Suggestions for Designing Sustainable Touristic Resort Complexes

With Emphasis on Static Cooling in Hot and Dry Climates

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ABSTRACT

Thinkers believe that one of the critical issues in present century is achieving a suitable life, observing the limitations and compatible with the optimum use of energy resources. Due to this idea, on the threshold of the third millennium, achieving the goals of sustainable development in order to solve the environmental crises, economical consumption of energy and creating sustainable economics has changed to the base of planning and managing in many countries.

Considering this issue is very substantial in Architecture and Urbanism and especially in human residential places. However, energy as the most important foundations of economic sustainable development, has not yet achieved the function and position proportional to its importance and efficiency in national and local development plans of Iran. The biggest amount of energy in the world is specified to the buildings; half of this amount is consumed for heating and cooling. Considering the fact that more than 2/3 of surface area of Iran is covered with desert and half-desert lands with a hot and dry climate, and one of the substantial factors for providing constructional comfort in desert regions is cooling, so designing the sustainable touristic resort complex with the approach to the methods of creating sustainable cooling in these regions is very efficient in reducing energy consumption and the expenses related to mechanical utilities.

In the present research, following the study of the methods for cooling in hot regions, the principles of designing residential resort complexes with the purpose of accessing to the process of designing the sustainable resort and tourist complex in hot and dry region is offered. The presented materials are collected through the library studies, referring to internet sites, etc.

The research opens with some generalities concerning the importance of the subject of sustainable cooling in hot and dry regions. After studying the texts related to this subject, the theoretical fundamentals of sustainability in ecological complexes, including the crises of modern development, formation of sustainable development and specifications of sustainable ecological complexes are presented by an approach to sustainable cooling in hot regions in three scales of city, neighborhood and building.

According to the presented methods and solutions in the third chapter, the principles of designing sustainable touristic resort complexes with an approach to the subject of sustainable cooling particularly in hot and dry regions (desert lands) of Iran are explained in details as the principles of designing.

And finally, conclusions of the research in the form designing sustainable resort and tourist complexes are presented in a way that the methods suggested to be used in the studied regions would be the most common methods of providing sustainable cooling for constructional comfort.

Keywords: Sustainable Development, Sustainable Tourism, Sustainable Cooling, Modern Development crisis, Eco tourism, Thermal Comfort

ÖZET

Düşünürlerin inancına göre çağımızın en kritik konularından biri enerji kaynaklarının daha etkin kullanım zorunluluğunun sınırlayıcı yönleri ile uyumlu bir hayat tarzını başarabilmektir.Bundan dolayı,üçüncü bir bin yılın eşiğinde olduğumuz günümüzde,pek çok ülke çevresel krizler enerji kaynaklarının daha ekonomik kullanımını ve sürdürülebilir ekonomilerle yaratılabilmelerini temel plan ve yönetimlerine baz almaktadır.

Bu konu mimarlıkta,kentleşmede ve özellikle toplu yerleşim alanlarında geniş bir yer tutmaktadır. Ancak,sürdürülebilir ekonomik gelişmenin temeli olan enerji henüz önemli ve etkinliği ile doğru orantılı olması gereken esas yerini, fonksiyonunu iran'ın ulusal ve lokal gelişme planında bulamamıştır. Dünyada genel bir uygulama olarak enerjinin büyük bir bölümü konutlara ayrılmıştır;bu miktarın ise yarısı ısıtma ve soğutma için harcanmaktadır.

İran'ın üçte ikisinde kurak ve çöl ikliminin hakim olduğu gerçeğini göze alırsak sürdürülebilir imar konforunun sağlanmasının ne kadar soğutmaya bağlı olduğu anlaşılır.Dolayısı ile ,sürdürülebilir turistik resort komplekslerinin dizaynı ile bu bölgelerde sürdürülebilir soğutma yöntemlerine yaklaşım, enerji ve mekanik tüketimi azaltmada oldukça etkilidir.

Bu araştırma,sıcak bölgelerde kullanılan soğutma metodları çalışmalarını, resort konut komplekslerinin dizayın ilkelerini takip ederek,sıcak ve kuru alanlardaki turistik tesislerde sürdürülebilir dizayn yöntemine ulaşma amacı ile

sunulmaktadır.Sunulan materyaller kütüphane çalışmarını ve ilgili akademik sitelere başvurarak tedarik edilecek.

Araştırma kuru ve sıcak bölgelerdeki sürdürülebilir soğutma konusu üzerine bazı genellemelere başlar.Bu konu ile ilgili referanslara başvurduktan sonra,ekolojik komplekslerdeki sürdürülebiliriğin teorik temelleri,modern gelişmenin beraberinde getirdiği krizleri sürdürülebilir gelişmenin formasyonu ve sürdürülebilir ekolojik komplekslerin beliryecilerini de içeren sıcak bölgelerdeki şehir,civarı ve bina olmak üzere üç açıdan sürdürülebilir bir soğutma yöntemi şeklinde ,sunulmaktadır.

Üçüncü bölümde,sürdürülebilen turistik resort kompleksleri dizayın ilkeleri,sunulan method ve çözümler çerçevesinde,özellikle İran'ın sıcak ve kuru çöl iklimi bölgelerindeki sürdürülebilir soğutma konusuna bir yaklaşımla dizayın ilkeleri şeklinde detaylı olarak açıklanır.Sonuç olarak,araştırmanın sürdürülebilir resort ve turist kompleklerinin dizaynını şeklindeki sonuçları, öngörülen metodlar şeklinde yapı kontoru açısından sürdürelebilir,yaygın ve etkin soğutma yöntemleri olacak şeklinde sunulur .

Anahtar kelimeler: Sürdürülebilir gelişme ,Sürdürülebilir turizm, Sürdürülebilir soğutma , Modern gelişme krizi ,Eko turizm ,Termal konfor.

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…….TO MY FAMILY

AND TO THE ONES HELP ME TO LEARN

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF CHARTS

LIST OF GRAPHS

INTRODUCTION

1.1 Introduction

Today, city as an alive and dynamic organism keeps on going its own way but it does not grow and develop. This problem results from ignoring different subjects that all together make the concern about lack of energy, extinction of natural resources and environment into a widespread and common problem for the developing countries; as today we can see the pollution of world common resources, extinction of the main biological systems and the high rate of the risks threatening the health of urban areas. Tourism and consideration of tourism industry with a sustainable approach is one reason of paying attention to biological systems in the country. Those rich economic, socio cultural and environmental consequences of tourism in general and presenting known subtitles in tourism including nature tourism, green tourism, neutral tourism, ecotourism all make sustainable tourism as the main subject with all its principals, objectives, characteristics, executive obstacles and priorities inevitable.

(Toulaee.S, 1386, 2007)

In recent years the industry of tourism was taken into more consideration and the authorities have realized its importance. Nowadays tourism has turned into an industry with high comparative advantages all over the world and attracts managers' attention to planning and optimum management to have an inclusive plan for tourism because this industry is very helpful in economic development.

Iran, regarding its special situations and enjoying natural, artistic, cultural and historical features can compete with important touristy countries across the world. Iran can become one of the most important countries in tourism industry through

augmenting fundamental elements and the bases of tourism development. However in the structure of legislation, this country does not have a definite plan for absorbing tourists and developing tourism industry yet.

Iran is one of the most ancient countries in the world. Thousands of ancient historical sites justify this claim. But why is not this country known by foreigners especially tourists as other countries are? Regarding this fact in recent years the following discussions were the focus of the authorities:

1. How can we put the issues related to the environment and attracting tourists in its true place in planning programs?
2. How can we take into account the issues concerning ecotourism in order to protect the environment and energy in urban planning and in architecture and urbanism?
3. What are duties of experts and specialists of urban planning, architecture and urbanism with respect to the subject of energy, environment and protection of natural resources for attracting tourists?
4. How can we encourage members of society as the most important consumers of energy to reduce their energy consumption and protect the environment?
5. And finally how can put the issue of energy as the most important issue in sustainability of environment and sustainable ecotourism into the right place? (Mofidi.M, 1385, 2006)

The present research attempts to study tourist resorts from the sustainable tourism perspective with a focus on “sustainability of environment” and with emphasis on “static cooling” and determine the relation between this subject and dimensions of spatial urban framework of tourist resorts. Finally it is going to present suitable suggestions in designing a sustainable tourist resort with emphasis on static cooling. The questions arise in this research are as follows:

1. What are the principals of environmental sustainability of tourist resorts in hot dry regions of the country regarding static cooling?

2. How can apply the proper solutions in designing and building the sustainable tourist resorts in hot dry climate with emphasis on "static cooling"?

The present research while studying the characteristics and features of sustainable tourist resorts in hot and dry regions and by benefiting from the natural methods for cooling will suggest proper solutions in this field and at last it will present proper models for improving the industry of sustainable tourism and achieving the principals of sustainable development in this project.

1.2 Statement of the Problem

There is an organic relation between sustainable development and sustainable tourism. Though the term sustainable development consists of two words, sustainable and development, we cannot consider this concept as a mere combination of these two concepts. In fact this combination denotes political, economic, cultural and ecologic aspects. Sustainable development was introduced first by Barbara Ward in the mid 1970s. Since 1992 this term changed into one of the principal issues in planning and the concept of sustainable development changed into the plan of the world in 21st century. This development emphasizes sustainable development objectives so that the next generation will benefit the same advantages mostly ecologically and environmentally. Organization of world tourism defines sustainable development as a kind of development that makes attempt to provide the present needs without risking the interests and needs of the future generation. Sustainable development must be able to fulfill five essential needs of the society: combination of protection and development, fulfillment of the primary needs of the human, social

justice, cultural totality, and keeping ecologic unity. Sustainable development is a solution for a development which would organize total assets and natural, human, financial, physical sources in respect with a long-term increase of society prosperity, poverty decrease and society comfort. (Toulaee.S, 1386, 2007)

Since 1992 (after Malle's and Rieu's statements) the term of sustainable development was introduced as one of the essential issues in 21st century planning. Principals, details and focuses of 21st century instruction are as follows:

1. Development is the right of both present and future generation. In other words there should be an intergenerational and intergenerational balance.

2. Environmental protection is an essential principal of development. The primary objectives must be paying attention to the limitations of ecosystem, capacity, accounting on them and realizing the environmental values.

3. Man is the focus of sustainable development. In another words this is man's definite right to have a healthy life based on nature.

4. In human societies, participation of local communities especially the youth and experts in different levels including local, national, regional, international as well as their contribution in making decisions are necessary.

5. Optimal resource allocation

6. Retaining identity, culture and interests of native individuals

7. Taking population policies and observing the models of sustainable consumption and production

8. Rendering environmental evaluation and respecting the international laws regarding protecting the environment, introducing and informing the tourists about natural disasters

So, sustainable development with the goal of fulfilling present generation's needs while protecting resources for the next generations attracted attention to itself and influenced different levels and aspects of life. Among various aspects of sustainability, energy as the most essential issue influential in economic development of society is not in its true place and is disregarded in micro and macro policies of development. Ignoring environmental issues in designing architecture and urbanism and in consequence the increase of energy consumption on one hand and the limitation of principals, executive laws and management faults on the other hand, generate many obstacles for the sustainable urban development. Some of these obstacles are:

1. The limitation of finite energy resources (oil, gas, etc.) and their unreliability
2. Consumption of more than 50% of world energy reserves in buildings
3. Consumption of more than 45% of energy in buildings for cooling and heating
4. Utilizing mechanical equipments and utilities for making buildings comfort and increasing energy consumption
5. Increase of necessary energy for comforting as the result of incompatibility between building and environment, habitat and design background

Some consequences of damaging the environment are:

6. Pollution of primary sources (air, water and soil)
7. Increase of greenhouse gases, destruction of ozone layer and at last increase in earth's temperature
8. Increase in earth's temperature and melting of polar ices and snows
9. Increase in sea level
10. Increase of frequency and long rainy seasons
11. Distribution of various diseases

These consequences are more influential in developing countries and are accounted as a serious threat for the future generations. Unfortunately as Iran enjoys a large amount of fossil energy such as oil and gas, the issue of shortage of finite energy resources is ignored and the high consumption of these energies in building, transportation, industry, etc has damaged the environment and economy of the country. Regarding this fact, the present research discusses issues related to environment and natural resources and focuses on the subject of energy and saving energy using strategies for static cooling in hot and dry climate of Iran.
(Mofidi.M, 1385, 2006)

1.3 Argument

Paying attention to sustainable development and observing its principals in sustainable tourism is of great importance, because tourism is based on an ecosystem and historical and cultural legacy. Destruction of these resources is damaging to tourism and its sustainability. Actually sustainable tourism is one part of sustainable development (Figure 1.1). This kind of tourism consists of different elements interacting with each other so that a change in one of these elements affects other elements of the system. In other words trying to fulfill sustainable models of tourism would impact other elements of non tourism. For example, falling of tourist arrivals decreases damages to environment and also economic benefits resulting from tourism. On the other hand providing labor force in tourism because of its economic advantages leads to decrease of labor force in agriculture and will damage agricultural economy.

There are two obvious, intense relationships between sustainable tourism and sustainable development:

1. Sustainable tourism is accounted as an influential tool for fulfilling sustainable development because as a kind of catalyst it provides agricultural products and improves the market and finally leads to revival of local economy.

2. Sustainable development is a prerequisite for sustainable tourism because an unsustainable development may impact the quality of tourism products and related services.

A sustainable tourism is an industry which by considering facilities, fulfills different economic-social, cultural needs and tourists' expectations and simultaneously protects ecological unity, environmental health, cultural identity and totality of the host society and leads to economic development, eradication of poverty and welfare of society members. (Toulaee.S, 1386, 2007)

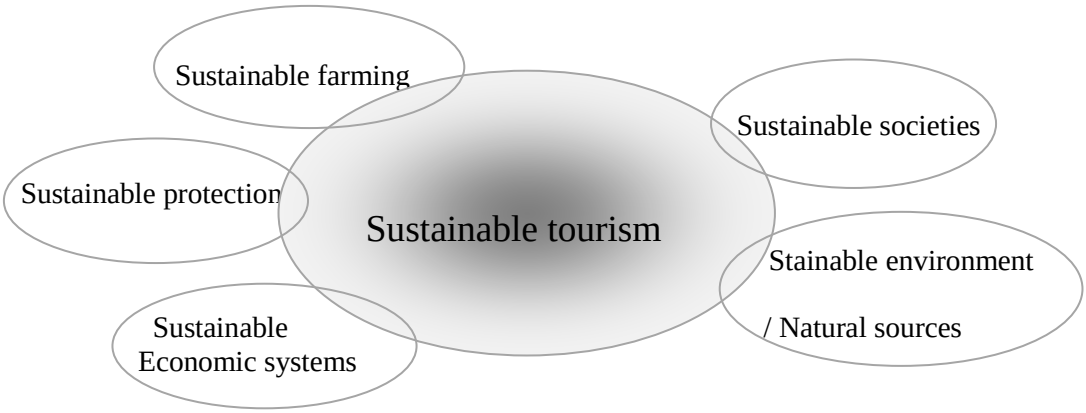


Figure 1.1: the relation between sustainable tourism and sustainable development

Source from: Mechanical Discussion, Mofidi, M1386, 2007

Regardless of high expenses of cooling resident places situated in hot climate, this issue was paid little attention by Iranian specialists and designers. Regarding the location and climatic and environmental characteristics of the central plateau of Iran which occupies more than – of country's total area, using natural methods for cooling

is very helpful in decreasing consumption of finite energy. So the present research is an attempt to study carefully the static techniques for cooling and suggest proper solutions for increasing the comfort and decreasing energy consumption in hot and dry regions. (Mofidi.M, 1385, 2006)

1.4 Motivation

Regarding the subject of the project which is designing resort places and sustainable tourist places with emphasis on static cooling, this section present the reasons of choosing this subject is one by one.

1.4.1 Motivation for Choosing Tourist Resort Complexes

- Iran is rated among the first 10 countries of the world regarding historical and ancient attractions and among the first 5 countries of the world regarding natural and eco-tourist attractions.
- Lack of sufficient substructures for the benefit of tourists and also shortage of financial facilities as well as essential equipment for improving industry of tourism
- The obvious gap between Iran's revenue from tourism and other countries' (Iran ranks 57^{th} among tourist countries)
- One of the most potential and crucial advantages of tourism is providing opportunities for employment in the country (each tourist may provide 15 to 18 opportunities for new jobs and improve other jobs as well.)
- Iran is successful neither in attracting those tourists interested in historical sites, nor in ecotourism as one of the branches of tourism industry. (According to the statistical data of world tourism organization 50% of the

tourists all over the world are eco tourists, while in Iran these tourists are less than 2%)

- The officials do not consider tourism as a source of income and do not improve tourist culture
- Weak advertising for introducing attractions and historical sites of Iran
- Absence of efficient practical planning schemes for improving domestic and international tourism
- Absence of planning schemes and discouraging the private sector is the most important problem of tourism development
- Precious resources of Iran are not known to the majority people all over the world
- Tourism is the most important and the most influential and largest social activity of man and may be the origin of cultural, social and economic effects
- Improving culture and introducing own culture to the people all over the world
- Tourism can improve national grounds of the country
- Sustainable tourism activities lead to respect for the environment and more attention to it
- Existence of virgin nature which decreases tourism expenses to half
- The high number of tourists and travelers in all seasons

1.4.2 Sustainability

Among the three dimensions of sustainability, environmental dimension is one of the most essential one which is in mutual relation with the rate of energy consumption and the way it is generated. This dimension committed to considering environmental facilities, its proper exploitation, keeping balance in nature and preventing much

exploitation of resources, also leads to saving energy. The subject of the present research is energy as one of the three fundamental bases of environmental sustainability namely energy, environment and ecology, and also reduction of energy needs through modifying Yazd environment. Accordingly in this research among natural influential elements in reducing energy needs for cooling, the use of water and wind is studied because of the following reasons:

1. Water and wind are the most abundant resources after solar resource in the world (water covers – of the earth's surface).

2. Water, covering – of the earth's surface has potential for thermal storage in comparison with the average storage of thermal energy by other materials on earth. So water is suitable for thermal storage and preventing its transfer.

3. Existence of abundant resources of groundwater such as flume and their exploitation in combination with wind is very useful for static cooling.

4. Wind transfers 30% of total heat in the world and so it is very good for cooling effect.

Using water and wind for comfort does not need a complicated technology and is also economical.

1.4.3 Static Cooling

Focusing on static cooling in designing tourist resorts especially in hot dry regions is of great importance. The reasons are as follows:

1. Over than – of Iran's surface is desert and semi desert having hot and dry climate.

2. Desert regions have long hot periods (more than 7 months of a year) and exhausting dryness.

3. Mechanically thermal comfort in hot regions (using water and gas coolers, etc.) consumes a great amount of fossil energy.

4. Despite the efficiency of natural cooling in traditional architecture and urbanism, it is taken into little consideration by the experts.

5. Considering solutions related to natural cooling through compatibility with environment and using local potentials will decrease use of fossil energy and its disadvantages. So in the present research this issue as one of the proper solutions in making environmental sustainability is studied.

1.5 Research Objectives

The research objectives are as follows:

1. Achieving the objectives of environmental sustainability.

2. Providing tourists' welfare by maximum use of local potentials and minimum use of energy consuming and pollutant machines.

3. Maximum use of renewable energies especially solar storage with water.

4. Reduction of environmental pollution resulted from use of fossil fuels.

5. Reduction of the need to finite energies for heating and especially cooling.

6. Achieving architectural and non-architectural methods and strategies in order to prevent wasting energy in building.

7. Exploiting native materials for static cooling which are simultaneously attractive for the tourists

8. Achieving new models of locating the place according to topography of the region and easy access for the tourists based on static cooling and in order to utilize the existing plant and producing vegetation cover.

9. Achieving new models of height and size of residential buildings for the tourists based on characteristics of static cooling.

10. Establishing adjoining residential units in order to shade each other and the interval spaces.

1.6 Proposed Research Questions

The proposed questions in this research are as follows:

1. What is the relation between human health as the main focus of sustainable development and energy?

2. Is it possible to find quantitative and qualitative criteria for the issue of energy in building?

3. Do these criteria have high flexibility co efficiency in order to be applicable in different periods?

4. How can we find some criteria of sustainability in architecture by comparative study of the principals and methods of fulfilling the needs of residents in traditional architecture?

1.7 Approach

In case of gathering primary information in present research due to subject of the research and limitations the methodology includes the literature survey and documentary research and case study rather than developing a new approach that suggest solutions for designing a sustainable complexes with emphasis on static cooling in hot and dry climates .

The methodology which used is as fallow:

1. Documentary search s as ,books , journals ,articles ,and thesis witch related to the topic is in two part:
    - Firstly research on sustainable architecture and using principles in designing sustainable architecture whit emphasis on static cooling
    - Research on sustainable tourism which answer the present needs of tourists and the host society ad also the needs of future generation .

2. Search on the net sites witch related to the topic
3. Observation and researching existing examples in similar climates and analyze them.
4. Interview with specialist in this case and teachers and local peoples.

1.8 Outlines

Chapter 1

Chapter one first discusses the main subject of the project namely the manner of achieving a stable equilibrium between increasing growth of population and limitation of energy resources, it also discusses making a balance between limitations and the available facilities to find purposive methods as one of the most important issues of the present century. Then the importance of paying more attention to urban sustainable executive and operational issues to achieve purposive planned and practical development in developing countries like Iran and the necessity of finding sustainable models in designing tourist resorts as an important step in solving the problems and crises resulted from urban unsustainable development are studied.

Chapter 2

The primary purpose of this chapter is to provide a total recognition of theoretical basics, principals and the purposes of sustainable development in urbanism and architecture in order to be applied properly in future designing and planning. In this chapter firstly the crisis resulted from development are presented in the form of economic, social and environmental crisis. Following that the elements generating sustainable development, the background and its development are presented and a brief introduction to the definitions of different theoreticians in the field of sustainable development are provided. Finally this chapter offers concepts,

objectives, foundations, executive and operational principals, three dimensions of sustainability and then methods of sustainability.

This chapter provides human resident places with sustainability particularly in the field of architecture and urbanism. Seeking to observe environmental principals, inhibiting damages to main essential ecosystems and retaining the health of urban areas and the necessity of protecting natural resources and energy reserves in designing sustainable resort places, the chapter while studying the characteristics and particularities of sustainable environmental complexes ranging from macro scale (metropolises) to micro scale buildings, will offer exact definitions of city, region, location and sustainable building, and at last the characteristics of tourist resort complexes as a sample of a sustainable location will be studied.

Chapter 3and 4

This chapter first studies the basics related to principles of climatic designs of buildings including the issues related to thermal comfort and the methods of producing, methods of transferring thermal energy and energy dominance in building, static cooling, its sources and the methods of generating, application of static cooling in traditional architecture in hot regions of Iran, various sustainable systems with an emphasis on environment including static and over static systems. Next, strategies of designing resort places are discussed in three scales of complex buildings, buildings and components of buildings. Regarding the subject of the project and climatic needs of the studied region which is hot dry region, the results of this chapter are presented in the form of design strategies for sustainable resort places regarding energy. These results are offered in two groups of cooling strategies and cooling-heating strategies.

LITERATURE SURVEY

2.1 Introduction

Increasing growth of population all over the world has usually brought about catastrophes for natural habitats on the earth. Too much energy consumption, jungle destruction, and extinction of plant and animal species are among theses catastrophic outcomes. Many believe that increasing growth of population which itself is the result of the change in industrial developing systems and increase in health service in industrial societies, leading to urbanization and extreme, irresponsible consumption of fossil energy and gradual warming up of the earth, threaten cities seriously and has done irrevocable damages to the world environment. Much amount of this wasted fossil energy, results from typical and nonstandard building structures; as the structures are not compatible with their climate, energy wastes for heating and cooling and would pollute the environment. In contemporary architecture, the changes regarding the sustainable and climate-environment standards get more and more important. We can interpret sustainability in architecture as the future designing and building, not only limited to physical sustainability of the building but also sustainability and preservation of this planet and its energy resources. Therefore it seems that we can consider sustainability on a model in which materials and available sources will be used efficiently rather than being ignored or wasted. (KhanMohhamadi, M, 1384, 2005)

This chapter makes an attempt to study the historical background and evolution of sustainable development after recognizing the crisis resulted from modern development and the causes leading to sustainable development. This chapter offers

a brief introduction to the definitions suggested by different thinkers about sustainable development, and finally, ideas, purposes, foundations, executive and practical principles, triple dimensions of sustainability and sustainable pyramids are discussed. The chapter accesses to knowledge of principles and purposes of sustainable development regarding urbanization and architecture, and even the issues such as tourism, for the efficient application in future designing and programming.

