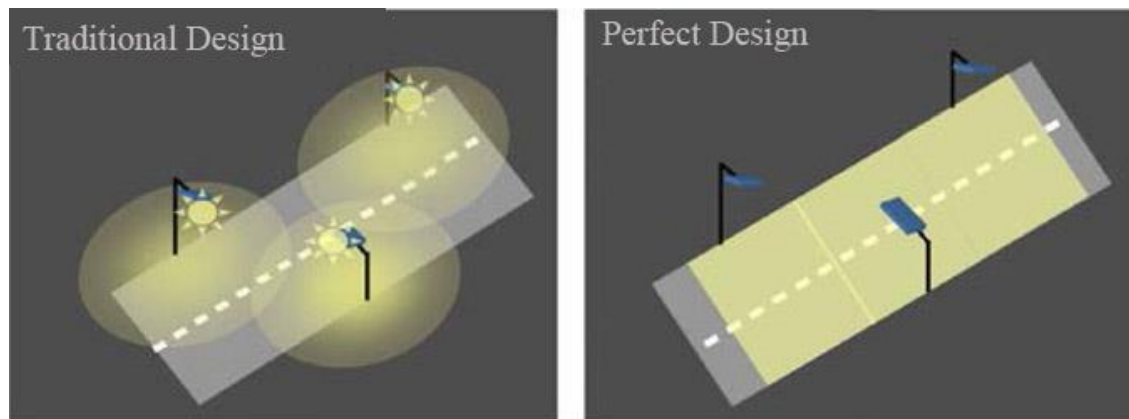


Figure 4.34 : Comparison of traditional and perfect design.

Figure 4.35 shows the master plan of the Sehit Ahmet parking lot. For providing a sustainable and environmentally friendly parking lot the main three heading: Ecological & Environmental, Aesthetic & visual quality and Social & Human health and their components and related strategies are applied in the designing process. Figure 4.35 and Figure 4.36 demonstrate the detailed section of the parking lot



Figure 4.35 : Proposed plan for parking lot.



Figure 4.36 : Section A-A.

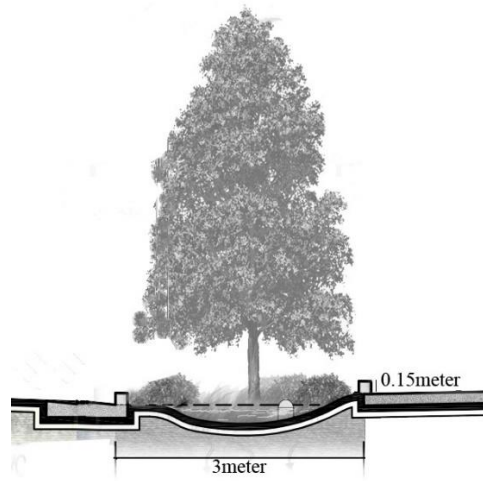


Figure 4.37 : Section B-B.

4.2.4 Comparison with current applications

After the designing of green parking lot this parking are compared with the conventional parking lot that was designed by the Ispark. Figure 4.37 shows the parking lot plan for the same land with the conventional standards of the Istanbul municipality.