2.2 Modern Development Crises

In civilization of the Renaissance, with a new attitude toward the world, experimental attitude dominated rational one. Experimental attitudes, leaded to discovery of new phenomena, discovery of nature secrets and equipping man with developed equipments. In this way the foundations of modern technology took form. Western civilization, till then a defeated civilization, became independent of world of Islam in different fields of economics, politics and military issues by Renaissance. In modern era, control of diseases led to health development, population increase led to business development, urbanization expansion led to expansion of cities and development of industrial products led to the effective methods of production. The chain of scientific discoveries of 17^{th} and 18^{th} centuries, including shipping, military development, new political relations, appearance of new attitudes in art, growth of population, etc. led to industrial revolution in western societies.

(KhanMohhamadi, M, 1384, 2005)

After passing a quarter of a century accompanying economic growth and two decades of development, at the end of 19^{th} century, western society got aware of being threatened by a very dangerous crisis of development which cannot be accounted as a passing or transient period. Looting the resources and high level of

pollution was the characteristic of production and consumption model. The result was nothing other than inequality between different countries, poverty and hunger, lack of health service, illiteracy and destruction of biological ecosystems, and challenging the western civilization with instability.

Development project being almost half a century old, regardless of many hopes, yielded without fulfilling these hopes; the old schools lost their integrity and changed to a disparate mass. The developing countries which were to gain development, welfare and freedom experienced poverty, inequality, and retardation more than before. At this time, the crises resulted from modern development appeared in the fields of science, economics, ethics, environment, politics, and population. . (KhanMohhamadi, M, 1384, 2005) .Here in this section, some of these crises regarding urbanization and the relevant issues of human and environment are studied.

2.2.1 Economical Crises

Speed, quality and low efficiency of urbanization industry have different reasons, from which the most important are lack of knowledge, poor culture of the society as well as poor economy. The low quality of designing, inaccurate performance, using traditional methods of building, lack of mass production of standard tourist places and endless process of building, are among the basic problems of contemporary cities. Energy and the related issues are other important issues of urban economics and any waste of energy will bring about damages to the city and sustainable development. Construction of buildings as one of the most wide local industries can be a source of both wasting and preserving energy. Long and complex routes, large area of the city, high costs of construction, depreciation, security against earthquake,

undesirable quality, drilling problems, and other issues including economic problems concerning urban understructures. Inaccurate location, limited capacity for population, and improper location of public places are among the problems of modern cities. Some reasons are formation and the random extension of the cities, many limitations as result of lack of land, high price, and high costs of organization of urban spaces. Energy, water and transportation are important issues in a city and have immediate influence on city economics. . (Tabatabaie, A, 1383, 2004)

1. Energy: Some examples of energy wasting in cities are: wasting energy in building construction, transportation, home facilities, wasting thermal energy in buildings, city light and etc. All these cases lead to economic damages in modern societies.

2. Water: Predictions about changing the competence for reaching water sources into armed conflict in Middle East, gets more and more believable. One of the most important issues related to water, is it pollution which is worsened in result of little attention to the environmental issues. As a result of city expansion and poor facilities, considerable amount of water is wasted through the old pipes and the splits and leads to much costs for supplying water needed in modern cities.

3. Transportation: Environmental pollutions and other disadvantages of large number of automobiles, threaten not just city and human but all the earth. Global warming and ozone depletion which are mostly the result of green houses gases are affected much by pollution caused by the machines. Other problems caused by the automobiles are: air pollution, noise pollution, stress, accidents, traffic, high consumption of energy, the costs related to maintenance, repair, etc.(Tabatabaie,A,1383)

2.2.2 Social Crisis

Family as the smallest social structure in current cities, are threatened greatly. Economic problems, stresses outside, stresses caused by the work inside, lack of the accurate mechanism of realization, and poor culture of the people are among important causes of family problems. One of the hidden problems of modern cities is the reduction of social and family relations which leads to bad effects on the citizens and should be relieved.

1. Stress: Some portion of the stresses refers to the urban construction. Stresses, financial and service problems in modern cities would intensify these problems.

2. Life Quality: In a modern city, welfare equality is impossible. The city structure makes welfare equality impossible. In other words, the city is constructed on the basis that always some people are poor and the others are rich.

3. Lack of Housing: One of the important issues regarding the housing is its high cost. Lack of housing in some countries have changed to such a problem that its quality is not accounted at first hand. Improper access to the facilities, improper designing of the plan, improper light and ventilation, noise penetration to inside and outside, and elimination of privacy of the family are some examples of low quality of housing.

4. Unemployment: Unemployment or work misdistribution, pseudo jobs, and poor consumption management are integral problems of cities in developing countries. Management means on one hand the consumption efficiency and on the other hand reduction of consumption. The important issue in this regard would be the consumption culture.

5. Hygiene Crisis: Air pollution, pollution of drinking water, unhealthy distribution of foods and cosmetics, heat heatstroke and frostbite, firing and the consequent

injuries, accidents and injuries, stresses and mental break down, lack of drugs, etc. are all the consequences of indifference to hygiene in modern cities.

(Tabatabaie, A, 2004)

2.2.3 Environmental Crises

Climate change, global warming, air and water pollution, increase of green house gases, developing water surfaces, destruction of natural resources, etc. are among the environmental crises. Here in this section, some of the most important crises are discussed here.

1. Global warming and Climate Change: Change of climate is a new discussion which is related to different kinds of jobs and fields of life and is the result of warming and change in other environmental characteristics. Temperature increase of the earth surface in the recent 100 years has been 1.8 degree and according to the predictions, in future 100 years this increase would be equal to 2-5 degree. Continuation of this process definitely will lead to melting of the polar ices. The consequences of climate change are: big, irregular waves of the seas, coolness in the valleys, floods, rising of water surface, diseases, drought, and continuous destructions, and heavy rain falls. As this issue is very important, here we should study some of theories suggested by the thinkers in this field.

Theory 1: Pale climatologists

This theory suggested after studying the polar ice sheets in ancient past, is indicative of two ice ages and an age between ice ages. It means that after each 10,000-20,000 years, fall in temperature and increase in earth temperature happen. However this theory is rejected by other scientists because of “time incompatibility of temperature increase”.

Theory 2: Solar Pattern

This group believes that the sun is the main reason of climate changes. This theory just like the previous one is rejected because of time incompatibility.

Theory 3: Global Greenhouse Effect

This theory believes that global warming happens as the result of accumulation of green houses gas in atmosphere. According to the researches done, increase in temperature leads to increase in co_2 and vice versa. The amount of CO_2 is so much that the earth is not able to absorb it.

Some consequences of climate change are: reduction of rain fall and relative humidity in the lands inside the continent and those regions surrounded by the mountains, quick melting of polar ice sheets, increase in sea surface level, high waves in oceans and seas, imbalance rain fall in different seasons regarding the amount and frequency. Therefore climate change will destroy the self constructed environment, human civilization and achievements. In such a situation people have to take shelter in urban areas and caves. (Mofidi, M, 2006)

2. Air Pollution: Air pollution not only effects human, plants and other creatures' lives, but also effect the monuments and the buildings constructed by human kind and will force much costs to the economics of countries. One of important issues regarding air pollution is the global warming in result of green house effects. Temperature increase of the earth will lead to climate changes, melting of polar ice sheets and increase of sea levels.

3. Garbage: One of the most important sources of pollution is the garbage produced by the residents of cities. In absence of an efficient recycling system, garbage changes into an important problem.

4. Green Environment: Green environment plays more important role than just a luxury for the citizens. Some problems regarding green environment are its small area in proportion to the constructed environment, low quality, and the problems of its maintenance, costs and its pollution.(Tabatabaie,A, 2004)

2.3 Sustainable Development

The present world indicates many complex crises threatening the biosphere greatly. Continuation of this process would be catastrophic. Man is in a critical era of the history. Inequality between different countries as well as inside the country goes to establish itself forever; poverty and hunger, lack of health service and illiteracy are all increasing and those ecosystems which human's life is dependent on them are declining.

Among these, the new discussion (sustainable approach), while avoiding the linear, one directional, one variable theories, meaningless generalizations and abstract hypotheses regardless of time and place, changed into a wide discussion for analyzing all the relevant factors especially understanding any factor's contribution to the whole discussion. Sustainable development is a new discussion which accounts simultaneously politics and culture as well as economics, business and industry. Sustainable development supports both environment and coexistence with the environment and the equality between people. It emphasizes both interior affairs of the countries and international affairs. Sustainable development is humanistic and considering the wide discussions and its large potentials, it has changed to the most important present discussions and one of the most important challenges of 21st century.

Sustainable development is a new discussion which suggests new doubts to the old order by the use of the hypotheses, innovations and new flourishing. The discussion may be the foundation of the new order.

In 1992, the 2nd conference of The United Nations was held on environment in Rio. "Sustainable Development" was a proper term which replaced "Ecologic Development" due to some political considerations. The new ambiguous term, still considering the goals of ecological development, let the problems of sustainability be introduced. In conference of Rio, the executive obligations for "sustainable development" were not determined, but many elites and representatives of many countries accepted sustainable development. (Nasiri, H, 1379, 2000)

2.3.1 Terminology

The term "SUSTAIN" has been applied since 1290 in English language and this word is taken from the Latin word "SUB and TENEP" which means reservation or protection. There have been other meanings and forms of this word for years, but the use of this word with the present meaning that is "sustainability" what "which can sustain for future" goes back to the recent decades. (KhanMohhamadi, M, 2005)

Stable, Everlasting, Fixed, Permanent, Constant, Inexhaustible, Perdurable

SUSTAINABLE DEVELOPMENT: development, expansion, progress, promotion, growth, appearance

2.3.2 Concepts

The term "sustainable" was first introduced in mid 1970s by Ms. Barbara Ward; however the term was first presented officially in 1987 in the report under the title of "our common future". The concept is known as one of the newest and most

important paradigms of development in late 20th century which is based on the ethical principals relating to generation equality, human races and different groups in different regions. Sustainable development has considerable dimensions including environmental, financial, physical, social, economic, cultural, political and psychological dimensions. One of the most important concepts of sustainable development is the circular process instead of linear one in exploiting the resources and their recycling. There are four essential concepts in the definition of sustainable development offered by the Brant Land Assembly. These concepts are as follow:

1. To provide for the future: According to the sustainable development the land is not inherited from the ancestors, but is lent by the future generations

2. Environment: Efficient management of the environment, its supporting and protection of the natural sources

3. Equality: The sources being available for all in both local and worldly scale

4. Participation: Providing necessary prerequisites for diagnosing the issues related to the environment according to the people participation and their free access to the information for improving quality of their lives and the future generations.

(Mofidi, M, 1385, 2006)

2.3.3 Executive and Practical Principles

In order to perform those projects leading to sustainable development, and in order to perform these projects in the society, we should pay attention to the following points in management of the cities and environmental issues.

- **Using Renewable Energy Resources**: Using renewable energy resources, being replaced by natural processes at a rate comparable or faster the rate of

consumption by humans, is one of the first and most important principles of sustainable development.

- **Optimizing Non-renewable resources**: Using non-renewable resources which are consumed at a rate faster than the rate of being replaced and consumed, would damage the environment and is accounted as the main obstacle to the sustainable urban development.
- **Reducing Wastes**: In order to achieve sustainable development, the wastes and pollution in both local and worldly scale should be absorbable by the environment.
- **Healthy Environment**: In addition to fulfilling the present generation's needs, a healthy environment should sustain for the future generations and the present activities should not lead to problems for the future generations.

2.3.4 Sustainability Pyramid

The sustainability pyramid (Figure 2-1, right), showing the general and social aspects of sustainable development are as follow:

1. Social Values: the main discussions in this part are: economics of the society, social equality, culture of the society and the cultural diversification, education and teaching

2. Environmental Resources: the main discussions in this part are: energy resources, basic resources (water, soil, and air); those resources which are not consumable now but are potential for future consumption.

3. Technological Knowledge: the main discussions in this part are: renewable energy and new energies, handicrafts, environmental design.

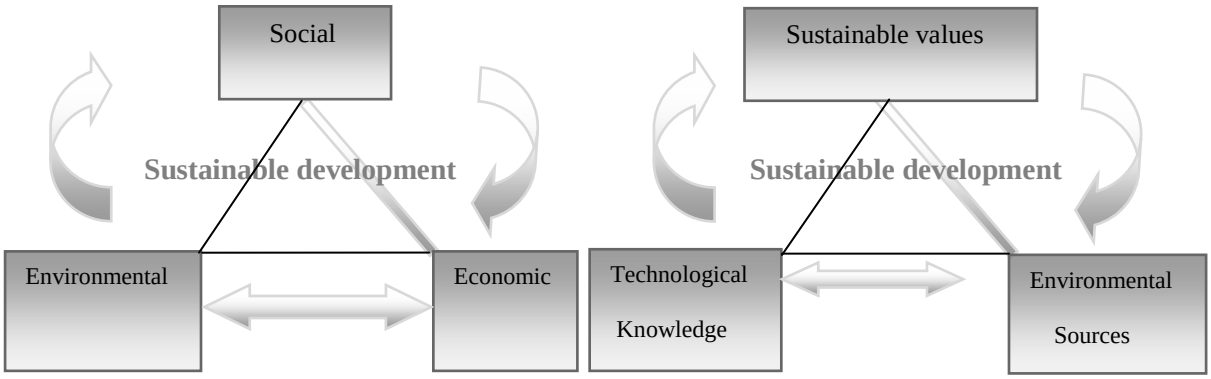


Figure 2.1: Right, the main pyramid, Left three dimensions of sustainability

Source from: Mechanical Discussion, Mofidi, M, 2006

2.3.5 Dimensions

The sustainable development is discussed regarding three main dimensions. These dimensions are:

1. Social dimension concerns the social problems and issues and finding solution for them.

2. Economic dimension which concerns the issues related to economic problems of the societies.

3. Environmental dimension concerns the solutions of environment protection and reducing the damages to it.

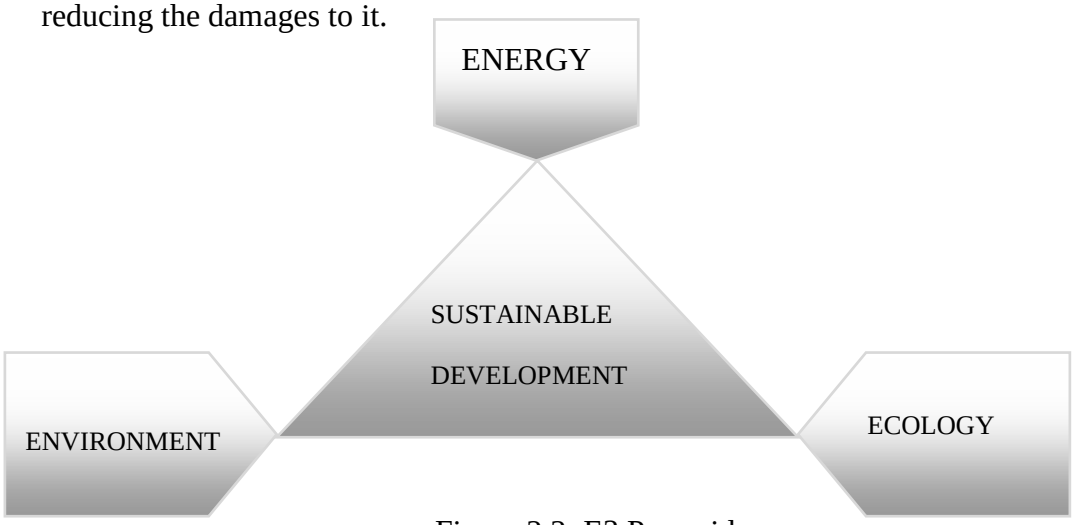


Figure 2.2: E3 Pyramid,

Source From: Mechanical Discussion, Mofidi, M, 2006

2.4 Sustainable Development and Sustainable Tourism

The sustainable development has an organic relationship with the sustainable tourism. Although the term "sustainable development" consists of two words of "sustain" and "develop" but using the simple addition doesn't sound wise in relation to a complicated phenomenon like the sustainable development, because this term also consists of political, economical, cultural and ecological sides. The term of sustainable development introduced at first by Barbara ward in mid 1970's.

From 1992 on the term sustainable development became one of the key discussions for programming the universal development in 21 century. This kind of development underlines the continuation of development goals in a way which in it the next generation has a similar opportunity especially in the parts of environment and ecology with the present generation. The international tourism organization defines sustainable development as a kind of development in which the current needs are fulfilled without risking the benefit of next generation and their needs.

The sustainable development should fulfill 5 basic needs of societies that are coexisting of protection and development, preparing basic needs of human to live, social equality, culture integration and keeping the ecological integration. Sustainable development is a guideline of development in which all the wealth and natural, human, economical and physical resources are rearranged to gain an endurable increase in public wealth, decreasing poverty and increasing social welfare. (Charles, R. Geolner, J.R, 2000)

From 1992 (after MALE and RIO statements) the term sustainable development introduced as one of the main discussions on programming for 21 century. The elements, main parts and axis of the 21 call instruction are as follows:

1. Development is a right which should be equally granted to the present and next generation, in other words the main goal should be keeping balance in a generation and between generations.

2. Protecting the nature is an inseparable part of development. Noting the limits of ecosystem, its capacity and its loads and noting the local values should be the main goal.

3. Human being is the center of a sustainable development, in other words having a healthy and natural based living is a natural right to the mankind.

4. The participation of local society's especially young people and clear sighted by any means in local, national, regional and international discussions and letting them to participate in decisions is a basic right of human societies.

5. Optimized admeasurements of the resources

6. Protecting local peoples identity, culture and benefits

7. Politics of population and keeping the standards `in sustainability in production and use. (Pourvakhshuri, Z, 1377, 1998)

Noting the sustainable development and obeying its principles is important in sustainable tourism, because the tourism is based on environment and historical and cultural heritage. If these resources destroy the tourism itself and enduring of it would be doubted. In fact the sustainable tourism is a part of sustainable development (Figure 1.1).

This kind of tourism consists of a number of elements that communicate each other in a way that any change in one would result to a change in other parts of the system. In other words developing the sustainable kind of tourism would effect on other non tourism elements. For example, reduction on the amount of tourists reduces the bad effects on the environment and reduces the profit coming from tourism at the same

time. All the same, providing working forces in this section leads to reduction of working forces in agriculture section and harms the economy of agriculture because of its economical vantages. (Toolaiy, S, 2007)

There are two clear and strong relations between sustainable tourism and sustainable development:

1. The sustainable tourism is considered as a strong tool to help providing a sustainable development, because it works as a catalyst for developing small business by providing market for agricultural products and finally leads to reconstruct the local economy.

2. The sustainable development is a prerequisite for the sustainable tourism because a non-sustainable development could effect on the quality of tourism products and the related service.

The tourism is sustainable if along with fulfilling various economical, social and cultural needs fulfill the tourist's expectations, ecological unity, environmental health and cultural unity and identity of the hosting society and helps towards gaining development in economy, reducing poverty and improving social welfare.

2.4.1 The Sustainable Tourism Definitions

Butler introduces the sustainable tourism as an activity which begins in a place, develops and acts in a way that it lasts to an unlimited time as a sustainable activity. In addition, it should never impact the environment and should not stop the successfully develop of other activities.

The global council for traveling and tourism, the global tourism organization and the earth council define sustainable tourism as a kind of tourism that fulfills the current needs of tourists and hosting society and at the same time protects the benefits of the next generations. In addition to a good knowledge of social, economical and

aesthetic needs they should respect the cultural integration and ecological process. Olseln introduces the sustainable tourism as an activity that doesn't impact the environment, has benefits for the hosting society, recognizes the environment as a kind of wealth and believes to its limitedness and limited quality.

According to Esvar Brook, the sustainable tourism is a kind of tourism that fulfills the needs of tourists, tourism industry and the hosting society without doing any harm to next generation wealth by this act. Furthermore, this kind of tourism has its economical justification and doesn't harm the ecology and social and cultural structure of its hosting society. Along with differences there are many things in common in definitions above that could be observed as the basic elements of sustainable tourism. The global council for traveling and tourism charts these elements as follows:

1. Defending, advocating and reclamation of ecosystem based on a sustainable model of production and expend.
2. Participation with the hosting society
3. Local programming
4. Respecting the cultural integration of the hosting society
5. Making global lows and obeying them, saving the ecosystem and acting globally

(Boo, E, 1991)

The sustainable tourism should be considered from various points of view. One of these important things is the matter of the kind of dealing with the profits coming from tourism and the way these profits are administrated and controlled. The other thing is tourists themselves which should be observed in their interests and behavior models perspective. The tourism industry also should be observed from the legal point of view, in relation to its relations with the hosting society, process and

solutions had been found for a sustainable tourism and employment policies. Another thing is the governmental policies about appropriation of budget and capital, laws and programming criterion. Another important thing is methods, policies and ways of saving the ecosystem that consists of natural and demographic programs, domestic live and settlement. The way of using natural resources such as water, soil and food in parallel to considering any kind of air, water, noise and visual pollutions is another thing which could not be omitted from consideration. At the end, another important thing is practical policies of related organizations of tourism about handling wastes and sewage and saving policies for energy resources. (Figure 2.3) (Toolaiy, S, 2007)

2.4.2 The Sustainable Tourism Goals, Attributes and Principles

According to what we said above, increasing awareness about the ecosystem, conservation of the environment, promoting equality in development culture, respecting the principles of justice and equality in a generation and between generations, optimizing the quality of hosting society and making potentials for tourist to gain experience should be considered as main goals for a sustainable tourism. Another goals and attributes of sustainable tourism are increasing the participation of local people (the hosting society), preservation of cultural integration and unity and social unity and respecting the local culture, adapting tourism programs to other local, regional and global programming.

The sustainable tourism, in general, is based on the long time profits, comprehensive caring for environment, equality, participation of all the gainers and losers of tourism (figure 2.4) and the result of analyzing the costs and profits in this section. Braswel et al consider sustainable tourism as a good solution for incorrect using the human and natural resources. According to them, the sustainable tourism isn’t an anti-growth

approach but it insists on making some limitations for the growth in order to abandon tourism in these limitations.

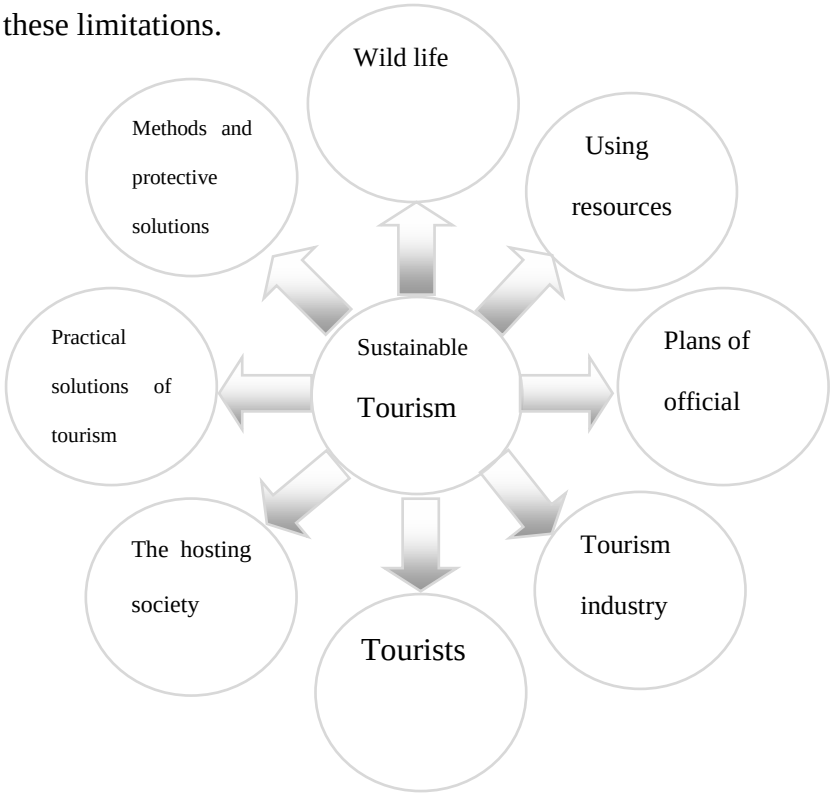


Figure 2.3: Important dimensions in the sustainable tourism

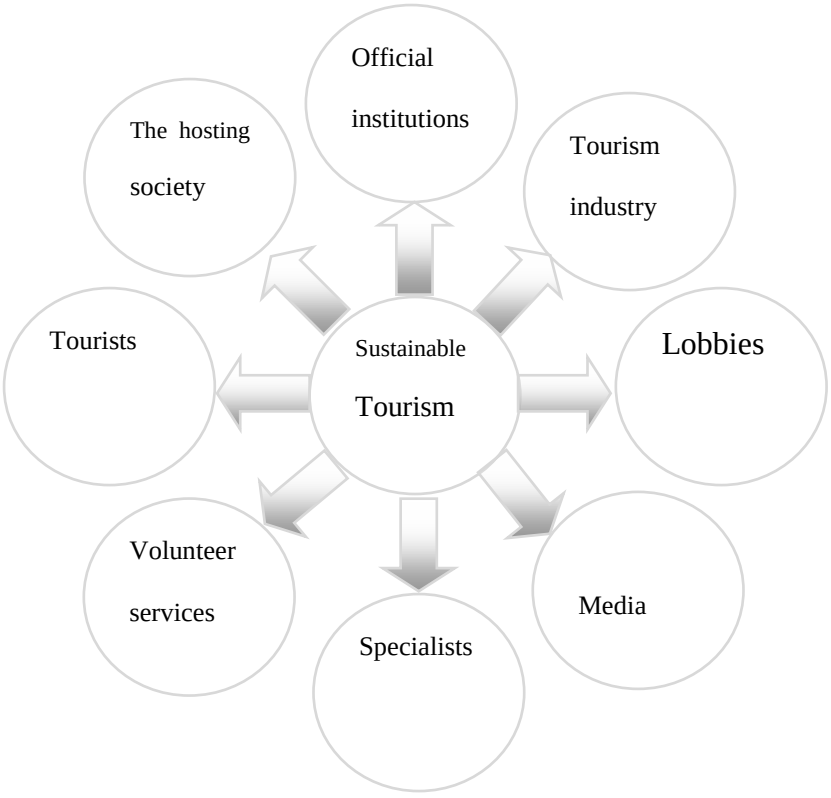


Figure 2.4: Winners and Losers of the sustainable tourism

Source from Review on Sustainable Industry, Toolaiy, S, 2007

2.4.3 Benefits of Sustainable Tourism

The sustainable tourism guarantees equal administration of profits and costs. It has a good role in encouraging others to participate in industries like running hotels, transport and handcraft. It helps local economy to be profitable and developing by increasing foreign exchange and occupation opportunity. It helps to develop foundations and social welfare. In addition, local people would be profited from it. It has a good role in cultural richness, protecting cultural heritage and conservation the ecosystem and decreasing bad impacts on it. . (Charles, R. Geolner, J.R, 2000)

Differences in common terms	
Sustainable tourism	unsustainable tourism
Slow development	fast development
Development under control	development without control
Good scale	bad scale
Long time	short time
Quality based	measure based
Controllable locally	far distance control
Differences in development approaches	
Development based on programming	development without a program
Plan ← terms	plan ← project
Local development	outside development
Local workers	importing workers
Local and traditional architecture	foreign and imported architecture

Chart 2.1 differences between the sustainable tourism and unsustainable (group) tourism

Wilfred et al introduce preferences in tourism for the year 2005 as follows:

(Shakeri, R, Master thesis, 2002)

1. Maximization the quality of resources and mineralization of wastes and providing a solution for recovery and reducing usage of energy and polluting gases

2. Protecting the quality of water resources and effective using of them and protecting the sea ecosystem

3. Replacing the dangerous products with nature friendly products and approaching to less polluting technologies

4. Encouraging the hosting society to participate in tourism

The last thing is that we should keep in mind these things to gain sustainability:

-Considering the benefit of the hosting society instead of focusing on tourism industry

-Participating with all the involving people, casts and groups in tourism and giving way to their participating in related decides

-Gaining national and global cooperation

-Using renewable resources in a sustainable way and protecting finite resources

-Participating in programs to protect ecosystems, domestic life and local culture

-Trying to save the hosting society's values and heritages

-Responsibility about bad impacts on ecosystem and using adjusting solutions

-Improving the ecological knowledge and giving necessary educations Practical repressors (Shakeri, R, Master thesis, 2002)

2-5 Ecotourism

The acceptance of the concept of sustainable development in the majority of countries when discussing tourism leads to the appearance of ecotourism. This term consists of two terms of ecology and tourism. This kind of tourism in an ideal condition is a nature friendly tourism and it is translated to Persian as passing by the nature (tabiat – gardi). It is an almost new section in tourism industry. This kind of

tourism consists of various activities like visiting caves, climbing, geologic researches, walking in the nature, diving, surf riding, hydro ski, boatmanship, fishing and hydrotherapy. Although the comparative weight of ecotourism is less than the mass traditional tourism but it is in progress rapidly in countries like east and South Africa, Kosturica, India, Nepal, Ecuador, Indonesia, Australia and the United States of America. (Toolaiy, S, 2007)

Responsible natural tourism in close interaction with local communities can lead to sustainable natural resources and sustainable living. In fact humans are important part of ecosystem and the inhabitants are obliged to protect and enliven it. Tourism not only provides the tourists, governments and scientists to support the protected area, but also demands contribution of local communities. In ecotourism, protection of habitats, biological varieties, and ecologic cycles should be considered. In addition, the effects of establishing resort places in natural areas should be regarded carefully. Tourism in general and natural tourism in particular, is like a two edges sword. A proper planning can guarantee the proper profitability for local communities and protection of natural sources. It can also increase the supporters and fans of nature and make economic growth compatible with the process of protection of natural resources especially in developing countries.

According to the World Tourism Organization, in the first decade of 2000, ecotourism section had a 10T 30% growth, so that natural tourists are 7% of the total of all world travelers. This amount is equal to 20% in 2010. Tourism by absorbing 40 to 60% of all international tourists (530,000,000) is considered as one of developing sub sections of tourism industry. This kind of tourism has led to considerable income (166 to 250 milliard dollars), out of which 166 to 183 milliard dollars belong to those tourists interested in wild life. Kastrika in Central America is one of the veterans in

ecotourism and can provide 80% of tourism market and 1/3 of total foreign currency income. 5000 tourists yearly travel to Rwanda for visiting a special gorilla. Each individual by paying 200 $ entry fee, and by paying averagely 600$ as a tourist, can produce 6 to 80 million dollars income. . (Toolaiy, S, 2007)

2.5.1 Definitions of Ecotourism

According to Bow, ecotourism not only includes natural and protective aspect but also educational and economic aspect. According to him, this kind of tourism is a nature based activity which promotes and protects the environment by producing income and occupation opportunities as well as environmental training. ZIFER believes that ecotourism is a kind of tourism with a planned approach with emphasis on natural history of the region and the native culture. In addition it contributes to protection of the environment and welfare of the residents of host's society by providing labor force and financial facilities. Green Wave Magazine mentions a term, "combined tourism", in which points to different activities such as sport, wild life, natural landscapes, historical monuments, local rituals and anthropological attractions are considered. BLAMY believes in three natural based concepts, educational based concepts and sustainable based concepts in regard of ecotourism. Natural based concept most often is applied in protected areas and in some cases in national parks, and its purpose is protection of environmental varieties and ecological aspects and particular natural heritage.

Educational based concept is in fact the distinguishing aspect of ecotourism and other kinds of natural based tourisms. In this attitude, the main purpose is promotion of knowledge of tourists in important ecological places and promotion of the behavior and attitude of the tourists toward the environment. In addition, protecting

the environment and training the local people should be considered among primary tasks. (Toolaiy, S, 2007)

Sustainable based concept was introduced first by FIGGIS. According to him, tourism studies should enjoy natural based concepts in their planning. In this symptom, tourism activities should be oriented according to environmental potentials and detach itself from demand driven and illogical demands of the tourists and it should be more supply driven. (Toolaiy, S, 2007)

2.5.2 Goals and Basic Principles of Ecotourism

Minimization of natural, physical social disadvantages, presenting necessary ecological training to tourists regarding the protected, damaged areas and contribution of local people in planning is among the main goals of ecotourism. (Charles, R. Geolner, J.R, 2000)

In additional, these people while enjoying information and environmental knowledge are benefiters and/or ill affected of front of tourism activities, and therefore their ideas should be paid attention in tourism planning generally and in ecotourism in particular. Actually, local societies are parts of ecosystem tourism and they should have considerable contribution in developing and protecting natural resources. (Toolaiy, S, 2007)

According to the main definitions of ecotourism and the relevant main bases we can name the principles of ecotourism as follows:

1. Avoiding damaging the environment and maintaining the ecologic integrity

2. Training and convincing the tourists regarding the importance of maintenance of the environment and cultural values

3. Specifying the income for protecting the natural fields ad managing the protected areas

4. Emphasizing the necessity of sustainable tourism and protecting the boundaries of social and environmental boundaries

5. Making and extending the substructures compatible with the environment

6. Decreasing the consumption of fossil fuels

7. Protecting the plants and wildlife

2.5.3 Advantages and Disadvantages of Ecotourism

1. Consequences and Positive Results of Ecotourism

Tourism can be effective in protecting ecotourism by decreasing erosion, protecting ecological integrity, promoting the environmental teachings and its transmission to the tourists and the host society, providing financial motivations and autonomy. Applying cultural plans are among the environmental benefits of ecotourism. Providing credits in the form of alms, for doing the protective plans are among the protective solutions. Other benefits of ecotourism are recreation and rejuvenation of natural places and deformed habitats and promotion of their environmental quality.

Obliging society people to be responsible about the environmental welfare and other environmental protections are among implicit environmental benefits of ecotourism.

Being lucrative and providing job opportunities, improving economic welfare of the host society, changing other parts of local economics, augmenting rural economics and agricultural part and preventing the destruction and annihilation of the villages are all among the positive economic results of natural tourism. In New Guinea, training the youth as the "Nature Guides" has led to the development of the remote places and providing the job opportunities. (Charles, R. Geolner, J.R, 2000)

Effect	Ecotourism	Tourism
-Effect on physical environment	-lesser demand for foundations	-building many new buildings contradicted to local architecture
-Relations of the hosting society	-less and limited marketing	-local architecture of new buildings
-Economical effects		-more demand for foundations
-The kind of experience and	-More informal contacts	- More formal relations
-The quality of experience for the tourists	- more local working forces	-less contact with local people
-Tourism behavior	-Keeping the income of tourism in the local society	-Spending the capital and foreign money for
	- More income from traditional activities	fees of foreign investors and
	-Special experiences	-Providing importing needs of the tourists
	-Deep understanding about special places and trying to gain more experience about these kind of places	-Priority of tourism in the hosting society and making it in danger of damage
	-Making the tourists conscious about local traditions	-Common experiences available easily elsewhere
	-Being affective towards the local people living	-The non important short time experiences (Sunning)
	-Being responsible	-Being indifferent To the local

Chart 2.2: the results of ecotourism

Source from: Review on tourism industry, Toolaiy, S, 2007

2. Studying the Negative Consequences of Ecotourism

Natural ecotourism may lead to environmental, social, cultural and economic disadvantages. Growth in number of eco tourists will increase pressure on the environment and the following tensions. Belligerent disadvantages are mostly caused from ecologic and environmental origin. Too much exploitation of the natural resources and too much consumption, not controlling of sewage, increase of garbage, increase of stray dogs, worsening water quality and health problems are among environmental disadvantages of tourism. In addition, buying the traditional souvenir made of different parts of rare animals and threatening rare species of animals, deforestation, desertification, removing plant cover as the result of destruction of natural passages, disturbing the ecologic balance and breeding of some species, extinction of some species as the result of behavior change in wildlife should not be ignored.

The officials in charge of park of America estimate that 84% of ecotourists have brought out disadvantages in fauna and flora of the region. In addition the butterfly habitats in Mexico and monkeys habitats in Kusturica are destructed as the result of deforestation. World biodiversity is extinguished with the rate of 140 Species daily. Therefore supporting and protecting the biological reservoirs of the tropical countries and countries at crisis are necessary. Improper distribution of the benefits resulted from tourism among the local residents may even lead to environmental destruction in the form of killing rare animals. The significant example is Banon Village in Bleez. (Toolaiy, S, 2007)

Direct cultural- social costs resulted from penetration of ecotourism within the cultural native context and the issue of removing originality, cultural destruction,

increase in cultural crimes, incompatibility with the native culture, social duality and creating potential disgust toward the tourists and disturbing them are very important issues.

Ecotourism also leads to economic disadvantages such as income and capital loss as the result of paying salaries and fringe benefits of foreign investors, providing import needs of this industry as well as those of the tourists themselves, costs of paying attention to tourism opportunity and losing other opportunities in return, increase of living costs and inflation. (Charles, R. Geolner, J.R, 2000)

2.5.4 Ecotourism Problems in Developing Countries and Suggesting Some Solutions

Lack of enough security for the tourists, lack of local job opportunities, detachment of different strata, ignoring the necessity of doing relevant researches and estimating the potential opportunities of the market and lack of continuous investigation of ecotourism politics, are among the substantial problems in developing countries in the field of tourism industry.

Regarding all the mentioned issues the following suggestions are recommended:

1. Accepting the fact that earth plant while being vulnerable, has a limited capacity.
2. Using the gifts of ecotourism is a general right for all the generations.
3. Informing and teaching the tourists regarding the programs related to environment protection
4. Creating local contact offices and providing the necessary maps and brochures
5. Doing researches and providing questioners created by the research institutions in order to recognize needs, priorities and tastes of tourists

6. Determining the indicators of social, ecologic and economic development and considering all the factors necessary for local sustainability

7. Considering marketing and producing new ecotourism products

8. Training tour leaders

9. Participating in specialized exhibitions

Moreover, for decreasing the disadvantages of tourism, planners and designers of tourism facilities, when providing inclusive plans, should predict substantial needs of tourists on one hand and should be also conscious about disadvantages of these facilities for the environment on the other hand. Lack of consideration regarding these issues would result in serious dangers for the wildlife and plant species and would also result in ecologic changes in environment. People's irresponsible behaviors, too much consumption of natural resources, ungovernable extension of cities, erosion, and pollution resulted from technology improvement and group tourism should be controlled.

In fact, protection of environment should be one part of cultural politics including promotion of environmental culture, teaching and informing about environment. Along this purpose, the best educational styles should be used in order to reach a competent, organized exploitation of the land and environmental resources as well as getting a balance between the visitor's joy and the necessity of protecting natural attractions.

Improvement of ecotourism under a perfect management and an organized plan, protecting the native culture and participation of the host society can be accounted as the main choice. (Toolaiy, S, 2007)

2.6 Urban Sustainable Development

One of the most important weak points of the present cities is the high rate of energy waste within them. Considering different crisis of energy all over the world and the strategic and vital role of energy, saving energy and increasing efficiency are necessary. Some examples of energy waste in cities include energy waste in constructing buildings, energy waste as the result of vast area of the city, energy waste as the result of transportation, house facilities, consumption culture, building thermal waste, city lighting, etc. Increasing thermal islands at city centers where the buildings, people and activities are more concentrated, compatible with morphology and city formation, lead to temperature increase within the cities and show 2-4 degree of difference between city temperature and the urban regions.

The reasons of formation these thermal islands are concentration within the cities, industrial growth, using mechanical facilities, automobiles traffic and briefly too much consumption of unsustainable energies in the cities. Thermal islands phenomenon provoke climate change phenomenon and in future make cities unbearable for man. In this regard in order to decrease energy consumption in cities, it is necessary to build cities with the maximum saving of energy, to use renewable and non-fossil energies and systems with low pollution, and also paying attention to recycling the materials and healthy weather.

After petroleum shocks and some energy crisis, all groups in developed countries began seeking solutions. One of these groups was urban designers. More than half of world energy consumption happens within the buildings, 25% in urban transportation, and 10 to 15 % in suburban transportation. According to the report of

fuel Consumption Optimizing Organization, yearly waste of energy in Iran due to the misuse of energy is equal to 5,000,000,000 $.

Now Iran is exporter of energy resources such as petroleum and gas, but increasing internal consumption indicates that in future all the state energy resources should be specified to internal consumptions. According to statistics, our cities now consume ¾ of total energy of the country and the rest is consumed in industry and agriculture. Meanwhile, in the world, 2/3 of energy is consumed within the cities. In Iran 5% of energy is consumed in suburban transportation, 20% in consumed in urban transportation. United Nations has suggested that by 2020, energy consumption in buildings should be less than 35%, in urban transportation less than 10%. In other words, just 45% of energy should be consumed in cities. This means that energy consumption in cities should be about 30 to 35 percent. (Tabatabai, A, 1383)

2.6.1 Fundamentals of Urban Sustainability

Nowadays sustainability of human life is threatened by some factors. Change in technology, economic activity, population growth and severe social and environmental changes are among these factors. These factors, following theory of sustainable development for supporting urban environment, led to the formation of theory of urban sustainable development.

Urban sustainable development can be defined as a development which improves long-term social and ecological health of the cities. Theoretical fundamentals of the sustainability concept in cities may be summarized in issues such as decrease of air pollution, reserving natural resources, decrease of urban waste, increase of recycling, no urban concentration, decrease of distribution, increase in average concentration in

suburban places and small towns, decrease of communicational distances, balanced social construction and achieving social justice, creating local employments, extension of small towns for removing emphasis on the large cities, public transportation, decrease of traffic, management of non-renewable wastes, distribution of resources and providing sustainable local food. Considering these issues, by applying a proper consumption manner, regarding urban planning and organizing the space, urban sustainable development shall be achieved. The elements of sustainable biological cycle which are accounted as the substantial pillars of urban sustainable development are demonstrated in the following picture. (Tabatabai, A, 1383)

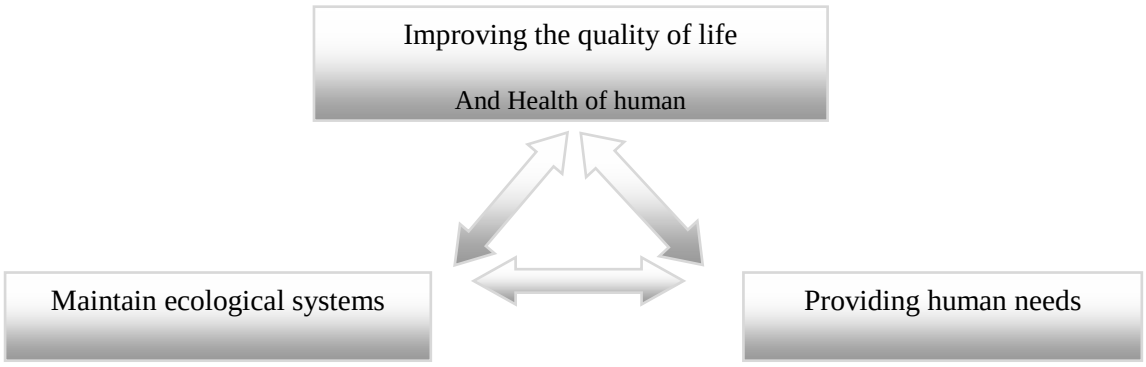


Figure 2.6: Substantial Pillars of Urban Sustainable Development

Source From: Review on tourism industry, Toolaiy, S, 2007

2.7 Sustainable City

Theorists believe that the sole practical way for designing cities regarding sustainability purpose, would be practicing designing in both micro and macro levels of the city. Therefore in order to enjoy welfare and at the same time to consider environmental issues, modification and planning should begin from the cities and residential constructions. While the world confronts with consumption crisis and the

resources are quickly destroyed, existence of mechanisms capable of decreasing consumption rate is necessary. If consumption rate of developing countries reach to that of developed countries then the earth would be soon destroyed and practically this is impossible. Therefore the sole way for improving the quality of life in developing countries would be changing life, consumption and social and urban life model. Sustainable city can be a solution for this paradox. In a sustainable city everything is consumed economically and this needs a strong will and program, which its performance in traditional cities is very difficult and in some cases impossible.

A sustainable city is the one which in result of economical use of resources, avoiding too much production of wastes, its recycling, and adopting useful politics would be capable of surviving in long-term. (Toolaiy, S, 1997)

2.7.1 Characteristics

The sustainable city, made up of not very complex components and sometimes simple, regular parts, is an optimum combination and is definitely a multifaceted city with multiple properties. The element which refreshes it and distinguishes it from other examples, is the combination of positive properties seen sporadically in the existing cities or suggested plans. (Tabatabai, A, 1383)

Generally the features of a sustainable city are as follow:

1. Compactness and Density: High gross density, the reasonable size and optimum compactness are distinguishing features of a sustainable city; in other words, one of the substantial principles of urban sustainability is high amount of activities, interactions, existence of active places and public and efficient transportation. High density means the use of the optimum density which is determined according to the sustainable capacity of the environment. This concept is the result of ecologic

knowledge. It means that each ecosystem has its specific capacity. Sustainable capacity is the maximum number of any kind of population that an ecosystem can accept and provide their needs without being damaged or lose its own environmental capacities.

As far as the environment concept is concerned, about the manner of compactness and what is called optimum compactness cannot be definitely judged. Determination and adjustment of compactness of different neighborhoods, ignoring the potentials and sustainable capacities of the ecologic region will inevitably lead to appearance and increase of destruction and pollution of environment. There is an apparent connection between compactness and environmental quality of the city. In planning in general and in determining the compactness in particular, considering environmental elements is necessary. The purposes of optimum compactness may be sought in achieving justifiable city knots, removing distance to the services and facilities, and somewhat decreasing traffic. Efficient factors in determination of compactness of a region are the features of the region and developed neighboring regions, natural features of the region (topography), social, economic and cultural features of the future residents, suggestions for inclusive or detailed plan, and accessing the substructures and facilities.

Some solutions for increasing compactness are: decreasing unnecessary uses, transmitting non urban uses to the country side, increase of residential, official, industrial and even agricultural compactness, removing empty, remote, unnecessary places, maximum use of the existing area, augmenting the function of public transportation, decreasing automobile function and the passages for automobiles, decreasing the size of buildings, increasing the average height and using the basement.

According to the present researches, the desirable impact and the controlling variables can provide and indicate the issues such as empty place for all services and necessary urban facilities, proper light, enough air and open space for the use of all the residential units, and providing private places for the residents. In addition, increasing population capacity of the city, saving the costs of city building, decreasing the costs of city protection, decreasing surface area of the city and the necessary lands for preparation, decreasing passages and the relevant costs, decreasing distances and duration of urban traveling, increasing the social contacts and interactions are among the results of relative compactness in urban textures.

2. Distribution (Dispersal)

Distribution means the distance between buildings and extension of the city in proportional to the specific number of populations. Distribution contrasts with the compactness or efficiency of special lodgment. Actually compactness may have negative connotation indicating too much density which is different from the optimum space which means not wasting space. This space may be on surface or on height. In any case this issue is very functional in the structure of the city and a disparate city would never be a sustainable, optimum city. Considering city problems we can reach to this result that transportation and access problems as well as many costs are increased due to the vast surface area of city. While by compacting city, these costs and problems would be decreased automatically.

The reasons of making disparate urban textures are as follow:

- The average height of Iranian cities is lower than 4 stores and we can state that most of the cities in Iran are 1 to 2 stores high.
- Empty spaces, big areas in the cities with no construction and the uncompleted buildings

- Transportation is mainly based on automobiles in most of present cities and public transportation is not so functional; therefore passages occupy a vast area. Of course extension of the city would increase the need to passages and there is a mutual relation between them.
- Parks and the green areas within the city such as courtyards in the houses, parks, and open spaces, regardless of many advantages would lead to expansion of city.

Extra spaces and the spaces not being optimum are among other reasons of distribution in cities. Increase of interurban traveling and increase in energy consumption, extension of substructures network and the costs related to their maintenance and repair increase in costs of expanding the passages, costs of construction, destruction of vast area of natural space and being covered with building materials, increase in water consumption are all among the results of distribution in urban textures. (Tabatabai, A, 2004)

3. Mixed Applications:

Unlike the distribution and expansion of modern cities, arguments in New Urbanism, has led to convergence of contemporary cities. This convergence in sustainable cities may be resulted out of the proper establishment of applications. It means that any neighborhood have access to the total daily needs, and the urban spaces be arranged in a way that obviate traveling to far places of the city. When constructing a new city observing this issue is free of charge and leads to much savings in time, expenses, energy and resources.

Nowadays transformation of the cities to the traditional, native forms, providing pedestrian walking and bikes passing on one hand, and development of science and technology on the other hand has decreased interurban and suburban traveling on the

other hand and has led to human health, decrease of energy consumption and improvement of social relations. Improving availability of services and local facilities, removing the need to travelling, creating fresh and active environment, augmenting social relations are among the goals of making cities with mixed applications. (Tabatabai, A, 2004)

4. Proper Distribution of Open and Green Spaces: managing open spaces should be part of designing program for a sustainable city. As much as the mixed applications and public transportation are crucial for a sustainable city, open areas are important as well, because existence of open areas lead to environmental sustainability. Social performances are the unifying factor of public spaces in sustainable city. Green area concept is limited to the green areas which are specified for spare time, playing and amusement; while other public green areas such as squares and roads are not included. In this regard, creating green residential complexes, studying and analyzing ecological values and encouraging living in the nature, maximizing biological varieties, protecting valuable supports and natural resources and maintaining perspectives, maintain rain water, decreasing erosion of natural resources and retention of human environmental features (perspectives) are all necessary. Some functions of open spaces and the real purposes of its designing are: providing enough light for the buildings, providing enough space for playing, creating necessary facilities for economic activities of families, providing enough space for social relations of different groups, mixture of plants and green space with buildings and its effects on conceptual psychology.

5. Concentration of Services in City Knots: Establishment of business centers and economic activities in city knots- the part for transmission from one mode of transportation to another mode, resulting in change in movement direction, is very

desirable, economical and optimum in a sustainable city. Establishing the necessary services in transportation knots, is a desirable act in view of sustainable development.