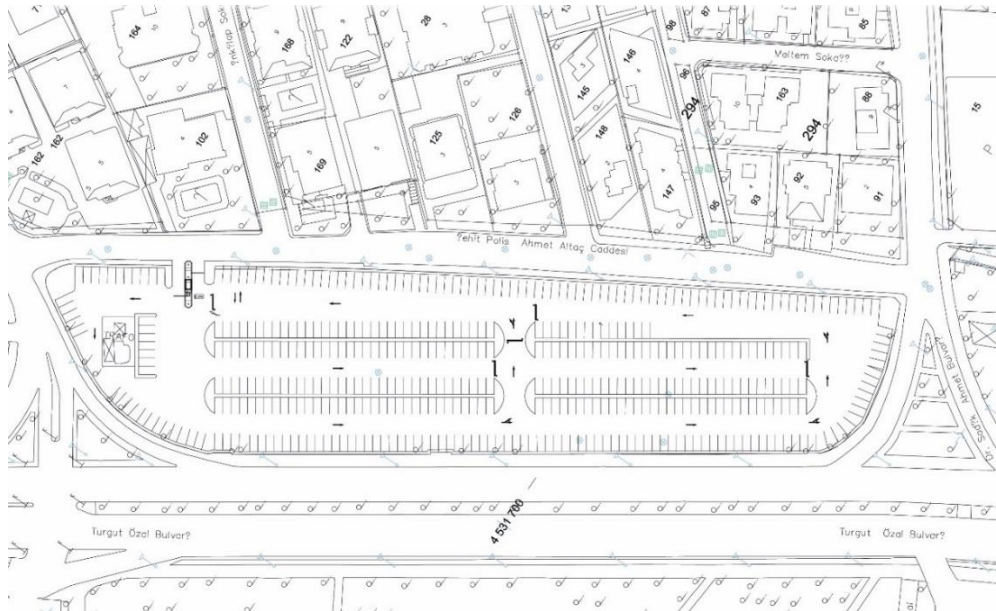


Figure 4.38 : Conventional parking lot designed by ISPARK.

Table 4.3 shows the different capacity and characteristics of the designed parking lot and current parking lot. applying the sustainable design strategies will provide more environmentally friendly and aesthetically pleasing parking lot. This parking is not a separate part of the urban areas. giving the chance to accommodating vendors and small shopping kiosks in parking lot, will enhance the local economy and also provide social connection.

Table 4.3 : Comparison of two types of parking lot.

	Car capacity`	Green roof (m2)	Impervious Ares (m2)	Porous pavement (m2)	Vegetated Ares (m2)	Walkway Ares (m2)	Solar panel area (m2)
Green parking lot	370	255	-	4298	3267	717	1070
Conventional parking lot	400	-	11637	-	1052	-	-

25.32% of the property devoted to the vegetated area that is approximately equal to the “4% of the total impervious catchment area” rule (by assumption of percolation rates of soil 5-10 inches/hour) according this rule for an effective stormwater treatment facility, the dedicated landscape space will be 4% of the total impervious catchment area (San Mateo, 2009, p108).

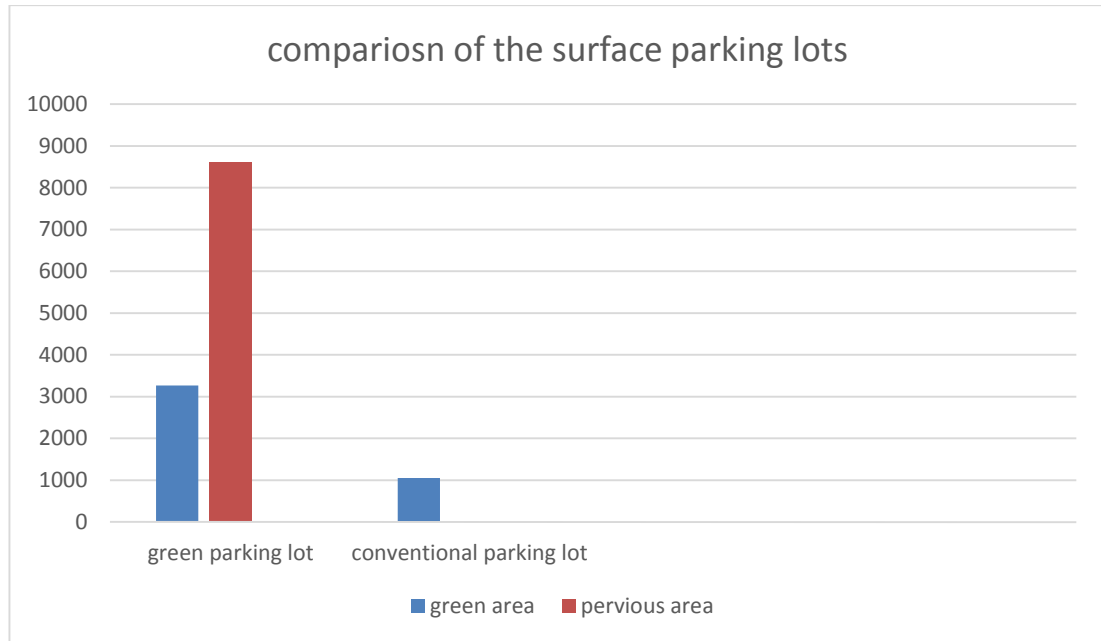


Figure 4.39 : Comparison of the surface parking lots.

By considering this in to account and by devoting of at least 4% of the surface parking areas to vegetated plants and bioretention areas in the Fatih District we will have 21530 m² more green areas. Figures 4.39_4.40 shows the perspective of current parking lot and designed one.