2.8 The sustainable district

According to Lynch: " Districts are areas with an identifiable identity Districts have a structural texture and standard usage with a visible and definable ambiance." A district is a structure in which 700- 1200 families are living with fluctuation amplitude of on foot access ratio of 300 – 375 meters (4 – 5 min) and has a cultural element of mosque and educational element of school. Each district would be separated from other districts with a network of roads around it would be separated from other neighboring districts. (Tabatabai, A, 2004)

2.8.1 Attributes

The attributes of a sustainable district could be indentified with two dimensions of space – structural and conceptual. Each of these dimensions includes components with an effective impress on creating and enduring a sustainable district. We consider here the needed attributes for each dimension in a sustainable district, though a few of these attributes like building primary school for children and shopping center aren't suitable for this project, but building a sustainable district as a tourism and entertaining complex is one of the basic and fundamental principles of a sustainable architecture. (Mofidi, M, 1385, 2006)

2.8.1.1 The space-Structural Attributes

It is necessary for building a sustainable district to know the structural attributes of it and giving design solutions in a district scale. The structural attributes of a sustainable district are that attributes which make the shape, body and structure of a

district including solidarity and dispersion of texture, relationship with the nature, combined usages and having suitable local facilities. Each of the above would be discussed here separately.

1. Solidarity of Texture: we mean by solidarity of texture to create a solid and adjoined texture either in physical sense of body of in a sense of vision. The vision solidarity in a sustainable district needs integration in the visible view of the texture and keeping the district's identity. The physical solidarity in a sustainable district means creating optimum compaction in it. In other words we shouldn't mix all kinds of possession for making a social mixture because by doing so the solidarity of the texture would be vanished. The high buildings, middle buildings and short buildings should be separated from each other and ordered with considering the environmental and natural conditions. In order to keep the solidarity of texture the conditions of the center of district should be as same as its edge without losing the mixture of habitation. In order to reach to an optimum compaction it is considered to do:

- There shouldn't be infill lot fields
- There shouldn't be rundown buildings
- All the parts and buildings should have a current function
- The buildings should be sorted based on height as high, middle and short.
- Different kinds of home shouldn't be seen mixed with each other without an order.

2. The Coordination with Nature: it should be supported in designing of a sustainable district by using the environmental background, existing trees, water paths and inequalities and the design should be done considering them.

3. The Soft Mixture of Usage: the mixture of usages and the distance between them in a sustainable district should be created in a way that reaching to them is easily

possible by walking and biking and it should have centralization around the public transport centers and center of the district.

The district should have a center with various usages like bus stop, residential over the shops, shopping center, park, community center, a few shops for daily needs, a little market, a short medical and dentistry center, post office, coffee house, newspaper stand, bank, library, playground for children and a space for agriculture should also be considered in a district. Anyway, probably the best possible condition for administrating services in a district is the condition in which the commercial space is used daily, instantly and continual and they are near the houses and the marketing places are either wholesale or are visited weekly or have a less number in the district and are co centered in a certain place. The little commercials all over the district could be suitable for encouraging the roots of society in a neighboring unit, especially if each two or three of them are joined together in one place. It is clear that the center of district should be placed in a location which has equal access for all the inhabitants of the district and there should be suitable conditions of access for anybody who wants to reach there by anyway. In a sustainable residential district there should be a soft mixture of elements as follows.

- Mixed working area
- Higher density housing and some working
- Predominantly residential area (Mofidi, M, 2006)

4. The Suitable Local Facilities: the structural form and the mixture of existing elements in a district is very different according to the time, place and inhabitant's needs. But it is clear that it divides to groups in a sustainable district based on human needs. The basic element in a district is home. But in addition to home as the fundamental element of a district two of the most important social services are a

shopping center for providing daily needs and a school for children under 12. In addition of these two some facilities is needed for amusement in open space and a kind of center for people to meet each other should be considered in a district.

On the whole the services and facilities that are needed in a district are as follows:

- **Educational Space:** along with the development in education in all age levels the necessity of developing educational spaces in housing complexes isn't deniable. Today the educational spaces are considered as one of the most important parts of districts. The type and number of these spaces is depended on the population of the district but in all districts the infant school, prep school and primary school are necessary. The primary school as the indicator educational element of the district should be located in a place that the security of children transportation can be guaranteed and enables them to reach their home in 4-5 minutes and conversely. It should also be located at a pavement as well as having access to street.
- **Cultural Space:** the mosque is the indicator identical element of a district and it should be located at the center of district near the main pavement. The mosque of district should have extent suitable to the extent of the district and it should have different kinds of cultural spaces. It is clear that along with the development and diversity in cultural needs and communications the creating of various kinds of cultural space in addition to mosque is necessary.
- **Spreading Spaces:** actually there are two levels of needs for inhabitants of a district. In the first level we can put daily needs such as food market, bakeries, fruit shops and etc which out to be located as near as possible to housing area. In the second level the weekly of even monthly needs could be putted. For example we can mention to barbershops, tailor, Souter, technical

services, sweet shop, book shop, dry washing, flower shop, key making, electronic shop, restaurant, coffee house, ice cream and juices shop. It is better for these kinds of needs to be fulfilled inside the district but in a divided space from housing area. Creating green spaces and parks in housing texture is one of the most important priorities in designing which could make happiness in individual and public spirit. In addition to bringing happiness to district, that could encourage public relations and can end to improve the air quality. The space can be placed besides the sport field of the district and would have a children library, sweet shop and washing services.

- **Sporting Spaces:** today a fundamental element of attracting exhilaration and glee to human societies is depended on sport spaces and due to this level of importance; it is necessary to create suitable spaces for that purpose in a suitable distance from the housing area. The sporting space in a district level should contain an open swimming pool, a little soccer field, a volleyball – basketball field and a locker room that this complex should be near the primary school and the district park.

5. Open Green Spaces: the hierarchy of open green spaces in a sustainable district is as follows:

- **Neighborhood Central Square:** the district central square is a center for a little united society which encourages social contacts between neighbors and leads them to have a common urban and districted sense. These kind of centers hook up that kind of social and commercial activities which is used by inhabitants of district daily or at least weekly. The center contains primary school, infant school, supermarkets, pharmacy, dry washing, post office, coffee house and restaurant. The central square of a sustainable district

should be appropriated to the district itself and in its geometric shape; access network and services should be designed in a kind that fulfills the daily essential needs of inhabitants in a district scale.

The developed network should provide an access to the central square equally for all the inhabitants and its several functions should have the least disturbance for the inhabitants.

- Packet park with play
- The local square
- Toddlers green
- Local corridor
- Creating and improving the greenbelts and local corridors has a effective role in connecting green parts and so it leads to integration of district green cover. These spaces connect together like chains and become a dynamic ecosystem in connection to other ecosystems. The geometric attributes of housing buildings effect directly to the character, properties and quality of the open space resulting from these shapes. The result of studies shows that the narrow open spaces with a high degree of binding placed between high building and having high shadows aren't pleasant to inhabitants. The narrow open spaces should be used only if there are other open spaces other than them near at hand. In complexes the open space should be accessible via pavement, biking or a short trip with public transportation. The shape of green lungs (parks, natural forest) is better to be like a claw and the local corridors be placed between axis of development.

6. The Transportation Network: the public transportation makes the center of district and local facilities and services economical. Due to an increase in public consciousness about traffic resulting from dependence to automobiles it could be expected that increasing in walking and biking and using public transport services makes the center of district and local facilities and services economical and because of an increase in people's dependence to them the districts have a motive for continuing to live.

The main goals of creating public transport services inside districts and housing complexes are more access to facilities and services, decreasing in dependence to automobile, decreasing in traffic and pollution, decreasing in usage of energy and creating a high amount of efficient movement in energy usage and being friendly to environment. The importance of the access hierarchy in designing healthy spaces with acceptable area and vision couldn't be denied. In order to be divided from the urban traffic and because of their clear and certain hierarchy based on criteria depended on speed and amount of traffic, respecting the public traffic hierarchy in a sustainable district should be as follows:

- Tram/light rail or main bus route
- Local bus route
- Neighborhood street
- Local distributor (segregated cycle & footpaths)
- Access road (combines cycle & paths)
- In order to decreasing the traffic of public transport in a sustainable district the following principles should be considered: decreasing trip demands by suitable spreading the facilities and services, giving priority to walking element in design, the soft transportation in adjusted to the climate, easy

access to public transportation, creating local soft traffic, placing the passing traffic outside the district, placing the local services in separated grocery shops in ground floors of buildings and decreasing the parking spaces for cars

- The parking spaces should be private to inhabitants so to encourage outsiders to use public transportation. Especially in the center of the district there shouldn't be foreseen any parking space except for invalids and taxies. Naturally these instructions can't decrease the usage of automobiles on their own. There should be other reducing acts such as pricing the roads, giving a very high price to gas and reducing the parking spaces in already build areas are necessary to convince people that walking and biking and using public transport is better than using automobile.

The elements of district communication network are as follows:

- **Entrance**: the entrance of the district is a joint between the semi – public neighboring life and urban living. The place that shows we are entering to a more private space with a more human scale and with priority for walker's activity and motion. The entrance of a district needs to be defined and at the same time to be marked. These two plus the dominance and alternation which are related to any kind of entrance, are the most important exclusivities of the entrance.
- **Streets**: these spaces are called in city design the combiners. The alleys and dead ends are always end to a road which has a combiner role and leads the flow of walkers and riders among the district. The thing that converts a street to a district main road is the amount of its compatibility to expectations of citizens from such roads. The peace and familiarity and comparative safety of a local street are attributes of a road in a sustainable district.

- **Riding Network access:** it should be considered in a sustainable district to forbid the local and urban traffic from entering to district, creating a limit of access for any vehicle such as buses, tracks and cars into the district, and designing the riding access. In addition to that the public parking far from the housing area such as what could be seen in many western cities couldn't be compatible with economical, social and cultural conditions of an Iranian family. (Mofidi, M, 2006)

2.8.1.2 The Conceptual Attributes

Creating and spreading art which has a direct effect on human growth could be done more easily and correctly in a sustainable district. In a diffused district with low efficiency there is no place for the art. Art not only causes the growth of hidden abilities of human and is a high level function of mankind but also it has many economical, social and even political benefits. The sustainable district brings art to its peaks. The inhabitants of such a district are artists and scientists. This way art comes between people and becomes their companion.

1. **Mixing and Coordination**: in a sustainable district there should be a coordination in shape between different buildings and their mixture in surrounding spaces in a way that the surrounding body in spit of being consisted of different buildings looks associated. This way the term of similar and coordinated units could be used in spit of different buildings and their complex would be associated and coordinated. The basic elements of creating a sustainable district which cause the complex to be associated and coordinated and in Iranian old district could be seen are considering things like the whole shape, direction, measure and proportionality from a part to total, each ordered and dependant to a code.

The symmetric vision is an important thing in a sustainable district because it would highly effect on people's justification of the place. As soon as a place can transfer some meaning with its shape to people and introduce their right to selecting to them, the place has a symmetric vision. In the urban spaces, the ratio of buildings height and the Z width (surrounding and semi surrounding) makes symmetry. If the symmetry be correct and manly it could mentally calm the watcher. But the amount of this effect depends on the relation between the space or thing measures to its surrounding spaces or things.

The Iranian watcher due to his cultural and climatic conditions is more accustomed to narrow and surrounded spaces than the western watcher. At the end the acceptable thing is to coordinate all the pieces of the architecture in a district from buildings to carpeting and urban furniture and green and etc while respecting the individual preferences and making a chance for these preferences to show themselves. (Tabatabai, A, 2004)

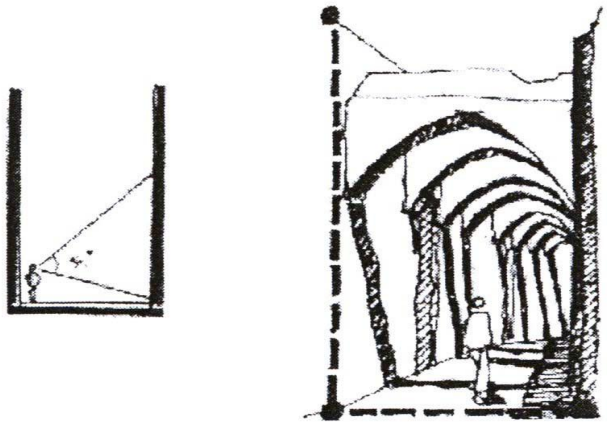


Figure 2.7 space symmetry in a sustainable district

Source frome: Mechanical Discussion, Mofidi, M, 2006

2. Bounding and Circle: Bounding the spaces is one of the basic elements of district design in many aged cities of the world. There is no doubt that the spaces between the buildings have a special effect on human sensation. Big spaces makes human to

think him as small. In the small housing spaces there is a sense of cordiality, confidence, conservation and security. According to this theory, human is the most important element of the space so the space should be scaled in a way to be used by him. One of the human attributes is having a certain limited circle of space for himself.

This circle could be public or private. But there is a frontier between these two and while studying old districts in Iran the circle could be indentified separately in three space zones:

. Private space consisting of the yard

. Semi private space as a dead end or a porch giving way to a few houses

. Public space like streets and squares

3. Legibility: some degrees of the right to selecting which is offered by a district depended on its legibility. This means that how much people are capable to understand the district. The roads and their crossings should be ordered by process of design and through the quality of space bounding in a way that their differences should be understood and compared. These spaces are located in a way that indentifying and finding addresses is very easy through them. So along with the coordination the iconic elements would help to the easiness of finding directions and sensing the place, it should also help to creating a sense of being a part of the district and make its limits.

4. Penetrance: the penetrance of a district depends on the amount of potential ways designed to pass from one point to another point. These potential ways should be clear and visible because other way only people who are familiar with the area can use them. Along with this the visionary penetrance is also important.

One of the main differences in various ways of designing districts is their difference in defining the district's frontiers. In an Iranian district there is no frontier. Many times there are two neighbor houses belonging to two different districts. The Iranian district is a social concept and its frontiers are defined by people's social relationship. In addition to that all the districts are related and need each other. It seems that creating frontiers or marked edges for a district is suitable for the cases in which the district is confronted with other users and especially disturbing users. But when a district is neighboring another with the same user conditions then forcing such an unbreakable frontier isn't wise and it is better not to destroy the transect relations of two district by creating such a frontier. Each of these districts can be independent but with giving a choice to inhabitants to use the services of each district we can help the social relations to become strong.

In the model used in Radbern the district is formed with a certain conclusive street and the role of street becomes the divider of districts instead of connector of them. In fact in this model the totality and identity of the district is kept by placing a cingulated street over it. If we want to omit this cingulated street how can we reclaim the identity of the district? In the model of Iranian traditional district this had been done by fortification the role of district center as a unifying and indentifying element. So the understanding of inhabitants from the space and society of the district was the most important element for creating the wanted identity. It should be considered that the insistence in the Iranian district design on dividing the public area from the private area is logical but the insistence of Radbern to complete dividing all the functional areas in a city and the absolute insistence of the common theory on complete and unlimited mixing of functions both can't be considered so logical.

5. Diversity: the capacity ability can't be so functional by itself. The places with easy access would be useful if they give order to the right to selection and the action of examining experiences. So diversity and especially diversity in usage is considered as a key quality. The nature and especially short or big plants are the most important element to create visual diversity which could be rarely seen in the model of Iranian old cities and it is used only in the most important and formal public spaces but in the design of districts following the model of garden – city including the city of Radbern this element is used largely and in a good way. The point that is important besides the dynamism and visual diversity in public spaces of a district is the visual unity of urban landscape and this could be seen in its best in Iranian city districts. The whole district is like an organism and the center of district visually acts like the heart of this organism. In the Iranian city districts the geometry of public spaces especially passing spaces is very different from the geometry of houses, it is in a way that here the landscape is more dynamic and encouraging for moving and provide a rich visual landscape for passersby.

6. Static, Dynamic and Space Contrast: one of the important attributes of communicating spaces is their static and dynamic. This means that the narrow linear roads have a dynamic and moving effect in their directions and the square – like spaces suddenly appearing on a major road make a sense of static and stop. In the local access design the static and dynamic attributes of the surrounded spaces should be noted. Placing certain elements in the alley or street direction and on the other hand in the square gives credit to the spaces. The value of contrasted spaces that have differences in dimensions of width, length and height and the surrounding elements would decrease the monotony of communicating spaces. Iranian old districts have a treasure of these kinds of spaces. In Iranian old district becoming narrow or broad or

being archway or open are two major attributes of contrasted spaces and the lather is very important for making shadow in desert cities.

7. Dependence: In the model of modern cities, prepared on base of an individualistic view, a neighborhood is shaped according to the distribution of services and therefore the social identity of the neighborhood is not considered. Identity means the existence of particular personality in a sustainable neighborhood and the consisting components take shape according to their historical, cultural and religious importance. The approach based on the contribution of the people is very valuable. However we should be conscious about this fact that in the best kind of people contribution, the majority of the people have to work and live in those neighborhoods designed by the others. Therefore providing the possibility for the residents to apply dependence to their neighborhoods is very important. This is the just way by which people can make their effects on their own environment.

8. Flexibility: The strong combination of the places appropriate for different purposes, provide the users with more choices in comparison with those places designed for a limited and particular application. Those neighborhoods with such conditions present the quality called flexibility. (Tabatabai, A, 2004)

2.8.1.3 The Goals of Designing a Sustainable Neighborhood

A sustainable neighborhood takes shape according to three aims of sustainability that are, social, economic and ecologic aims. Such a neighborhood extends gradually and survives. The aims of designing a sustainable neighborhood, considering the said three dimensions are as follow:

1. Social Aims: Social aims of designing a sustainable neighborhood are augmenting the family association, augmenting social associations, promoting the integrity

between the generations and providing social justice. All of these aims contribute to creation of a sustainable society. (Tajfar, S, 2006)

Hereby the methods of achieving these social aims of sustainable designing are explained in brief:

- **Augmenting Family Association**: Creating a suitable time table for doing daily activities (working, resting, and enjoying spare time) for promoting the family relations, providing a desirable quality in the house, beauty, comfort, security, providing private yard, appropriate size for the internal spaces, privacy, are among the methods which augment the family association and creates a sustainable neighborhood in regard of social dimension.
- **Augmenting Social Associations:** Creating a suitable time table for increasing the social interactions, increasing the pedestrian walk to provide the possibility of continuous, meaningful and face to face relations, locating the residential buildings in districts with rich background, protecting social privacies (determining the privacies, boundaries and facets), creating active, fresh and attractive places in different urban scales for increasing social relations, emphasizing the importance of mosques as the cultural religious element at the center of the city in different scales, creating diversity of activities and making the urban spaces suitable multi purposes in order to promote the time table for using the space, avoiding the separation of social-economic and ethnic choices and combining the social groups, preventing slums, active contribution of the people in decision makings and creating conversation halls are among the methods augmenting the social associations.
- **Chronicle Integrity Between Generations:** In order to fulfill this purpose, we can use the methods such as optimizing, reconstructing and rebuilding the

buildings and historical textures, protecting and preserving the values, ethnic, local and native rituals and habits, coexistence of different generations in familiar and social surroundings and using the historical models, patterns and forms in producing the productions and urban spaces.

- **Social Justice:** Providing the appropriate and equal opportunities for all the strata of the society in order to enjoy the facilities and services, respecting the individual, human differences and avoiding the strengthening the social distinction, providing employment and job and economic security and preventing unemployment and production of false jobs, justice in distributing the goods and social sources, are among the methods of providing social justice.

2. Ecological Aims

Some of ecological aims of sustainable design are compatibility with the nature and protection of natural environment. The methods of achieving these aims are studied here:

- **Compatible Design with the Nature**: Considering the form of the ground, considering the climatic characteristics of the region, preserving the natural perspectives, preserving the contact with four elements (soil, water, wind, plant), preserving the contact with the sky, preserving the contact with other creatures, appropriate orientation regarding the direction and severity of light and wind, being located in secure natural places, would all lead to the designs compatible with the nature.
- **Protecting the Natural Environment**: Protecting the natural environment prevents the earth warming up and forming the thermal islands, prevents the destruction of natural sources (forests, unevenness, water resources), prevents

the pollution of natural sources with fossil fuels, nuclear tests, industrial wastes, extension of green spaces, plant covers and protecting agricultural lands and preserving the local biological systems and the major habitats, biological variety and biologic species.

3. Economic Aims:

The economic aims of creating a sustainable neighborhood include the optimum use of renewable resources and the optimum use of un-renewable resources. The methods for achieving these aims are described here:

- **Optimum Use of Renewable Resources**: Using the energy of sun, wind, water for supplying necessary electrical energy in the building, transportation and industry, using the energy of sun, wind and water for cooling and heating, inventing effective methods by combining the renewable energies (wind guard, hole, use of ground slope for controlling and directing water), are among the methods of using renewable resources in a sustainable neighborhood.
- **Optimum use of Un-renewable Resources:** Economical consumption of energy needed in the building, transportation and industry, economical use of water, recycling the urban waste water for agricultural use, reasonable reuse of the wastes for supplying energy, using public transportation, little use of private transportation for accessing the central parts of the city, facilitating and optimizing the pedestrian walking and bicycles, application of the appropriate model of production and consumption (producing endurable products, decrease of wastes, decrease of production and transition costs), decreasing the distance between the resident place and working place, concentration of the various social activities, concentration of development,

using the local materials and decreasing the costs of production and transition of constructional materials are among the methods for optimum use of un-renewable energy resources. (Tajfar, S, 2006)

2.9 Sustainable Construction

Sustainable design is a kind of interference with the environment which attempts to invent some methods regarding an inclusive approach to all the environmental, social and economic aims, to achieve a balance and provide a life with high quality for the present generation and an appropriate legacy for the future ones.

The sustainable architecture while benefiting the values of all historical experiences and using reason and logic, reaches to the resultant of those three elements. This approach to the architecture is not on the basis of accepting environmental determinacy existing in the designing of traditional design, not on the basis of realization of a plan in the constructional form of the building, not on the basis of practical tendency rooted in the intellectual tradition, not according to the presentation of sensual, spiritual or psychological issues appeared in postmodern period, and not on the basis of the disturbance in the poststructuralist ideology.
Actually, sustainable architecture had been an inclusive issue which does not lead to a particular style of architecture unlike the previous tendencies, and while its main concern is the environment, it enjoys all the previous tendencies which concern about the deduction of using the materials and energy.

Building construction is the second biggest industry after agriculture in the world. Nowadays, the performances of the architectures are presented in a worldly dimension. Designing the cities and buildings all over the world, sometimes leads to the improvement or destruction of the environment. These ecological effects are not

just limited to the particular locale but they affect the oceans, poles and atmosphere. The present cities all over the world confront with the dangers such as earth warming, destruction of ozone layer and acid rains resulted from the overusing energy and other natural resources.

These problems may be solved by the less consumption of energy. On the other hand, it is necessary to revise the designing of internal spaces of the building. Ventilation, lighting and other mechanical systems are unprecedentedly extensive and comfortable. Anyway, the result of man's too much dependence on mechanical systems and irregular energy consumption is the increasing destruction of environment. Considering this relation, designing of the buildings which are helpful in saving energy and protecting the natural resources would be one of the most important responsibilities of the architectures. Sustainable architecture- the architecture compatible with the environment (economic, social and natural) - is the process of creating the space through which natural resources are damaged the least during construction and exploitation. Environmental revolution in architecture and designing introduced itself as the sustainable planning and designing, this concept was presented in the form of different words. Green architecture, designing regarding the climate, ecological designing, designing with nature. Regardless of the name, what is called sustainable according to these designers, include the designing of an artificial environment with a symbolic relation with the surroundings of the design as well as the environment out of which the materials are originated. In another words, that's a designing method which base its principles and foundations on the nature. Due to the exacerbation of the world ecological crisis at the present time, regardless to the three dimensions of sustainable architecture (economic, social and ecological), it is seen that in many cases the term "environmental architecture" is used as the

synonym of the term “sustainable architecture”. Sustainability is considered on a model in which the materials and resources are used with more efficiency. By environmental architecture we mean to have more emphasis on combination of environmental, climatic factors and changing them to special qualities, comfort and form. The substantial aims of environmental architecture are: attraction, comfort, providing a shelter compatible with the environment at the time of construction and exploitation. (Ahmadi, F, 2003)

2.9.1 Aims

Regarding three aims of sustainable architecture, mentioned above, Betel Mac Carty points to the following issues:

1. **Environmental Aims**: Creating a high environmental quality, possibility of being recycled, removing wastes, using resisting materials, water recovery from the waste waters, eliminating the distribution of pollutants
2. **Economic Aims:** Making high values, decreasing current costs, decreasing energy consumption, offering perfect solutions, easy production methods, providential solutions
3. **Social Aims**: Security, compatibility, applying the quality of elimination of poverty of energy, making acoustics, joint programs, healthy life, domestic cares, continuing education, delivery at home, compatibility.

A building which fulfils the biological needs of the present generation on the basis of efficiency of the natural resources, while making secure and attractive neighborhoods regarding the ecological, social, cultural and economic issues, is considered a sustainable building. The process of designing a sustainable building should consider the following five areas:

- Protection of natural resources
- The reasonable use of the artificial and un-renewable resources, protection of the ecosystem and recovering it
- Equality in using the resources
- Providing health and security

  The architectures should pay attention to this point that a sustainable building cannot create a sustainable district by itself, but the cases like access roads, transportation, designing of the landscape, nixing usage, density of water resources and etc. are important in achieving a sustainable district.

2-9-2 Attributes

The sustainability of the building does not relate just to its physical attributes but contains a large extent of social, economic, ecological and aesthetic considerations. Considering the issues such as air quality outdoors and indoors, reducing chemical materials, harmony between the building and the natural landscape, contribution of the users in designing and managing, diversity instead of sameness, protection and supporting the existing habitats rather than changing or destructing them and also reusing the, are among the necessities of creating a sustainable building. In addition, the sustainable building should have quality and resistance in order to be able to resist to the natural problems. Generally, the attributes of sustainable building are as follow:

1. **Compatibility with the Environment:** In order to decrease undesirable environmental effects, the sustainable building should be designed compatible with the environment. Among the cases which should be considered in order to make a building compatible with the environment are the maximum use of renewable energies, using a system for managing

energy in the building, designing with regard to climate, designing with the aim of protecting human health, improving construction industry and maximum use of readymade components, using the local constructional methods, using the recyclable materials, designing with the purpose of the minimum waste production and recycling it and designing a building resistant to dangers and natural damages.

2. **Improving Life Quality:** designing for fulfilling the function, combination of work and living spaces, designing with the purpose of protection and improvement of the air quality are the attributes of the sustainable building which would lead to improving the quality of life.
3. **Considering Identity and Culture:** Considering aesthetic elements compatible with local architectural forms and movements and in harmony with the nature, is another attribute of a sustainable building.

   Flexible designing: Designing a building potential to change of usage in the future and using readymade components for making the building flexible is another attribute of sustainable building. As mentioned earlier, sustainable designing should not disturb man's comfort. Designing should promote the quality of working and living places. This leads to the increase of efficiency and decrease of mental pressures and would have a positive effect on people's health and comfort. (Tajfar, S, 2006)

2.9.3 Principles of Design

The principles of designing a sustainable building may be studies under two groups of primary and secondary principles. (Khanmohammadi, M, 2005)

2.9.3.1 Primary Principles

In order to promote the ecological sustainability, in each building three substantial principles of sustainable designing should be observed, an inclusive look to designing, constructing, exploiting, protecting the building, recycling and reusing the resources. The basic principles of designing a sustainable building are:

1. **Economical Consumption of Resources:** in each building there is continual incoming-outgoing flow of natural resources. This flow begins with the production of constructional materials and endures as long as the building endures. So the architect can reduce the usage of un-renewable resources in the construction and function of building by correct and carefully use of resources. The building should become component and article for other buildings after its useful lifetime. The principle of economizing the usage of resources consists of three guidelines each emphasizes on a certain kind of resources needed for building and operating a building: conserving energy, water and material.

   Conservation of energy: after ending the process of construction, a building needs an endurable flow of energy that enters it while it is operating. The environmental effects of using energy in buildings may take place at first out of their site and while mining or picking up from the energy resources and producing the power.

   .conservation of water: in each building a large amount of water is used for drinking, cooking, washing, toilet and watering plants. All these kinds of water need to be filtered and transferred that needs energy. Furthermore the water used in the building and going out as sewage should be filtered too conservation of material: the waste resulting from the construction process and fixing equipments is notable. After constructing the building a soft flew of material continues into the building in order to conserving, replacing and reconstructing it.

2. **Designing based on the Life Cycle**: the traditional model of building's life cycle is a linear process consisting four main phases: designing, constructing, using & keeping and destroying (picture 2-8). In this model the concept of life cycle is seen in a very limited range and the problems related to providing and producing the construction material and waste management reuse and recycling the resources isn't considered in it.

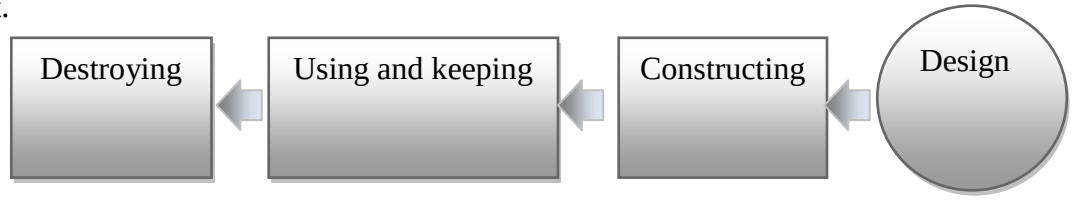


Figure 2.8: the traditional model for the life cycle of building

Source from: Thought in sustainable architecture Khanmohammadi, M, 2005

This principle introduces designing of a building based on the life cycle. This approach consists of the environmental results of architecture resources from the preparation to going back to the nature, from cradle to the grave. Designing based on the life cycle is formed on this thought that the material is transforming from its useful form of life to another form and there is no end to the usefulness and usability of material. For clearing the meaning of the building's life cycle it could be divided to three phases: before construction, construction, after construction (Figure 2.11). These three phases are connected to each other and the borders between them aren't clear and certain. It is possible to reach the design guideline based on the life cycle that is based on bringing the buildings impacts to the environment to minimum by these phases. A deeper understanding from the circumstances of design effects, construction, using and destroying the building with a model of better life could be provided by analyzing the process of the construction in each of the three phases. A sustainable building could be achieved only by finding ways to reduce environmental impacts of the building through all the three phases of its life cycle.

3. **Humanistic Design:** this principle is the third and maybe the most important principle of designing a sustainable building. While the economizing in wasting resources based on the life cycle relates to the efficiency, conservation and preservation the humanistic design is about the life capacity of all parts of the universal life order consisting of plants and wild life. This principle is deeply based on the need to save the chained elements of universal order that the life of human beings is depended on them. In the modern societies more than 70 percent of human life would be spent indoors. So the most essential role of architecture is creating built areas that are able to endure the security, health, physical comfort, mental health and efficiency of their inhabitants. The three following guidelines are concentrating and insisting on improving coexistence between buildings and the environment and the inhabitants in humanistic design.

   Conservation of Natural Conditions: the architecture should minimum the impacts of the building on the ecological condition of the place (the current topography, plants, wild life).

   Urban Designing and Programming the Site: the districts, cities and all the geographical places can be imparted the results of group programming for reducing demands for water and energy. The result of such a program could be an urban area more enjoyable and far from pollution and nature friendly.

   Human Comfort and Welfare: the sustainable design shouldn't defect on human comfort. Designing should improve the quality of working and habitation areas. This would cause increasing in efficiency and a decrease in mental stresses and would have a good effect on the people health and comfort.

   These principles form a general base for sustainable designing in building. Such a base helps the designer to find suitable solutions rather than offering some already

designed collection of solutions to them. In fact the particular solutions compatible with the design of a particular building is resulted from these principles.

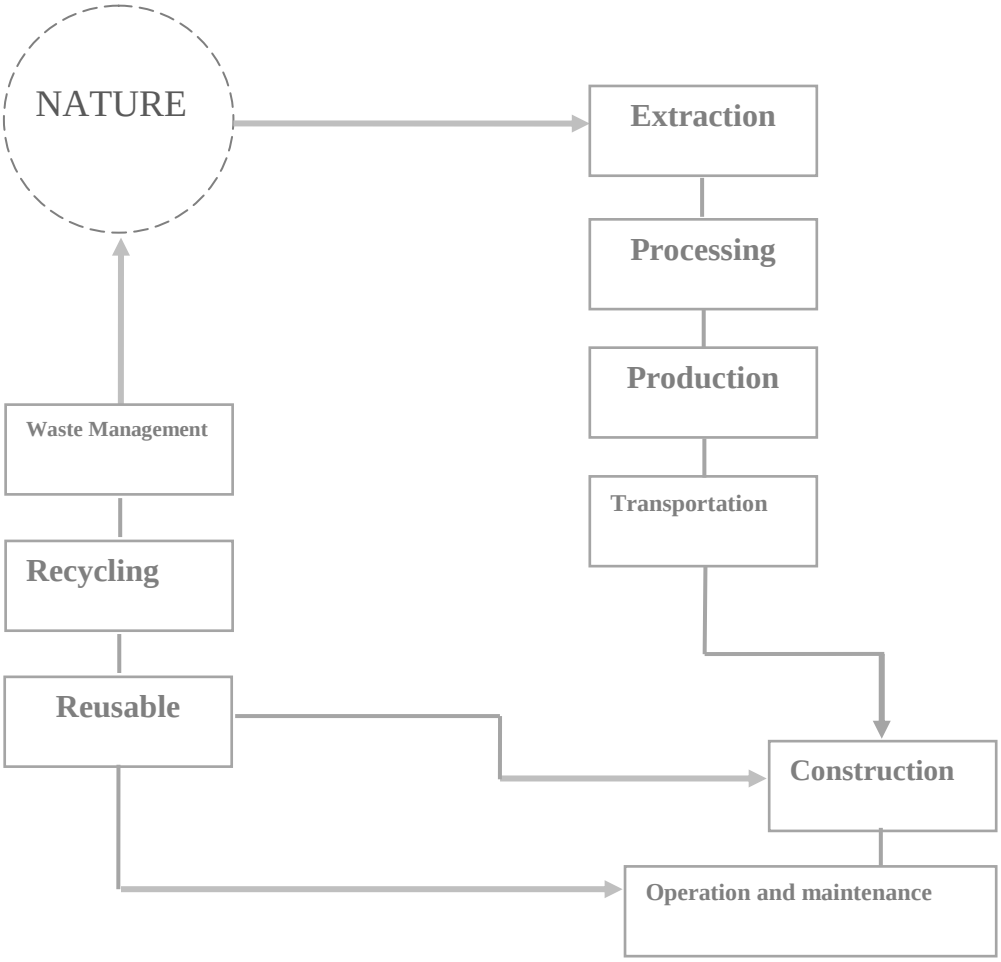


Figure 2.9: The model of a yard in a sustainable building

Source from: Jankim, J, Rijdan, B, 1382, 2003

2.9.3.2 Secondary Principles

However it may seems idealistic, the future sustainable building contains both intellectual values and comfort. Sustainable building, more comfort, less energy consumption, independency, and more health and harmony with the nature are provided with a sustainable construction. Considering economic, social and ecological dimensions, essential for creating a sustainable building, the following

principles are concluded as the secondary principles of designing a sustainable building:

1-Ecological Principles

- Designing the building in such way that implies integrity with the nature
- Designing compact building to reduce energy waste
- Orientation of the building according to solar geometry, wind direction and harmony with the nature
- Enjoying natural energies, active and passive use of sun and wind energies
- Replacement of un-renewable energy resources with renewable ones and maximum use of renewable resources in the building
- Using desirable wind of the region for ventilating the building in hot seasons
- Reducing heat exchange of cooler facilities with the outdoors
- Using natural light of day time in order to reduce electrical energy consumption
- Using energy generators equipped with timer system
- Using solar panels for producing warm water
- Using photovoltaic cells for producing electricity
- Using thermal, humidity and vocal isolation
- Using local, healthy, renewable and recyclable materials in building
- Using local materials in order to reduce the energy needed for transporting the materials to far distances
- Considering the details especially the Connections of the floor in order to reduce energy consumption
- Preventing rain water waste
- Using internal partitions for creating private and small spaces

- Comprehending the opportunities for economic development in the region
- (Jankim, J, Rijdan, B, 1382, 2003)

2. Social Principles

- Dividing public and private spaces
- Locating the buildings with half public spaces and common facilities for encouraging social interaction
- Using open spaces (streets, parks and squares) in order to secure social interactions and public welfare
- Using the building as a proper opportunity for educating the society in regard of sustainability
- Providing the residents' needs with various potentials in using the building
- Observe and estimate the cultural and ideological needs of residents

3. Environmental Principles

- Designing with the suitable perspective to the surrounding environment and without the environmental disadvantages
- Designing the building in integration with the location
- Designing the efficient system regarding the energy according to ecological principles
- Using the Progressive plant leaves, private gardens, natural habitats in integration with the building
- Designing the building with the purpose of recycling the materials, reducing the building wastes and reducing the destructive effects of construction
- Using recyclable materials on the way of waste water
- Preventing the pollution of surface water by the wastewaters (Tajfar,S,2006)

2.10 Conclusion

It seems that nowadays, sustainable development and the related concepts are properly compatible with the purposes of architecture and modern urbanization and can be offered as efficient factor for realizing the aims of sustainability. The structure of neighborhoods and resort and tourist complexes as the sustainable micro cities are built upon people interactions, public transportation and welfare services which provide accessibility to the services, facilities and transportation centers and therefore supply the most essential practical needs namely providing the services, goods and movement. Regarding the before said discussions we can briefly say that a resort tourist complex is sustainable when it is able to supply all the physical needs of its residents with high density, optimum compactness, mixed applications, public transportation, low traffic jam, disparate transportation with motorbikes, with a hierarchy of facilities and services as well as open and green spaces. In order to provide security needs, such a complex should be quiet, far from environmental, vocal pollutions and exempt from social disorders; the open green spaces should be carefully designed and the distances and privacies between the buildings and sites should be properly observed. In order to fulfill the need to communication and belonging, collective and location sense should be observed in designing the resort and tourist complexes and emphasize social communication in case of not leading to disintegration of the texture. In order to fulfill the need of being respected, designing resort tourist complexes should be in a way to grant the residents partial independency and self sufficiency. It is necessary also particular identity and conceptual image in the residential units exist.

It should be possible for the people to interfere and supervise the process of designing and constructing resort tourist complexes and contribute in creating

visual-formal qualities, designing the elements and details of resort, tourist complexes. In this way their need of creativity would be fulfilled. At last, the sustainable resort tourist complex should be designed in a way that fulfills aesthetical needs.

It should be designed in a way that identifying characteristics distinguish it the natural potentials of the location are reserved. In building scale, the factors which should be considered when programming, designing, choosing materials and constructional devices, and constructing in order to have a sustainable building were mentioned. A conscious construction with artistic particularities, possibility for doing collective activities and electronic communications are among the particularities of sustainable residential complexes which by delaying special goals such as proper and economical shelter, health and treatment and providing essential services for the citizens provide a secure, human and active environment exempt from crimes.

Security, cleanness and continuous services are among the residential characteristics of these complexes. Paying attention to the industry of tourism, self sufficiency as much as possible and according to the natural and geographical facilities, in all fields of knowledge and information, industry, agriculture and recycling are among the economic characteristics of residential sustainable complexes which are made no only for the mere consumption but also they are very good producers in all fields. Proper use of water and plant cover, possibility for passengers and bicycles pass are among the outstanding constructional characteristics of these complexes. And at the end, formation of a sustainable residential complex necessitates the combination of ecological, social and economic in all periods of planning, supervising and performing.

ANALYSIS TECHNIQUES

3.1 Introduction

Designing building is the first defensive line against outdoor climatic changes. In all climatic regions, those buildings built according climatic design principles, minimizes mechanical cooling and heating and instead they enjoy natural energy surrounding the building. Designing buildings regarding natural energy imposes less pressure on cooling and heating systems and instead causes the buildings to provide their comforting situations quietly by themselves without imposing pressure on central generators. (Donald.W, 1372, 1993)

Physical and structural comfort in buildings is the result of balance between temperature of human body and its surrounding environment. Heat exchange between human body and building surfaces and materials is done reciprocally in a complicated manner. Heat transfer is done according to physical rules. Each rule and physical principles of climatic designing of building will be discussed fully in first section. As an introduction we can see that climatic elements reserved in earth generate cooling and heating natural resources and are directly related to comfort conditions of humankind. Climatic design makes attempt to provide indoor comfort conditions in different seasons using climatic elements or inhibiting these elements effect on buildings. By using implementation tools of climatic design we can provide an environment with balance between man and environment.

In this chapter, after learning about basic principles of climatic design of building, passive cooling and its application in traditional architecture of hot regions of

country are studied. Following that, different kinds of passive systems, passive and super passive systems of generating energy, building and its components are studied; at the end, methods of designing of residential complexes are presented in three dimensions of group buildings, structure and its components. The results of this chapter regarding the subject of the thesis and particular climatic demands of the studied region – hot and dry region– will be presented in the form of designing solutions for resort and sustainable touristic complexes regarding energy in two categories of cooling and cooling-heating solutions. (Eslami.M, 2004)

3.1.1 Basic Principles

The purpose of architecture is to provide man with comfort conditions. Any architect or environment engineer must try to provide these conditions in designing a building. Comfort conditions mean providing both structural and mental comfort which is in mutual relationship with each other and each one affects the other one. Body comfort inside the building too demands thermal and visual comfort. Most researches indicate that the most important issue for residents of a building is thermal comfort.

3.2 Thermal Comfort

Providing thermal comfort needs observing cooling and heating demands of a building. In order to provide comfort in hot regions the primary concern is providing cooling demands of residents which requires much energy and cost. So learning about principles and basics of generating thermal comfort and different methods of providing sustainable energy is the essential and primary step for finding designing solutions. Thermal energy is measured in ASHREA scale in which man is satisfied with thermal conditions of surrounding environment. Now the main question here is that how we can get sure that buildings are satisfying for residents regarding thermal

conditions? The obvious answer to this question is searching the proper temperature of comfort. For determining indoor comfort condition two methods are proposed.

The first one is having contact with people during their daily activities at home or at work, evaluating simultaneously their sense of heat, measuring temperature and finally using statistical methods for coming to conclusion about the relationship between sense of heat and thermal environment which itself is indicator of generating elements of comfort. This method is known as field method.

The second is the use of physics of heat exchange between body and environment which is used accompanying with thermal physiology of human body for anticipating people's reactions to the environment. Such methods are used for determining standards such as ASHERA/ANSI 7730 BFI/CEN/ISO Standard and Standard 55/1996. . (Saberi, O.Saneei, P, 2006)

3.2.1 Method of Heat Exchange

A healthy human needs a stable body temperature equal to 37c. Body temperature is related to the amount of man's activities and in many cases it should be modulated with the amount of emitted thermal energy. The amount of energy generated in body is proportional to the amount of man's activities. This energy is produced through metabolism of food in body and the type of activity affects the amount of energy.

One portion of produced energy changes to activities and the remaining portion are appeared in the form of heat in body and on the skin. Human body in rest up to severe activities produces 240 to 3000 Btu/hr, equal to 60 Cal/hr to 750 Kcal/hr in average which is equal to a 60 to 100 watt lamp . So indoor temperature should be balanced with body temperature so that man be able to perform his proper activities.

However there may be 20 to 70c difference between body temperature and outdoor temperature. Here what is important is control of environment temperature and creating thermal comfort. Heat exchange between human body and environment or inside the building is done through four ways:

1. Convection: Convection is heat transfer within fluids. There are two major types of heat convection, free convection and forced convection. In free convection fluid motion is caused by weight difference of warm and cold fluids like heat transfer through ordinary radiators to the space of room. In forced convection fluid motion is caused by the energy produced by an external source such as a pump or a fan. Transferring heat to air which is proportional to temperature and velocity of air flow surrounding body, skin or clothes is called convection. Air surrounds human body, so when temperature is lower than skin temperature, body heat is carried through convection and when temperature is higher than skin temperature, body will absorb heat. In cool and quiet conditions, air heated with body is activated and move upward and creates a column of air above human body and then it diffused. Each kind of convections is helpful in cooling body by driving the heated air surrounding body, especially the air which is in immediate contact with body. Almost 30% to 40% of heat exchange between body and environment is done through convection.

2. Conduction: is the heat exchange between molecules with high temperature and those with low temperature without any considerable movement of particles. Conduction is proportional to temperature of surfaces in contact with body. High percent of heat exchange between body and environment is done with immediate contact with hot or cold surfaces through conduction.

3. Radiation: is heat exchange from warmer objects to colder ones through radiation. In this kind of heat transfer the temperature of objects is not important like absorbing thermal energy from sun. Body radiates heat. Radiation of heat is proportional to the fourth power of its absolute temperature. Simultaneously surrounding surfaces are radiating too. So when it is cold, body emits heat and when it is warm, body absorbs heat. Emission of thermal energy to surrounding surfaces which is related to temperature of surrounding surfaces (radiated heat) is called radiation. Almost 40% to 45% of thermal energy is transferred through radiation between body and environment (Figure 3-1).

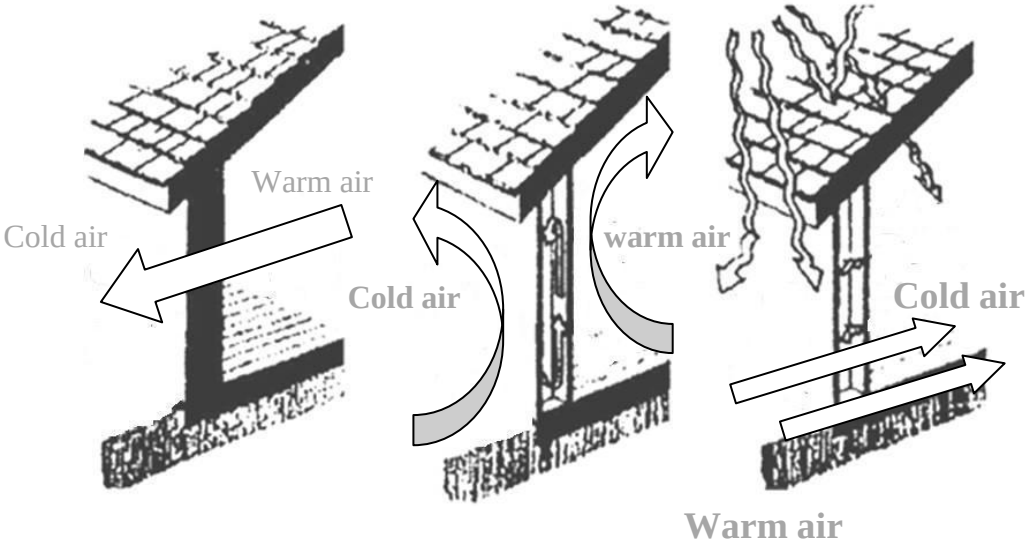


Figure 3.1: heat transfer ways in buildings

Source from: Architecure with minimum use of energy Saberi, O.Saneei, P, 2006

4. Evaporation: is heat transfer through vaporization of water which makes buildings cool. Emission of heat through skin which is related to humidity of air and velocity of air flow near body is called evaporation. So evaporation from the skin means absorption of latent heat from the skin and making it cool. This cooling phenomenon is very strong and body enjoys it through perspiration for cooling. About 20% to 25% of heat exchange between human body and environment is done through evaporation. . (Saberi, O.Saneei, P, 1385, 2006)

3.2.2 Methods of Controlling Thermal Energy in Building

In all buildings for controlling indoor thermal energy one of the following methods is used:

1. Controlling thermal energy through building shell. These buildings are called Dominated by the shell.

2. Controlling thermal energy through home appliances, utilities of building, mechanical equipments and plants. These buildings are called buildings with load dominated. (Mofidi.M, 2004)

3.2.3 Methods of Providing Thermal Comfort

In sustainable architecture, indoor conditions should be so moderate to provide residents with structural and mental comfort. Structural comfort means providing thermal and visual comfort. Thermal comfort includes providing needed energy for indoor heating and cooling and visual comfort means providing light and enough brightness inside the building. Providing comfort in building demands energy consumption in any form (fossil energy, non-fossil energy and …). For providing structural comfort we can use four methods. These methods are:

1. Extra Active Method: in this method, ordinary mechanical systems such as central heating, fan coil and water cooler are exploited. In these systems, the most portion of needed energy is provided by fossil and mineral resources namely non-renewable reservoirs. In such a system, the architect is not functional in designing and is just influential in replacement and determining passages in different parts.

2. Active Method: the large amount of consumed energy in this method (about 65% to 75%) is provided from renewable energy resources such as sun, wind, water, etc. and their influential needed energy is provided by non-fossil resources and a bit

portion (about 25% to 35%) is provided from fossil energies. However for transferring reserved thermal energy to consuming places, mechanical methods are used. An example is solar collectors of warm water in which solar energy is received naturally and its produced thermal energy is carried to other parts of the building through a fan. Designing these systems is not architects' duty but they should have enough knowledge about its manner of performance.

3. Passive Method: through this method, large amount of energy namely 90% is provided from natural and sustainable resources and mechanical method is used very little in the form of mere a fan or a small pump for transferring received energy. One example of those systems enjoying passive method is solar window, water roof, greenhouse space which is labeled as passive solar systems. Passive solar systems are those systems which use natural renewable energy resources for cooling and heating in order to provide structural comfort in building and use very little mechanical tools just for transferring collected energy.