Figure 4.40 : Proposed surface parking lot.



Figure 4.41 : Current surface parking lot.



Figure 4.42 : Bird -view of proposed parking lot.

5. DISCUSSION AND CONCLUSION

Urban surface parking lot is one of the essential components of urban fabrics. Entering the 21st century, and the ever-increasing human footprint will continue to consume natural resource and open space and ultimately test the limits of our ecosystems. since growth and development are inevitable, humans must solve the paradox of being able to meet the infrastructure and the spatial needs of society while simultaneously conserving the natural environment.

Urban surface parking lots have fundamental effects in the environment and people's health. Thus, the importance of the urban surface parking lots is enhanced. In this regard, the aim of this thesis is to probe the design evaluation features for surface parking lots, in terms of sustainability.

The criteria are obtained from the review of the previously defined literature which is relevant to urban surface parking lots. certain sets of parameters have been created by classifying the related criteria, sustainable design evaluation criteria have been categorized into three main headings: environmentally & ecological, beautification & visual quality, social & human health, which are different aspects of the urban surface parking lots from the sustainable design perspective.

In addition, Fatih District has been analyzed on the basis of impervious surface growth rates, and change in land-cover from 1966-2014 years by the use of maps and photographs. Afterwards typical surface parking lot of Istanbul has been examined on the basis of sustainable evaluation criteria.

In the next step Sehit Ahmet parking lot was designed according to the sustainable design strategies. Environmental and ecological consciousness are one of the basic feature of the green parking lot. For providing environmentally friendly parking lot On-site Stormwatre facilities, Surface material and Cost and energy conservation should be considered. These aspects of parking lot have been provided by designing the raingardens, bioswales, curb cut and conveying trenches, overflow system, green roof, using porous and light colored material for stalls and parking bays, using solar

panels and well-designed lighting systems, Storage and collection of recycled materials, Sustainable irrigation systems, local material and plants, Provide space for electric cars and bikes.

Beautification and visual quality are primary aim of the surface parking lot standards. for providing these aspects in Sehit Ahmet parking lot landscaping and site layout strategies are considered in designing process. Internal and perimeter landscaping, tree canopy for shading and ornamental trees to giving attraction for the parking lot, balancing parking spaces with landscape spaces and dividing parking lot to smaller pockets are the design strategies for providing this aspect.

In this study, Pedestrian and vehicles safety and accessibility, Flexibility and social connection, Educational and cultural statement and Economic activities are the components of the Social and Human health aspect of the urban surface parking lots. The aims of these parameters are to attract the public and provide social connections with surrounding area, and safety for pedestrians and motor vehicles. continuous pedestrian network system, site accessibility, control cameras, ADA parking stalls and signs, provide mingling and service area, temporary or permanent social and cultural installations, small commercial shops, provide spaces for vendors and swap or sale are the strategies that are used in the designing process.

To conclude, it is essential to consider certain strategies. According to the results of the research and analysis a sustainable parking lot will not only enhance the environmental conditions but it will also increase the social and human health consitions.

Indeed, a paradigm shift needs to occur between the relationship of the built environment and nature.in the past, the two have frequently been treated as separate entities. a different ways would be first examining in the surrounding environment and formulate a design solution that minimize destruction to habitat and open space. Urban surface parking lots in cities play various roles in different aspects. In the most of the communities those who make decisions about parking regulations have very little understanding of design and impact of surface parking lots. Parking lots are like a canvas that provide many changes and uses within the build environment.

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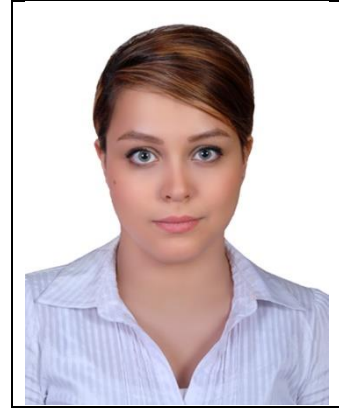
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CURRICULUM VITAE



Name Surname: Ouldouz Hajimohammadipour

Place and Date of Birth: Tabriz, Iran, 1986

E-Mail: ouldouz_mohamadi@hotmail.com

EDUCATION:

B.Sc.: Azad University of Tabriz, Department of Architecture 2004-2008