In all passive solar systems, heat transfer for consuming in living place is based on three principles which are called primary principles. These primary principles are absorption, reservation and dissemination. In other words any passive solar system for receiving solar thermal energy or avoiding it and transferring received energy to the consuming place includes these three parts. One part of the system which usually has a glass surface towards the south absorbs thermal energy. Received energy by this part is reserved in energy reservoir and is carried through thermal disseminators into living place when needed. In addition to primary principles, other factors are influential in efficiency of passive systems and reducing energy consumption. These factors are called secondary elements. These elements include observation and controlling system performance, its maintenance when using energy and protecting

energy when consuming it. Passive solar systems are classified to three categories regarding the combination of primary elements (absorption, reservation and dissemination): .direct absorption, .indirect absorption and .separate absorption.

- **Systems with Direct Absorption:** in those systems working with direct absorption, solar energy after being absorbed is used immediately inside the building. This system is in immediate contact with indoor space and after providing needed energy in living place, the remaining part is reserved in the particular reservoir. One example of this system is solar window in which received thermal energy produced by solar radiation enters indoor space directly and after warming living place, it will be reserved by the floor. One of disadvantages of this system is uncontrollable amount of received thermal energy in indoor space which may disturb residents through generating too much heat and causing waste of energy.
- **Systems with Indirect Absorption:** In such systems, thermal energy produced by solar radiation is reserved first in reservoir in the form of a retaining space between living space and receiving part of radiation. When needed this energy is carried into living place and is used for heating. Some advantages of these passive solar systems are their being controllable, protecting energy and optimum use in building. Some examples of this system are solar greenhouses and trombe walls which in both thermal energy is imprisoned in intermediate space after hitting the glass surface and changing into thermal energy; when needed it is transferred to living space through installed windows being opened.
- **Systems with Separate Absorption**: In such a system, absorption and reservation is done simultaneously and received thermal energy is transferred

to the building separately. One example of this kind of system is Termosifon. In this system thermal energy is reserved by flowing air when absorbed and then is carried into living space.

4. Extra Passive Method: This method is totally natural. It means that providing energy and its transmission is natural. This method is used in architecture of the building and its examples are direction, proportions, and manner of installation, materials and color of external surfaces of building (Figure 3.2). (Mofidi.M, 2004)

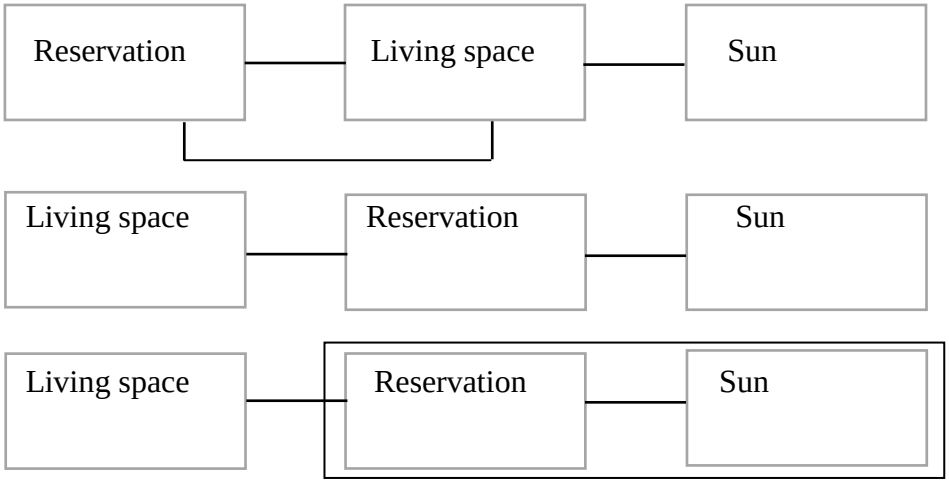


Figure 3.2: the process of transmission of thermal energy in passive systems (direct absorption, indirect absorption and separate absorption)

Source from: Climatic architecture, Mofidi, M, 2006

3.2.4 Passive Cooling (sustainable)

Passive cooling of a space is corresponding with passive heating. While passive heating is generated solely by sun, in passive cooling we can use many different coolers ranging from climatic changes for providing comfort in hot regions. While wide acceptance of passive heating is not so long, passive cooling has a longer history both practically and theoretically. However some of its general principles are used widely in contemporary buildings. General purposes of passive cooling are

avoidance of extreme increase of temperature in building which is firstly generated by sun. So passive cooling is never solar and is even anti solar. However as passive cooling and heating are both dependent on heat transfer through natural methods (conduction, radiation, convection and evaporation), they have many similar rules.

Main solutions for providing comfort in hot climates are mostly defensive methods. These solutions prevent absorption of thermal energy by the use of shading and reflecting obstacles. They also prevent heat transfer by the use of insulation. Beyond these defensive methods, passive cooling needs heat discharge from the building to those natural coolers on the earth which naturally modulate absorbed heat of sun namely atmosphere, sky and earth. There are two ways which operate as an inductor for heat transfer, ventilation and evaporation.

If humidity is low (such as desert regions), atmosphere will have little influence on decreasing solar radiation and vertical open surfaces become quickly cool after sun set. In reverse this phenomenon is decreased in humid regions considerably. Usually this phenomenon is called “night radiation” because it is considerable at night in absence of solar modulation effects. However this phenomenon exists day and night and we can call it more accurately “emitted radiation” in order to distinguish it from solar radiation. The earth is a strong cooler which produces fixed temperature (almost equal to average temperature of earth surface) in 6 meters deep under earth and deeper. Passive cooling as the cheapest solution for cooling buildings with the least environmental effects is based on 4 principles:

1. Reducing indoor temperature: saving lights, insulating warm water pipes
2. Decreasing received external thermal energy: compactness of building, shading, infilling doors and windows, ventilation
3. Using heat transfer patterns: Using wind and conduction for ventilation

4. Thermal energy discharge: Ventilation using north breezes, installation of fans above windows (Moor.F, 2003)

3.2.4.1 Sources

Each climatic element is somehow influential in generating structural comfort through cooling. Here the way each element is affected is discussed:

1. Wind: Directing pleasant wind and avoiding unpleasant wind using earth asperities, plants, wind guards and structures

2. Water: Reducing temperature of dry climate using reservation of thermal energy

3. Plants: Cooling through evaporation. Cooling effects of plants are:

4. Modulating temperature fluctuation and increasing relative humidity

5. Directing wind and decreasing its intensity

6. Using deciduous trees in south side of building for shading in summer

7. Using short plant covers (grass) for avoiding reflection to indoor and outdoor

8. Using bushes for directing wind

9. Earth: For building construction earth can be used in two directions

A: Earth Asperities

1. Using earth asperities for avoiding or directing wind to the building

2. Using earth asperities and special kind of soil for growing plants and modulation of climatic conditions

B: Earth Depth

1. Using earth as protecting building against climatic changes and fluctuations of temperature

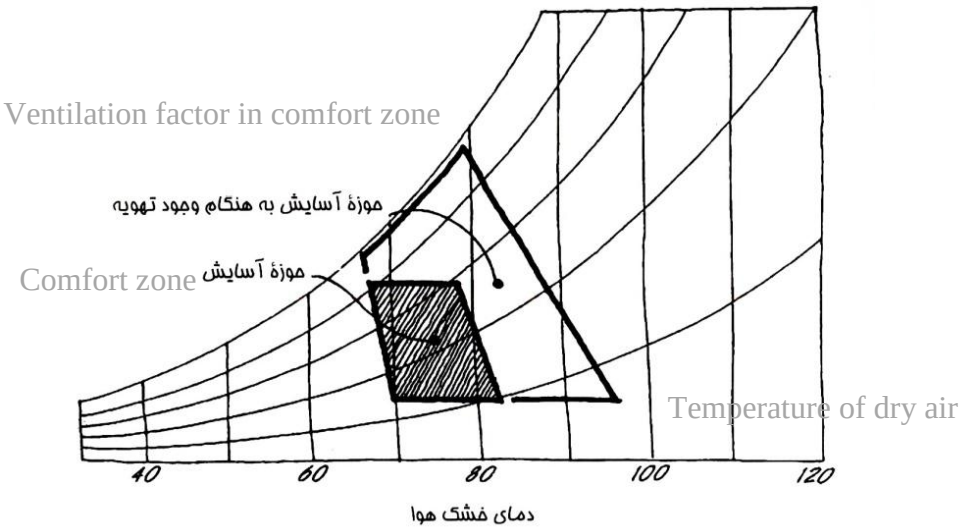
2. Using earth shell as a thick thermal insulator for avoiding conduction

3. Using depth of earth for protection against wind (Ghobadian.V, 1956)

3.2.4.2 Methods

Passive cooling can be interpreted as a set of research fields concentrated on main cooling systems. While this classification is very useful for scientists and inventors, it is a thwarting source for designers and programmers because many systems are involved in multiple cooling systems. For cooling we can use a combination of climatic elements or each one separately. Cooling methods are as follow:

1. Cooling through Convection: Convection is the base and one of the oldest methods of passive cooling which through increasing evaporation leads to cooling (Figure 3-3). In hot regions where daily temperature fluctuates much and buildings are very voluminous, ventilation is usually used at night. However hot and dry climate has many other solutions (especially evaporation and night radiation). In passive applications, air flow is produced either by wind or by chimney effect. In mixed applications we can use fan for carrying air. Ventilation provides cooling through two ways. One is discharging hot indoor air and replacing it with outdoor cool air and the other one is directing flowing air to the residents' skins in order to cool body through combination of convection and evaporation. (Moor.F, 2003)



Graph 3.1: Ventilation factor in comfort zone

Source from: Systems to Controling Environment, Moor.F, 2003

2. Ventilation with wind: Direction of buildings, rooms and particularly the entrance openings and exits inside the rooms are very influential in speed of ventilation. Many researchers have studied in this field using wind tunnels and models in order to develop designing rules for effective ventilation. One of the early researches done in engineering research station f Texas in early 1950s aiming at developing and extending general rules of pleasant ventilation seemed applicable. Bowen in 1981 collected results of this and other researches in the form of a comprehensive collection of diagrams illustrating rules of ventilation flow around the building and across it. These diagrams are very useful in understanding current patterns of air flow according to pictures below. In Figure 3.3 at the top, differences in air pressure in windward places, leeward and along wind, middle, formation of shadows of wind with the least potential of ventilation in result of linear disposition of buildings are pictured. On the bottom decrease of wind shadow as a result of cross disposition of buildings are illustrated.

A short building situated in windward side of a high building will result in a great amount of turbulent flow between them. Putting one building on pilot will decrease pressure in windward side of the building. This is done by flowing air beneath the building. Installing just one operable window in windward direction of the building leads to a weak ventilation of the building. So installing an extra operable window in leeward direction of the building which connects low pressure and high pressure parts of the building is essential for improving air flow across the building.

(Figure 3.3)

3. Ventilation through chimney effect: Chimney effect is the result of air density and decreases as a result of increasing temperature. When warm air moves upward toward upper operable windows, it is replaced with cool outdoor air which enters

through down operable windows of building. In order to increase convection through increasing difference of temperature in the system, we can augment this chimney effect by the use of sun and creating a solar thermal chimney. This is done by a collector of termosifon air for heating air flow after extracted from residential places of the building. Air heated by sun moves upward as a result of this effect when radiation on collector increases and air circulation inside increases as well. Scientifically speaking this phenomenon causes highest air circulation when needed

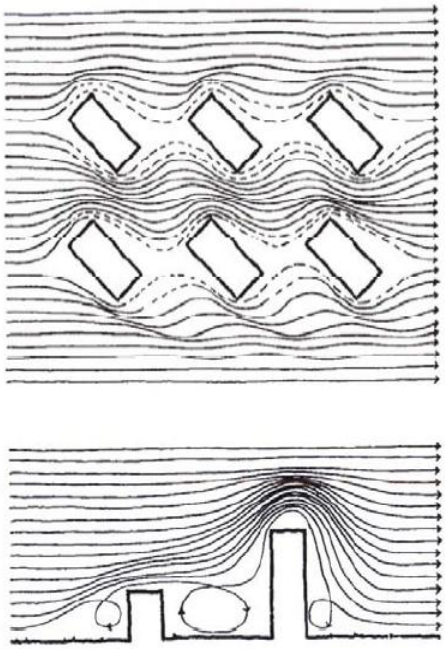


Figure 3.3: Top: pressure difference of wind around the building. Bottom: influence of building height on air pressure

Source from: Systems to Controling Environment, Moor.F, 2003

Practically, two other elements decrease efficiency of solar chimneys and in result decrease their cooling potential; first of all while vertical placement of solar collector for heating in winter and augmenting chimney effect is very favorable, its horizontal placement is better for collecting solar radiation in summer. Narrow sun angle in winter decreases vertical height of air flow and in effect will decrease the convection power and velocity of air flow. Secondly, the driving force which conducts chimney

effect in these solar chimneys is trivial in best situations. If the high exit of this chimney is placed leeward, then any wind is capable of augmenting chimney effect. However if the wind direction shifts, air flow direction may get reversed and causes the air flow heated by sun flows downward to the living space and chimney effect rather than cooling the building, will lead to heating. So, any solar chimney must have an active ventilation lid against wind in order to ensure that air flow is always positive.

4. Wind Ventilation Lid: In order to augment ventilation in buildings, we can use air conditioners solely or accompanying with solar chimneys regarding wind power for suction. Generally, any object placed inward, creates pressure difference. Upper window functioning just like an entrance of a wind guard accompanying an exit in below can overcome the tendency of chimney effect of indoor warm air to move upward. Installing a wind guard in leeward line augments chimney effect and increases air circulation. (Figure 3.4)

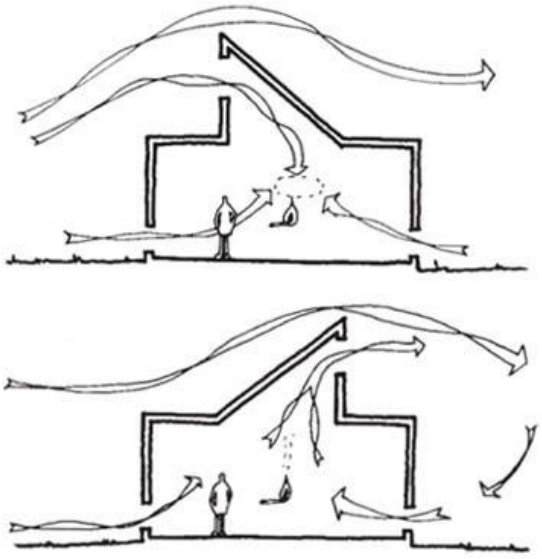


Figure 3.4: Augmenting chimney effect by putting a wind guard in leeward line

Source from: Systems to Controling Environment, Moor.F, 1382, 2003

5. Interior walls situated along the wind have little effect on wind velocity and direction. However if these walls are vertical to air flow, then they will control air flow pattern and decrease velocity of air. Thus those walls which are out of air flow will not have any effect, while those which somehow block air flow will create stagnant air in space (Figure 3.5).

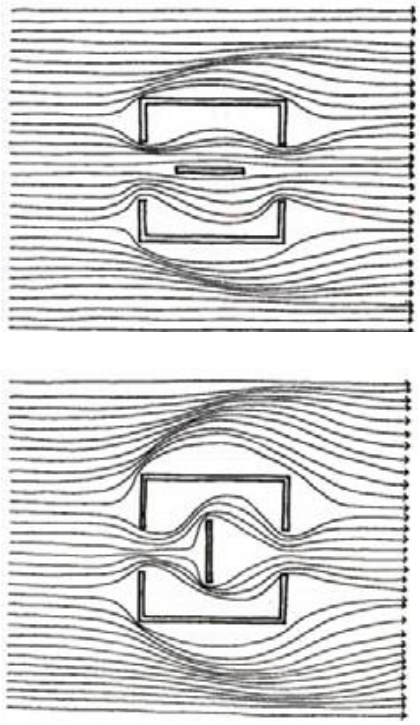
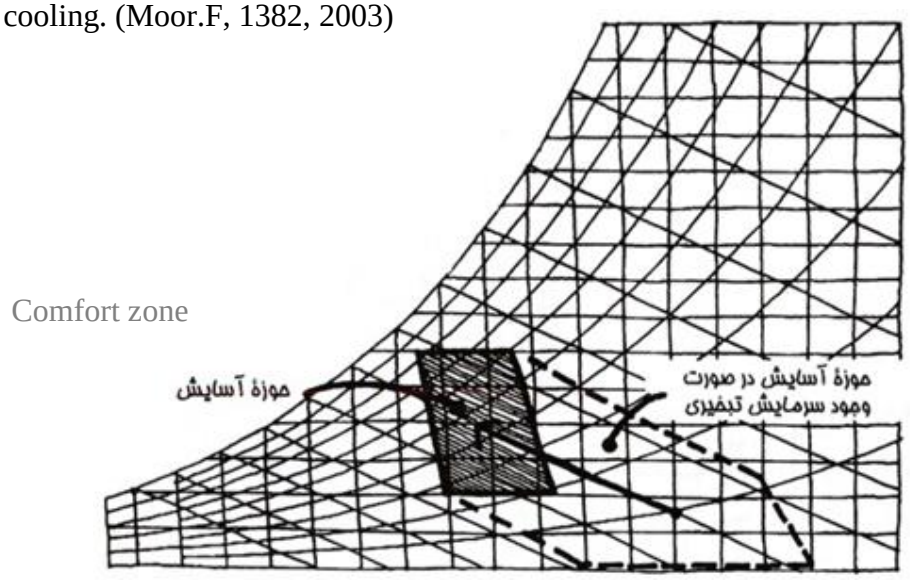


Figure 3.5: Effect of interior walls on wind velocity and direction

Source from: Systems to Controling Environment, Moor.F, 1382, 2003

6. Double Shell Roof Method: One of the undesirable main absorbing sources of heat in buildings is roofs. When roof surface gets warm due to high temperature of summer sun, the heat is transferred by conduction to roof and ceiling and finally to the rooms beneath. One of traditional influential method for this problem is defining a space between roof and insulated ceiling beneath it where air is ventilated. Nowadays, for solving this problem spaces occupied with jack trusses are used.

7. Evaporative Cooling: Exchange of sensible heat with latent heat of water drops on wet surfaces lead to evaporative cooling. This method can be used for cooling the building in which wet surfaces are dried with evaporation and building air which is cooled directly through evaporation or indirectly through contact with a previously cooled surface through evaporation, or people whose skin are cooled through evaporation and perspiration. This method is used in climates with humidity lower than 70 %(in hot and dry regions) with high evaporation capacity. Enthalpy of vaporization is stable because absorbed latent heat is equal to sensible heat emitted. In picture below, comfort zone is hachured. The dotted line defines general conditions which can turn to comfort condition by the use of direct evaporative cooling. (Moor.F, 1382, 2003)



Graph 3.2: The effect of evaporative cooling in increasing comfort zone
Source from: Systems to Controling Environment, Moor.F, 2003

8. Direct Evaporation: Direct evaporative cooling occurs when dry air flows on a wet surface. For example, an air flow blowing on a fountain, basin or an irrigated area is cooled through direct evaporation. In fact, presence of such elements in a perspective due to their aesthetical effects and partially automatic control of

evaporation process is one of the best solutions in applying this cooling method. One of the disadvantages of these methods is that their wetting and cooling effect will be scattered and wasted. Previously, for minimizing evaporative emission from green lands and fountains, central courtyard was used and living spaces were constructed around it. (Moor.F, 2003, P 233-241)

9. Indirect Evaporation: in evaporative coolers with indirect vaporization, the air cooled by evaporation, is separated from ventilated air of the room. This technique provides the possibility of decreasing temperature of dried air without any increase in temperature of the room. This technique can be used particularly where humidity is very high for direct evaporative cooling. Of course there is an exception for those places where dew point is low enough that we can reach comfort using sensible part in evaporation process. The other method in indirect method is closed ring in which outdoor air is irrigated in order to be cooled through evaporation. . This wet and cooled air in its own right makes cool the air which is circulated through a thermal generator before it returns to the building (Figure 3.6).

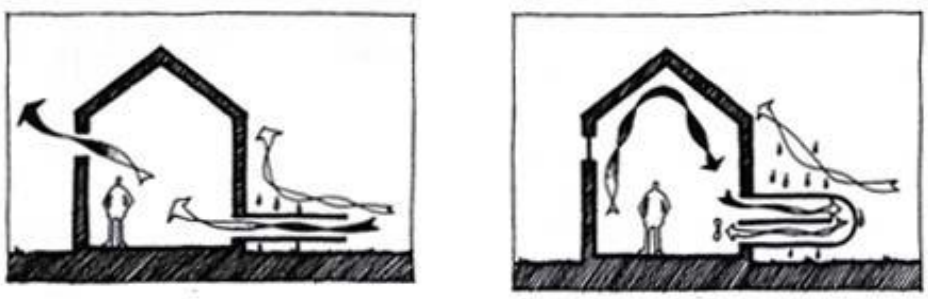


Figure 3.6: indirect evaporative coolers, open ring system, closed ring system

Source from: Systems to Controling Environment, Moor.F, 1382, 2003

10. Exterior Walls of the Building and Roof Surfaces which are warmed by radiation or convection can be cooled by irrigation. Evaporation makes these surfaces cool. Irrigation on surfaces should not be continuously; they should just be

wet. So by irrigating these surfaces casually we can have an efficient cooling. Comparing with similar dried roofs, this water can decrease heat exchange through roof by 8%. This general solution can be regarded as one form of indirect evaporation because outdoor wet air is usually kept separate from indoor air. However while heat exchange through building shell is much influential, this system rather than being a totally cooling solution, is a defensive solution based on decrease of absorption. (Moor.F, 2003, P 262-265)

11. Radiative Cooling: Nightly radiation from walls and coherent building materials which is dependent on clear sky leads to radiative cooling. Radiative cooling is a kind of heat transport from a warmer surface to the surrounding cool surface. This method can be used for cooling building through heat radiation from warm surfaces of building to the sky or for cooling residents by radiating heat from residents' warm skin to the surrounding cool surfaces of the room and to the cool walls of basement buildings. This method is a common method for driving out heat from earth surface.

In fact this method is the only way of transferring heat by which earth can lose heat. In order to retain heat balance for temperature maintenance, the heat equal to total solar radiation absorbed by the earth should be reflected to outer space. Generally, atmosphere drier, earth surfaces can radiate heat more easily. If there were no atmosphere, then radiation to space was very quickly. Temperature of the sky is equal to radiation temperature above horizon which causes the same amount of heat radiation from earth surfaces. This temperature is independent of temperature around the buildings and directly is related to humidity of air above the earth surface. This is the decreased humidity which causes decrease of temperature during night in desert regions.

Horizontal surfaces are the most influential surfaces for radiative cooling because they are placed in most direct position to the sky. Those angled cooling surfaces are situated under horizon and so they are exposed to higher temperature of atmosphere. Always there should be maximum thermal contact between ventilation space and reflecting surfaces. This part should be very large and its thermal resistance very trivial in order to be able to transfer heat from room to roof easily and make the roof warm. The roof warmer the temperature difference between sky and roof more and cooling affect more too. Even trivial difference in roof temperature can create big differences in daily comfort. For example, differences such as 4 F in warmer part of the roof double cooling process. So any solution which decreases air flow along the collector augments cooling effect. Velocity of air just above a flat roof with a crash barrier is less than the air far from the building. This indicates that common titles in building such as crash barrier porches may be influential in stopping convection.

Radiation ice basins, central courtyards, water roofs (sky them system) and cool basins are some examples of common methods of radiative cooling used in traditional architecture and appropriate solutions for cooling buildings.

(Moor.F, 2003, P253-258)

12. Basement Cooling: in cool regions, steep slopes and underneath buildings, static temperature of the earth can be used for cooling the building. The earth is an indefinite heating source. Its high capacity for reserving heat provides this possibility to use it for seasonal reservation of heat. Soil temperature in below 6metres deep is almost static and equal to annual average of surface temperature which is warmer by 2 or 3 degrees than annual average of air temperature due to solar radiation and high temperature of earth core. In shallow parts, increase in depth leads to decrease in annual fluctuation of temperature of soil. Moreover, increase in depth will creates a

kind of time delay in temperatures. Thermal characteristics of soil change due to the type of soil, its density and humidity which is different in proportion to rainfall and earth waters. Moreover, conditions of earth surface like shadow, insulation of earth and air temperature affect soil temperature. There are two main methods in using the cooling method through contact with soil. Direct contact in which building shell is buried fully underneath and indirect contact in which the building is cooled by thermal generators buried underneath such as pipes or air tunnels.

(Moor.F, 2003, P 257)

13. Direct Contact: Constructing buildings underneath is a solution in which walls or roofs are covered with soil. In some cases this solution may be in the form of construction underneath with just operable doors and windows. On the other hand this solution may be limited to covering one or some walls with soil. The main purpose for making direct contact between building surfaces and earth is enjoying soil mass for reserving heat. In cases that soil is almost thin, reservation is appropriate just for modulating temperature fluctuations at day and in a week. In cases that building is constructed totally underneath, the increased thermal mass of the soil will provide static temperature annually which leads to seasonal reservation of heat. This means that absorbed heat by surfaces in summer is reserved for months in order to be able to modulate heat emission in other seasons and in summer cool soil will be a great source for reserving heat which is very precious source for cooling. .

14. Indirect Contact: in this method, a fluid like air or water flows in an underground pipe such as a channel, a duct or a pipe and in this way it gets cool and makes the building cool in its own right. The pattern of fluid flow in this system may be open ring in which outdoor air is absorbed into channels and indoor spaces, or

closed ring in which air flows from the building to underground channels and return again to the building. Elkridge in 1982 suggested following instructions for designing underground channels.

- Using short channels in order that air temperature gets equal to surface temperature quickly.
- Using multilayer small channels. Using channels with specific length and large diameter transfer more energy in proportion to channels with small diameter and the same length.
- Putting channels deep so that the temperature of surrounding soil is minimum and almost static. Outdoor temperature is dependent strongly on arriving air, so using outdoor air which is absorbed to underground channels of open ring can lead to increase in exiting air temperature, increase in soil temperature and increase in relative humidity comparing with a similar closed ring system which circulates indoor air again.
- Using plastic and concrete channels in place of cuprous channels. The reason is that thermal resistance of the earth is so much that thermal resistance of the channel is trivial in comparison with it.
- Increase of air velocity can increase cooling. Rather than more influential heat exchange between channel and air through conduction, the reason is that in this situation larger amount of air is cooled. One of the most neglected features of cooling through contact with soil is opportunities provided for conscious change of natural temperature of earth surface. One of these opportunities is decreasing temperature of depth of earth through conscious cooling of soil for example by the use of a partition of vertical aspirators filled with pebbles around the building which winter cool air can enter its

open channels. This was suggested by Jivouni in 1980 (Figure 3.7). In summer, temperature of surfaces and deep soils can be decreased by limiting solar radiation absorbed by surfaces through shading and use of light color surfaces. Heat emission by wetting surfaces can cool them through evaporation. (Moor.F, 2003, P 275-280)

- Cooling through Dehumidification: Dehumidifying vapors in air flow of the room through diluting by drier air or distillation or desiccation is called dehumidification. This method is used in humidity over than 70% or 80%. In case of distillation and desiccation, dehumidification consists of exchange of latent heat of air with sensible heat of water drops on surfaces. Both these two methods are contradictory to evaporative cooling and so they are considered among heating processes. Although maximum and minimum temperature during summer in humid climates is not as much as these temperatures in dry region, much humidity is the main reason of lack of comfort in this climate.

In dehumidification three methods are used for driving out vapors from the room: Diluting by use of dry air, distillation and desiccation. Psychometric graph (Graph 3.3) which illustrates comfort zone for different cooling methods. In this graph (A) represents regular dehumidification effect, (B) represents ventilation, (C) represents much thermal mass, (D) represents comfort zone, (E) represents cooling, (F) represents much thermal mass with nightly ventilation, (G) represents humidification and (H) represents air conditioning.

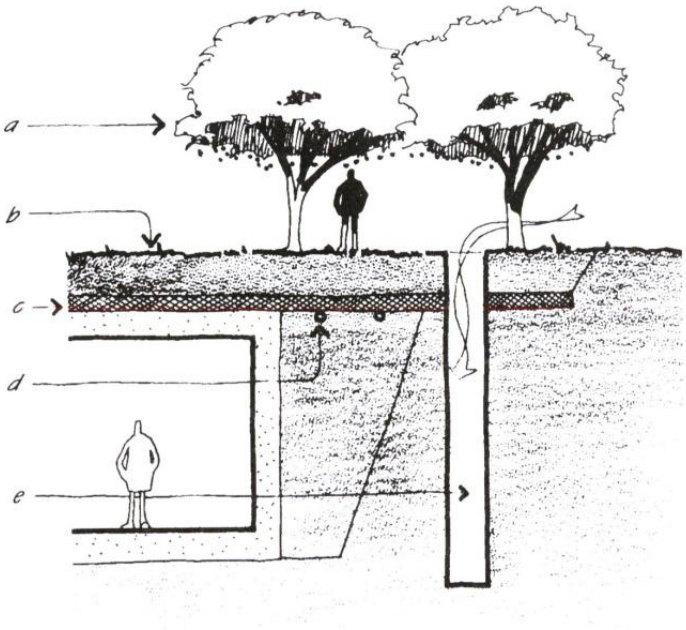
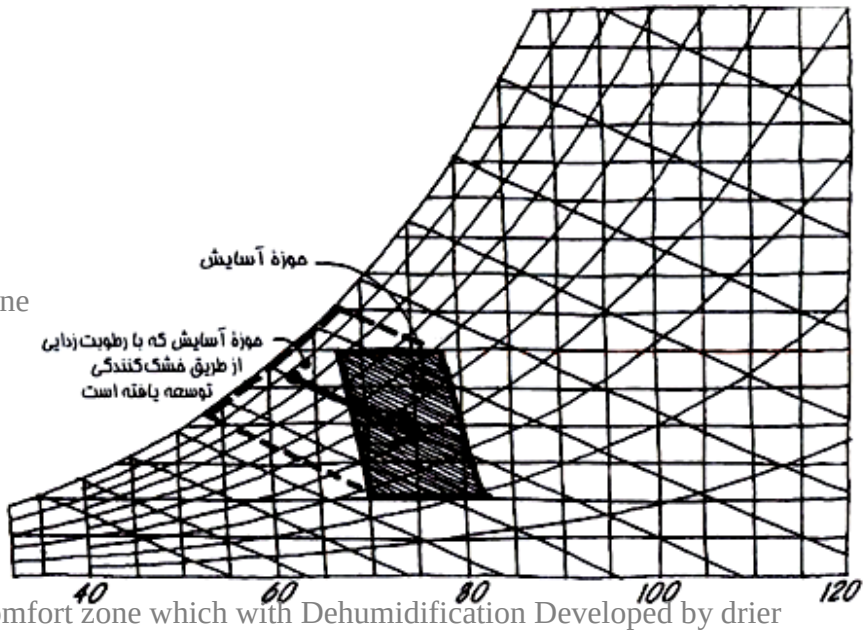


Figure 3.7: Shading on earth for postponing temperature changing of earth surface

Source from: Systems to Controling Environment, Moor.F, 2003



Graph 3.3: Comfort zone for different solutions of passive cooling in psychometric graph. Source from: Systems to Controling Environment, Moor.F, 2003

3.2.4.3 Passive Cooling in Traditional Architecture of Iran

Passive cooling is the main cause of comfort in hot regions of the country and so the way of its generation and its efficiency in designing sustainable resort and touristic complexes in two climates, hot and humid and hot and dry, should be studied.

1. Hot and Humid Climate: In southern beach of Iran with a hostile climate (long summers, hot and humid weather and temperate winters, little rainfall, high humidity, temperature fluctuation and little plant cover), cooling is the primary task for providing comfort. The texture of towns of these regions situated on the beach is something between open texture of north beach and closed texture of central regions.

This kind of texture makes draught possible in these regions and at the same time the shade of neighboring buildings and existing plants can be used for decreasing temperature. Urban texture in this climate is half concentrated with spaces partially surrounded and towns and villages stretching along the beach and confronting the sea. General structure of the building, central courtyard and inward part, benefit as most as possible from shading and draught, high rooms and long and stretched windows, large and high porches, flat arcs without basement and with light materials.

2. Hot and Dry Climate: Central plateau, occupying a large surface of Iran, has hot and dry climate, rainfall, little humidity and plant cover as well as winds with dust. Correspondence between lifestyle and natural elements lead to formation of concentrated urban texture, totally surrounded spaces, narrow and unorganized alleys, some covered with arcs, compact buildings, installation with respect to solar radiation and wind. All living spaces including urban spaces, passages, courtyards and buildings are protected against climatic elements especially undesirable winds. The use of desirable winds and solar radiation is performed with special care. The

structure of the building is totally inward and surrounded with central courtyard and usually basements, porch and wind guard. Other characteristics of native architecture in these regions are lower surface of courtyard in comparison with natural surface of the earth, high rooms, domical arcs, tick walls and use of materials with high thermal capacity (brick, mud and mud-brick). (Ghobadian.V.1335, 1956, P 124-142)

3.2.5 Sustainable Systems

Sustainable systems in this section means those systems which not only use natural energies for providing human comfort as much as possible, but also damage environment very little in comparison to other kinds of systems mentioned in section 3.2.1.3. Among four types of systems mentioned in this section, passive and extra passive systems enjoy this characteristic and so they are sustainable. Of course it may be possible to classify these systems as sustainable systems regarding yield rate of active systems in particular situations. However here we mean two mentioned systems namely extra passive and passive systems, and each one will be discussed widely.

3.2.5.1 Extra Passive Systems

Those methods which instead of mechanical equipments and energy consuming utilities use environmental elements and structural elements of building and environment for controlling comfort conditions inside the house are called extra passive methods. As in many regions of the country, solar radiation affects building more than other climatic elements different methods of using or avoiding solar heat in different parts of the building in different cases are estimated. Extra passive methods for controlling the heat generated by solar radiation are dependent on elements such as how the building is placed in location, the structure of building

(external shell surface in proportion to its volume), color of external surfaces, circulation, placement at slope, what materials the walls are made of, limitations and size of the windows and the awning. These elements are studied here briefly. (Eslami.M, 2006, P5)

1. Placement of Building in Location: By modifying climate or climatic conditions surrounding the building through two main methods, how the building is placed in location and how plant cover surrounds the building, we can improve interior comfort conditions and cooling and heating needs of the building. Appropriate orientation to sun movement in the sky is one of the necessities of a building with efficient energy. Regarding sun movement in northern hemisphere, the best orientation for a building is stretching eastern-western and northern-southern (Figure 3.10). The main courtyard is on the south and most of windows are facing this way and a few windows are installed to the north, east and west. This kind of orientation causes achieving the most amount of solar radiation in winter and the least amount in summer and enjoying seasonal change of the sun as best as possible. Another issue related to the manner of building placement in location is the way of its contact with the earth which is very influential in cooling and heating the building.

In buildings constructed in deep, heat exchange between the building and surrounding air is little and so little warm or cool air is needed for providing comfort conditions. Except in humid regions where need draught upper and below the building, in warm and cool regions contact with the earth can be used as a method of decreasing energy waste.

2. Building Structure: General volume and building structure (proportion of surface to volume) are very influential in thermal energy exchange. Generally speaking

coolness leads to compactness of building and much solar radiation leads to building stretching in east-west direction.

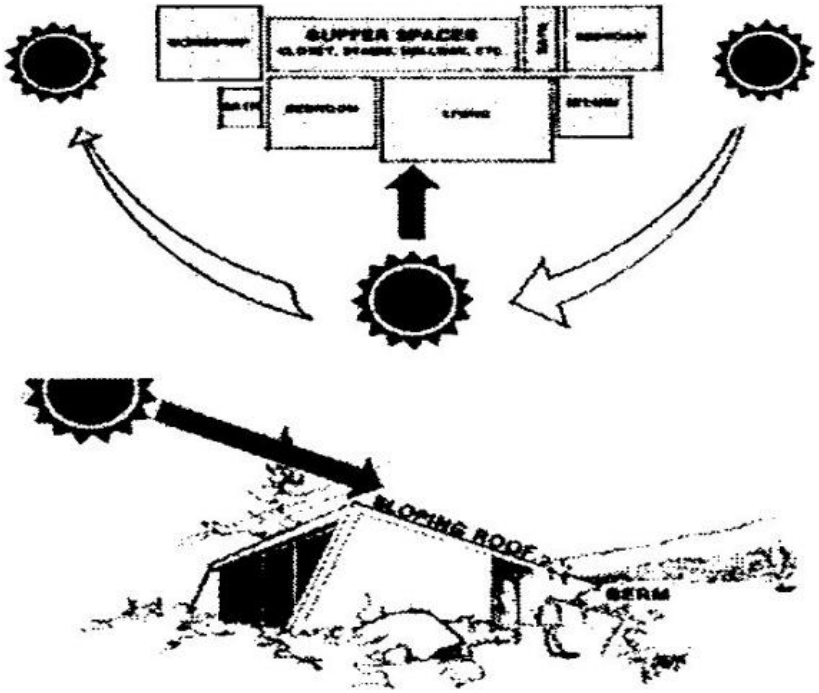


Figure 3.10: building placement in location

Source from: Architecture and Energy Eslami.M, 1385, 2006, P5

- In cold regions, closed and compact forms and cubic buildings or concentrated buildings are preferable.
- In temperate regions, choosing the form is more open; however building stretches from east to west.
- In hot and dry regions, compact and cubic forms are more appropriate. Moreover making a hole in the form of central courtyard accompanying shading trees and basins provide a more desirable climate.
- In hot and humid regions much solar radiation in east and west makes it essential for the building to be stretched and situated in east-west direction. (Eslami.M,2006, P 34)

3. Type of the Roof: Roof more than other parts of the building is under influence of climatic elements. At night and during cool season when it is colder than the roof surface, radiation with long waves from the roof surface causes the roof lose heat more and more quickly than the walls. In winter roof is the main cause of wasting indoor heat. In very hot regions roof may be the main source of heating warm indoor air.

External surface of the roof is under the most fluctuation of temperature and solar radiation. The influence of this fluctuation is proportional to the type of the roof and the color of its external surface. The main factors determining thermal characteristics of coherent and solid roofs are external color, thermal resistance and capacity of materials. The influence of color of external surface of roof is dependent on roof temperature, thermal resistance and capacity of materials. Ticker materials with high thermal resistance and capacity decrease the difference of maximum and minimum temperature of roofs with different colors. In light double shell roofs heat exchange and thermal transport is in a way that one portion of thermal energy radiated on external surfaces is scattered through convection and radiation to space and the remaining portion is transferred through radiation to the inner layer of the roof.

The factors influential on characteristics of double shell roofs are: materials and color of external surface of external layer, air conditioning between two layers and thermal resistance of thermal materials of two layers. The darker color of external surface of the roof, the less thickness, the less penetration of air, and the bigger thermal conductivity coefficient of materials would increase the function of ventilation of the air between roof and ceiling in preventing temperature increase.

(Eslami.M, 2006, P 5-7)

4. Wall Materials: The heat absorbed by external surfaces of a building is transferred after some changes to interior surfaces and finally increases indoor temperature. When a wall is exposed to solar radiation, it reflects a portion of solar energy and absorbs the remaining. The amount of absorbed heat is dependent on materials used for walls. When absorbed heat and velocity of heat transfer is more than thickness of the wall, influence of solar radiation on indoor heat will be greater. So for controlling indoor temperature, recognizing and studying the materials used in building body in respect to the way of heat transfer is very important. In order to decrease the influence of outdoor temperature on indoor temperature and provide better comfort situation, temperature fluctuation should be the least. Given the fixed outdoor conditions, maximum and minimum temperature of interior surfaces and temperature fluctuation of interior surfaces in proportion to external surfaces are dependent on thermal capacity and resistance of wall materials. When thermal capacity and resistance of a wall is big, then temperature fluctuation of interior surfaces will be the least and maximum of temperature will be bigger than external surfaces. Stagnant air is a good thermal insulation and generally light building materials having many holes and thin layer of air have big thermal resistance. (Eslami.M, 2006, P 20-24)

5. Limitation, Size and Color of Windows: Surface area of windows and aperture collectors are very influential in transferring heat in buildings. The smaller surface areas, the less heat transfer. Aperture collector surfaces due to their little thermal resistance in comparison with other parts of external shell should not face to cool and undesirable facets of the building. When the windows are small and awnings are influential, thermal resistance of the materials gets more important than its thermal capacity for minimizing indoor temperature. In such cases, materials such as light

concrete with appropriate thickness would be the simplest and the most economical materials. When surface area of windows are relatively large, or when awnings do not properly protect windows against solar radiation, as light materials get warmer in result of heat penetration, in such case thermal capacity is more important than thermal resistance. In this case, condensed concrete and materials with high thermal capacity with a thermal insulator layer near to the external surface of the wall will be useful. In case with larger windows, shell insulation should be stronger in order to reserve building thermal gain.

Surface area of operable windows in eastern constructions should be the minimum because it increases overheating in summer. Although operable windows installed in north facet of the building provide the building with higher quality of light and are useful in summer, the large size of these operable windows lead to waste of energy in winter. In southern facet as the result of more proper distribution of solar heat in comparison with other facets, also less effect of overheating in summer in comparison with eastern and western direction, large size of southern windows leads to improvement of thermal comfort of interior spaces in cold seasons. Moreover use of horizontal awnings like balconies is essential in summer.

(Eslami.M, 2006, P 40-41)

6. Plant Cover: Trees surrounding the building, by protecting against direct solar radiation and surface evaporation, will provide a protected space for residents. In this field below solutions are offered:

- Use of deciduous trees in southern facet of the building for preventing radiation in summer and use of solar thermal energy in winter
- Use of bushes, trees and other plants as obstacles around the building in order to decrease wind velocity and creating high and low pressure regions with

proper air conditioning, also increasing wind velocity in open spaces between windbreaks, use of evaporative cooling of external surfaces of building using basins and wet sandy surfaces

- Creating green roof on the building

Influence of plant cover on climate is in so that in a sunny summer day, in 1000 sq m grass land, 2000001 beech trees cool as much as 1000000 BTU every day. This is equal to cool weather provided by an air conditioner which works 20h per day for 10 usual rooms. So plant cover should be the maximum and wherever possible shade should be generated with trees for human constructed spaces.

(Eslami.M, 2006, P 30-31)

3.2.5.2 Passive Systems

Passive systems use architecture elements as design solutions for changing climate. A totally passive system does not use energy of fans, pumps or generating coolness and warmness but active systems are mostly mechanical. In primary stages of designing, an important question should be answered. What amount of heating, cooling and lighting should be provided by passive systems and how much with active systems? Another question is that how much any of these systems can replace the other one. According to these elements buildings are classified to three groups:

1. Both passive and active systems for providing building charge are designed.

2. Passive systems are dominant and active systems support them.

3. Dynamic systems are dominant but there are passive components in the building too.

The first choice is the best one. An active system is capable of providing cooling, heating and lighting for the building. In this case a passive system also supports the

building when needed. The first choice, while being proper will impose much cost on the building. So the designer usually tries to fulfill extra needs by choosing the second and the third choices. Passive systems are influential on the function of dynamic systems for heating, cooling and lighting. Here we try to explain some passive solutions of cooling in building. (Brown.G.Z and Dekay. M, 20000)

1. Cooling Systems: Among different available passive systems, passive cooling systems are very old in traditional architecture. These systems, by the use of potentials and utilities of the region, have been the best answer to desert conditions. Some of the systems used in traditional architecture have turned to proper solutions with some little changes. One of these systems is the use of solar chimneys and cooling towers which are the developed form of wind guards and other examples. This section is about some of passive cooling systems in traditional and modern architecture and the way they operate.

▪ **Wind Guard:** In building orientation, there are contradictions between orientation to the sun and orientation to the wind. One of the advantages of wind guards is that wind is available in all directions. In addition the primary structure of the building is designed according to availability of other sources of energy in location such as availability of the sun in winter. Average velocity of wind increases when height increases. So wind guards can catch winds with high speed. Thus the size of their operable windows is less than the size of operable windows in lower parts (Figure 3-11). Wind guard which is common in Iran and other Persian Gulf countries is a fixed set which operate both as a wind tower and as an exit. The vertical pipe in the upper part is open to four directions and a couple of separating walls are diagonal and crossing along to the lower part of the wind guard. Actually wind guard is a collection of wind tower with 3×3 and 7m high. Its upper part is open to four

directions and is capable of catching breeze from all directions and directing a cool flow of air into the room. It can also act as a chimney. In this case warm air is sucked from the back to the inside as the result of pressure difference. When wind velocity is low, ventilation through wind tower wind guard continues just by the help of chimney effect. (Mackarti.B , 2002)

In designing wind guard we should pay attention that the operable window in leeward is essential for air circulation and cooling the building. A wind guard should also be able to work reversely. If the operable window cannot be placed leeward, it should be placed windward. In this way air can enter through windows. Wind guard can be built in low pressure parts. In this case, suction in warm air starts air flow to the upper part and to the wind guard. It is better that wind guard ventilation system not stop at night because at night as the result of cold outside weather this system operates better and heat exit from architecture elements is easier.

(Saberi, O.Saneei, P, 2006)

- **Solar Chimney:** In urban buildings with fixed exterior to the west we can use phenomenon of light warm air as solar chimney. In building solar chimneys, below solutions should be considered:

Solar chimney should be faced to the summer sun and exits should be placed in the highest part. For better air exit, air exits of rooms to the chimneys should be placed in highest point of the room. Air entrance should be windward in the building. In this way light warm weather phenomenon regarding temperature difference between windward and leeward air heated with sun radiation makes air flow upward facing the sun.

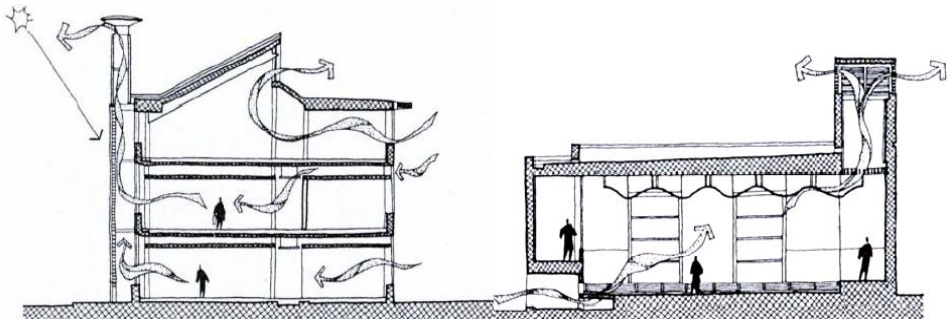


Figure 3.11: Right: manner of wind guard operation. Left: chimney ventilation in Research Institute in Russia

Source from: Sun Wind & Light, Brown,G.Z, Dekay,M, 2000, P 185

1. In solar chimneys we should avoid side operable windows because it makes backward flowing possible.

2. For making exterior covers of solar chimneys we should not use reflecting materials. Instead we should use materials with dark color which absorb much heat. These dark materials increase system temperature. (Brown.G.Z and Dekay. M, 2000)

▪ **Roof Windows:** Using roof windows or clerestories permits direct sun light enter to the building in winter and by their help natural ventilation is performed in building and causes natural cooling in summer. In designing these windows we should be careful that building be immune to summer sun, otherwise cooling effect of ventilation would be effect less due to direct sun radiation to inner parts of the building.

▪ **Cool Basin:** Cool basin is also another creative method for cooling roof passively. This system includes an open water roof which is shaded by the use of steep blinds which make possible for the water roof to access the north sky (Figure 3-12). In addition to evaporation this basin is cooled also through radiation to the sky. The cooling water is carried through a pipe to a large water channel situated below the building, in a way that when roof basin becomes cooler than water channel thermo

circulation happens. Cooling operation of this system is very interesting. In cool basin system, water channel can be designed in a way that it can act as a water wall for passive heating system in winter by being situating behind north windows of the building and blocking circulation to the water roof. (Moor.F, 1382)

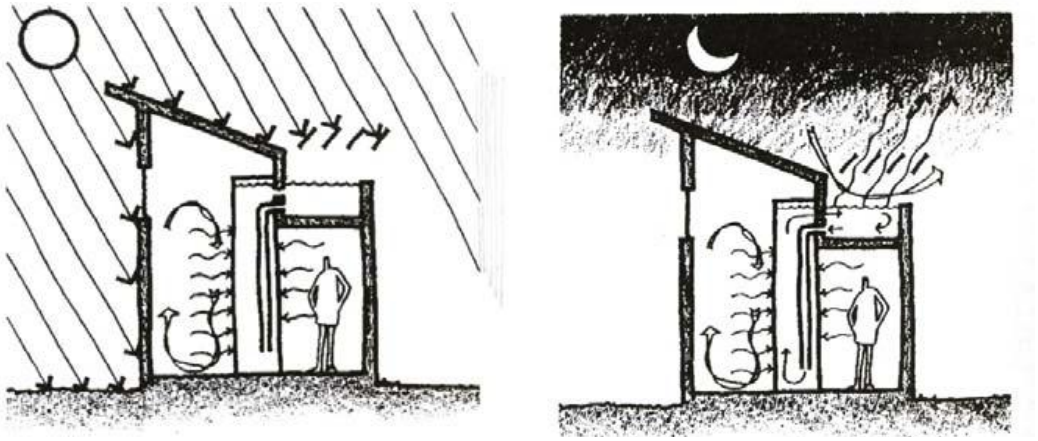


Figure 3.12: Cooling operation of cool basin in building during day and night

Source from: Systems to Controling Environment, Moor.F, 1382, 2003

▪ **Serdab:** In historical buildings built in hot and dry regions of the country (Iran), there is a space called serdab for cooling in summer. Serdab is an underground space through which Ghanat water flows. Ghanat deepness is related to the level which Ghanat water flow (about 6m). Due to the flowing of cool water in this space, it is very wet and cool in comparison with outdoor. In order to use this air, a channel is connected from the wind guard to this space which directs air flow to this space. There is another channel which directs wet and cool air flow to underground room, under the saloon. This room which is naturally cooler than the room around the yard gets cooler by this system. Finally cool air flow enters central yard by passing through basement room and making yard cooler as well.

▪ **Garden Hole:** Exploiting earth heat in winter and its coolness in summer are very cheap and secure. In houses with central yard, garden hole which on its below part

beautiful trees are planted and in some cases has a small basin, is a proper place for residents. In summer, trees prevent sun radiation to below spaces and in winter we can use sun radiation. In summer there is considerable difference in temperature between yard of garden hole and upper yard. Garden hole itself operates as a generator of fresh and cool air for upper space yards. (Moor.F, 1382)

- **Awning:** One of basic tasks for preventing overheating and lack of comfort of residents is preventing sun radiation to enter interior space. For controlling radiation through those windows in southern facet of the building, the use of fixed horizontal awnings is appropriate. In reverse, those windows in west and east facets of the building, awnings should be vertical regarding sun radiation. Exterior shadings are more advantageous than movable interior awnings. Awnings of windows and natural ventilation are more influential than windows orientation in determining interior temperature. In this way in a room owning windows with awning in which air circulates, windows orientation is not so influential in determining interior temperature. Exterior awnings can decrease thermal effect of sun by 90 % inside the room and exterior awnings can decrease it just by 20% to 25%. The amount of heat decrease depends on location of shade. Efficiency of movable awnings is related to their color and the place they are installed in proportion to window and also natural ventilation in building. Exterior movable awnings should be dark and interior movable awnings should have light colors to be mostly efficient. Exterior movable awnings transfer just 5% of solar energy inside. Exterior wooden blinds can decrease solar radiation by about 10%. In both east and west facets we can provide proper shade on window using awnings in the shape of frame consisted of vertical and horizontal awnings around the window. Especially if their vertical parts be situated to the south with 45 degrees. Vertical awnings make little shade on window in summer

and in winter they prevent sun radiation into inside and are not appropriate. In these two directions, horizontal windows are more appropriate than vertical windows. In south direction, south east and south west also horizontal awnings are more efficient than vertical windows. In south, south east and south west direction, horizontal awnings are more efficient than vertical awnings. In addition frame-like awnings are the most efficient awnings in all directions. (Eslami.M, 1385)

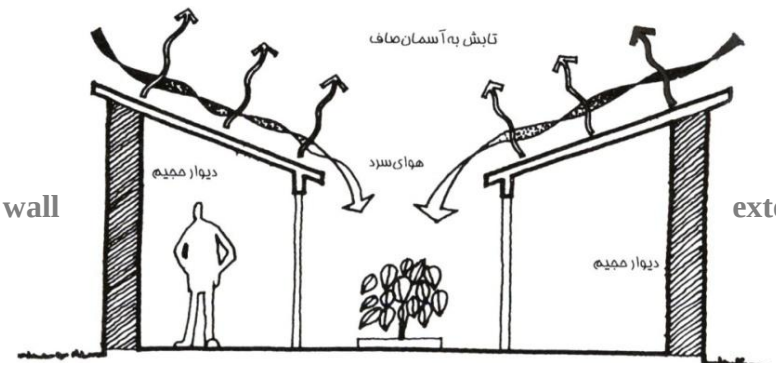
2. Cooling-Heating Systems: Some systems due to having some special conditions are able to fulfill both cooling and heating needs. These systems are very appropriate in regions with long and warm summers and cold winters with much temperature fluctuations in day and night and different seasons. In addition to providing needed heat in winter, they provide also summer cooling. Here we study some of cooling-heating systems in traditional architecture and also some examples used in modern architecture.

▪ **Central Yard:** One of the commonest forms of making house in hot and dry regions is designing the construction in the form of central yard which is a proper solution in providing winter heating and summer cooling in these regions. These houses are dependent on their interior yard for ventilation and gaining light. The house with central yard has some rooms located around the central yard. The yard is oriented to the south (south west or south east) and is divided to two parts of winter part and summer part.

In winter part there is a large room which properly receives sun radiation and gets warm very quickly in morning. This room gets warm by direct sun radiation. The floor, walls and ceiling of this room which are usually made of raw bricks, act as suitable thermal reservoirs. Much amount of heat is reserved in these reservoirs and in 7 to 9 hours this heat is released to the interior space at night. In this way nights

are not so cold. Summer part receives the least amount of solar radiation. This part usually consists of salon, wind guard, Sardab and the space under calotte. Calotte is a dome in middle part with windows for air to exit. The salon is a three layer space, oriented to the north. At night, coolness is reserved in walls, ceiling and the floor of the salon and then released during day. Without direct solar radiation this space does not get much warm. The ceiling of the salon has two layers like sash and the air between these two layers is a good isolation for the ceiling. Wind guard and calotte both are constructed on the roof of the chamber in the corner of the yard, where receives the least amount of sun radiation. The wind guard receives cool air and transfers it to interior space and the calotte directs warm air from the room to outdoor.

Surrounded patios and central yards enjoy radiative cooling (Figure 3.13). If trees block central yard view to the sky then nightly radiation will decrease. However this nightly radiative cooling is more than being nullified by protective shading in day time, perspiration or double evaporation. In central yards, the roof can be designed in a way that augments this cooling cycle. If the roofs of surfaces around the central yard are steep, when the roof gets cold at night due to radiation, the air layer over the roof gets cold as well and flows down to the yard and replaces the warmer air. Practically using this method for flowing down rain water to the yard and at the same time absorbing worthy humidity for evaporation is common.



Exterior wall **exterior wall**

Figure 3.13: Delay in heat conduction being mixed with the air cooled by radiation and voluminous exterior wall in central yard

Source from: Architecture with minimum energy, Saberi.O, Sanei.P, 1385, 2006

In addition to cooling phenomenon of radiation, convection and evaporation which turn central yard to an efficient method in hot and dry regions we should not ignore aesthetic and psychological effects of this oasis “ ”. “Reynolds” in 1983 analyses traditional central yards in Colima in Mexico and at the end comes to this conclusion that mental considerations of cooling in these buildings are beyond those measurable effects. (Saberi.O, Sanei.P, 2006)

▪ **Atrium:** Atrium or roofed central yard is a middle space in building such as a central yard with roof surrounded by some parts of the building. A sunny atrium is that kind of atrium with glass roof (Figure 3.14). Solar energy entering through glass roof is collected in interior space and a portion of it enters the rooms and after warming interior space, the extra heat is reserved in building materials. In winter, atrium acts also as buffer. In summer in order to prevent interior space to get warm, the atrium should be ventilated properly through upper operable windows and its glass roof should be covered with shading as much as possible. (Moor.F, 2003, P120)

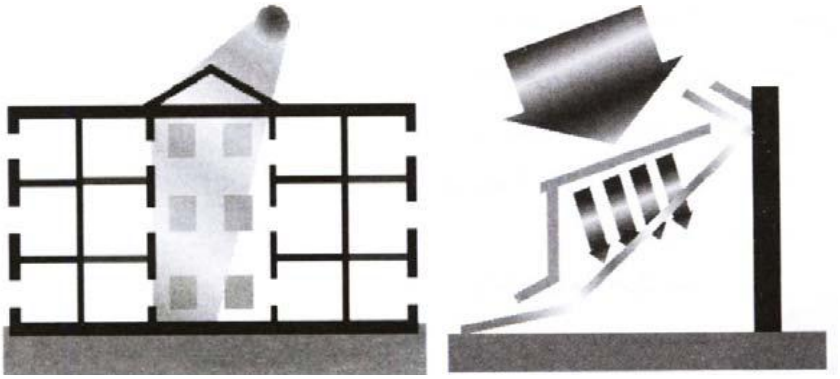


Figure 3.14: A slice of a sunny atrium

Source from: Systems to Control Environment, Moor.F, 2003

▪ **Water Roof:** In 1970 Harold Hay invented a water roof system which provides both passive cooling in summer and passive heating in winter. The registered system – skytherm – later was used in a laboratory with real size and also in a residential house. In this system, water should be on a support capable of thermal conduction (usually metal sheets) in winter days and summer cool nights exposed to fresh air. In those regions in need of winter heating, insulator lids should be used at night. (Figure 3.15) illustrates on the right hand the placement of insulation over water in day time and its removal at summer night, on the left hand the removal of insulation in day time and its placement in winter night.

In buildings which use water roof for fulfilling their heating and cooling needs, in summer day's water absorbs heat through ceiling from its underground room and is protected against solar heat by the help of insulator panels. At night, panels are removed and enable water bags to radiate heat to night sky. In winter days, water bag covers are removed and in result solar heat will be absorbed. This heat is conducted through the ceiling and is radiated to the underground room. At night, bags are covered with insulator panels for decreasing heat release. Using the second cover made of plastic which is a bit swollen for creating an insulator layer of air improves this system efficiency.

In summer for augmenting evaporative cooling, a large area may be irrigated or filled with water. In addition it is possible to use ceiling fan for increasing convection between room air and the metal ceiling. Researches done based on computer assimilations indicate that cooling through water roof can generate comfort through these two methods (using irrigation for evaporative cooling and using ceiling fan) in any region of USA. Nowadays many methods for improving the primary system of water roof are suggested. For example, researchers in "Nebraska" University have

suggested that instead of moving insulator panels, we can use pump water over the panels. This system in temperate climate which needs both heating and cooling is the most efficient solution. (Moor.F, 2003)

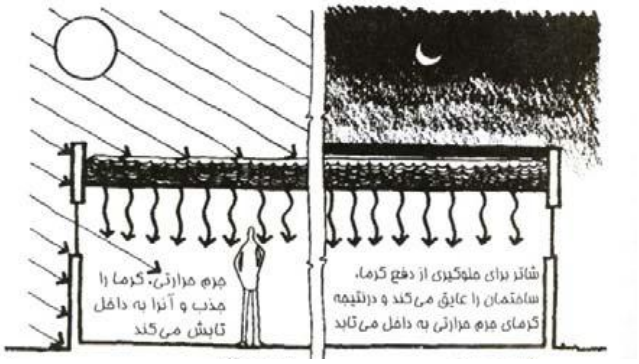


Figure 3.15: Using insulation in roof

Source from: Systems to Control Environment, Moor.F, 2003, P 256

▪ **Thermal Storage Wall:** In thermal storage wall system, there is a thermal mass between the glass and the living space. In this case during day, it is necessary for the absorbed heat to be transferred through all thermal mass. This process warms up all thermal mass. At night, thermal mass protects living space against coolness just like a shield. A thermal storage wall consists of the below parts: a wall and a glass on its exterior surface. Big mass of the wall reserves thermal energy and usually is made up of solid materials (trombe wall) or containers of water (water wall).

▪ **Trombe Wall:** It was Edward Morse who for the first time in 1889 suggested the use of solid materials for thermal storage walls in solar heating systems. These systems usually are dark in their glass facet in order to be able to absorb sun light. In these systems heat is conducted through the wall slowly. The ticker architectural materials, the less temperature fluctuation in living space and the longer the delay in heat transport through the wall. Thickness of the wall can be so efficient that its heating effect will be delayed till night when the most amount of heating is needed. Trombe wall in comparison with other passive systems operates properly. This wall

put thermal mass between living space and sun and glass and in this way it creates a natural shield between residents and temperature fluctuation of absorbing solar surface. These walls transfer heat slowly through thermal storage and as its result temperature is modulated and delayed. This feature provides the possibility of releasing solar heat in a secure and predictable way inside the building.

(Moor.F, 2003, P165-169)

By making changes in the building and in trombe wall, we can use this system as a cooling system. These changes are making exit windows for warm air in glass part of trombe wall and also operable windows over the windward facet of the building. These operable windows cause cool air enters through windward operable windows and warm air exits from the space between glass part and building wall.

Figure 3.16: Right: Cooling operation. Left: Heating operation of trombe wall

Source from: Systems to Control Environment, Moor.F, 2003, P167

▪ **Water Wall:** Trombe walls and water walls both collect and reserve heat in a similar manner except in one case that water walls transport heat through water convection by the wall while trombe walls transport heat through conduction with materials (Figure 3.17). As the result of this convection water is mixed in container in a way that temperature remains fixed from one line to the other one. The result of this feature is that the effect of absorbed heat in solar facet of the container will immediately be filed in the facet facing the room of the container. In other words in

these walls comparing with trombe walls there is no delay. However as the absorbed heat should increase temperature of the total container of water , temperature of the container room remains fixed. Daily temperature fluctuation in these walls decreases just like trombe walls in comparison with direct absorption systems. As special heat capacity of water is high, it is proper for thermal storage.

Yearly thermal storage in a water wall is similar to thickness of half of a trombe concrete solid wall; though the manners of heat transfer in them are different. Water walls despite trombe walls transport heat immediately through mass of thermal storage and they operate almost properly.

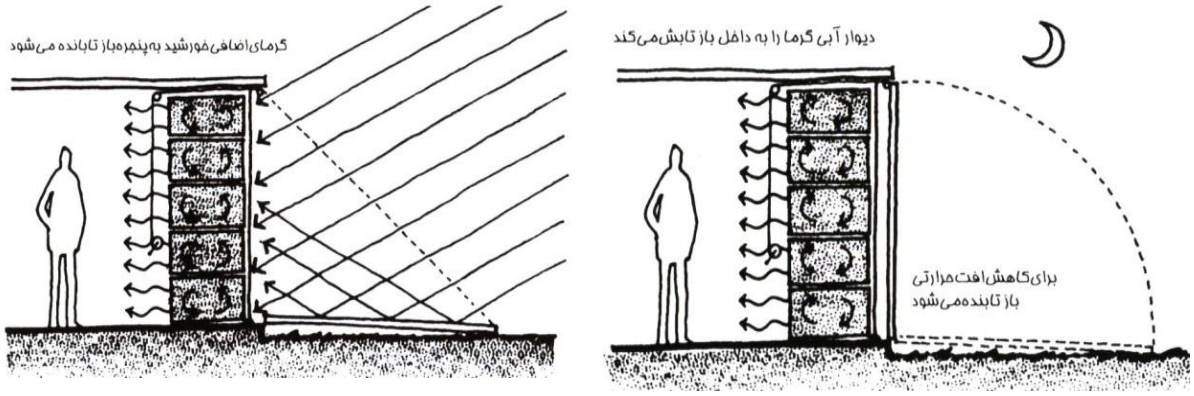


Figure 3.17: Manner of functioning of water wall as a cooling-heating system

Source from: Systems to Control Environment, Moor.F, 2003, P176

Water is an excellent mean for reserving heat and constitutes almost one third of volume and one fifth of weight of building material but it has exactly the same reserving capacity. This characteristic of water walls reduce the needed weight for thermal reserving mass and provides possibility of using water walls in upper stores of the buildings with wooden skeleton without major changes in the structure of the building.

In ready- made water walls thermal reservoir is almost free. Water containers according to their type can be installed in a way that provide access to the operable

windows and nightly insulation and simultaneously provide natural light and summer ventilation. The main deficiency of these walls is keeping water in these containers. (Moor.F, 2003, P173-174)

▪**Full and Empty Spaces:** We can transfer heat by the use of full and empty spaces and make some parts of the building cool as well as hot parts of the building. (Figure 3-18) Availability of thermal resources such as sun and coolness resources such as night sky are not the same in different parts of the building. So some buildings need heat transfer to cooler parts of the building in hot seasons of the year and coldness transfer to hot parts in cold seasons. Those buildings which are cooled through the internal roof have some parts with additional heat and coldness. This heat should be transferred to those parts which need heating, such as the space in north part in winter. In this method in order to provide needed light and heat in all parts of the building, upper windows, channels and mid-open internal spaces are used.

- Intermediate Parts: These parts are useful for moderating the fresh ventilated air before arriving to the occupied spaces of the building. Thermal converters are used for moderating heat or coldness arrived for ventilation. In surrounded buildings in which receiving and wasting thermal energy through the building shell is controlled carefully, heating and cooling the fresh arrived air assigns maximum amount of energy consumption to itself. (Figure 3-18) when ventilation is lower than one roof in an hour, dangerous pollution exists in building which occurs naturally in result of chemical dissemination of building materials and accumulation of radioactive gas of Radon. One way of reducing consumed energy for heating or cooling the arrived air without decreasing in volume is the use of illusive heat or coldness from the building. In this system, air channels use fan power for transferring heat. The exiting

air from the building which passes through some light metal plates transmits some proportion of heat or coldness out.

The arrived air also passes through the same plates and brings heat and coldness in. Thermal converters are able to retake 70 to 90% of emitted heat or coldness. The windows transmitting air and terrain- aerial thermal converters moderate fresh air for ventilation. In buildings with greenhouse spaces and intermediate space, this space in winter is warmer than outdoor air. Ventilated air can be usually transferred by the help of fans and thermal converters from these spaces to intended rooms.

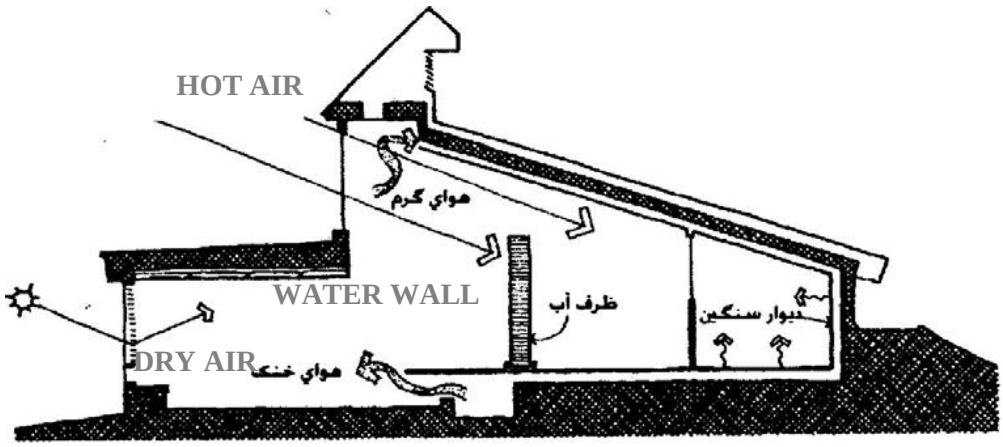


Figure 3.18: Use of internal mid-open spaces and upper windows in conversation hall in Concord, Conservation Center, Concord, New Hampshire

Source from: Sun Wind & Light Brown.G.Z , Dekay. M, 2000, P 288

▪**Thermal converters of earth to air:** These converters moderate arriving air flow for ventilation in all seasons and help cooling building in summer too. Earth temperature does not fluctuate much in deep underground. Its temperature regarding the average of air temperature has one month delay and this leads to the fact that it is warmer in winter and cooler in summer in proportion to the air on the ground. (Figure 3.19) When air is conveyed out by the use of fans power through the underground channels called cool pipes or ground pipes, its heat is transferred with the air. The system which can preheat or pre cool the ventilated air can be used for

providing coolness of some parts of the building. In summer it may get enough cool to be used with no extra moderation. Just a proportion of cooling of the building can be supplied in this way. The amount of transferred heat is proportional to temperature difference between air and earth, type of the soil and its humidity, the amount of passing air through the channel and the length and diameter of the channel.

The main efficacy of designing ground pipes is in result of finding enough space of a proper construction. The length of the channel should be between 10 to 90 meters and its diameter between 2 to 3%. Shorter channels have better thermal control but are more expensive. Channels with shorter diameters have a larger area in proportion to the area of their cross section. The proper depth is 1.5-3 meters. From the ground to the air, temperature difference increases with depth. Air velocity in channel should be between 2.5-8 m/s. higher velocity increases general cooling but decreases fluctuation of air temperature. Channels should be surrounded in 5 centimeters with sand in order to ensure the proper thermal touch and preventing damage. They can be made up of any material such as plastic, metal, ceramic or concrete.

For recognizing the length of the channel we should know the amount of three elements. First, estimating the amount of transferred heat from the building, other received heat or wasted heat. If underground channel is designed just for ventilation, it contains just received heat or wasted through ventilation. Secondly, estimating earth temperature in a depth where channel is installed and third estimating temperature of outdoor air in one month. Usually the temperature of the plan in summer is considered for a completely sustainable building, or the average of high temperature for a building with the supply of mechanical cooling. In winter, the lowest temperature is used. (Figure 3.20)

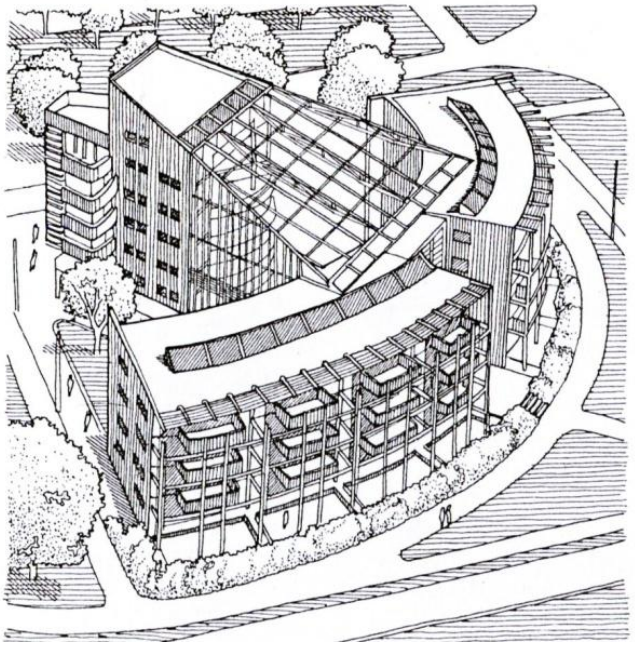


Figure 3.19: Using intermediate regions for moderating arriving air flow

View from south west, Urban Villa, Amstelveen

Source from: Sun Wind & Light Brown.G.Z , Dekay. M, 2000, P 290

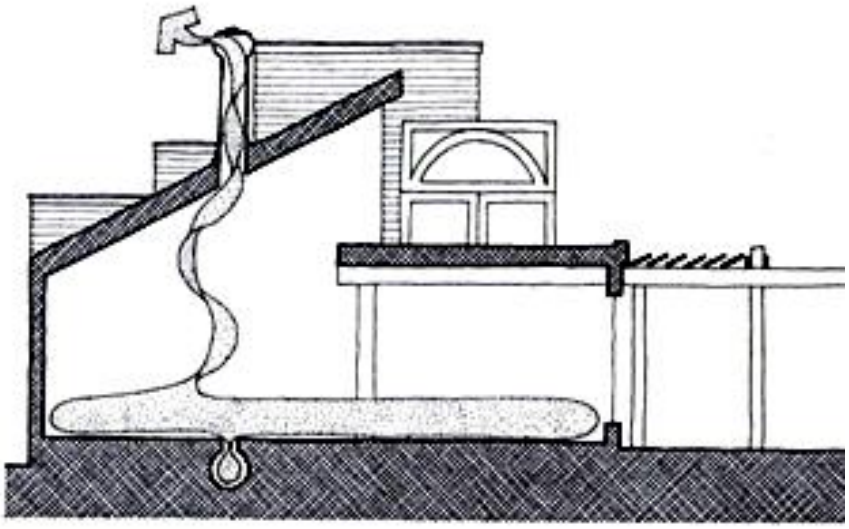


Figure 3.20: Using thermal converters of earth to air

Lane Energy Center, Cottage Grove, Oregon, Equinox Design

Source from: Sun Wind & Light Brown.G.Z , Dekay. M, 2000, P 291

DESIGN STRATEGIES

4.1 Design Solutions

Architectural complexes in one hand are constructed in result of interaction of residential units as the primary core of the city with each other and on the other hand these residential complexes are what form cities in interaction with each other. So for cooling in architectural complexes, we should study them in three scales of group buildings (context), building and elements of building. The principal constructive elements of a complex include communicational routes, open spaces, green spaces and buildings. Solutions applied for providing more comfort emphasizes communication between buildings and the said spaces. So here we study these solutions and point to those elements which should be considered in designing each component of architectural complexes.

4.1.1 Group Buildings

Solutions used in scale of group buildings (context) for providing comfort are some subjects which are usually ignored by architects and urban designers. Considering these solutions as designing tools is difficult because total control of all the models and considering all the solutions for providing comfort in urban design is difficult. Here some major solutions of sustainable design (with emphasis on sustainable cooling) in context scale are indicated which provide accessibility of constructions to natural sources such as sun and wind and are very influential in increasing or decreasing cooling and to some extent heating of buildings. Design solutions of group buildings should regard planning and designing building in relation with

neighborhood and the issues related to urban design. In projects related to designing a building, designer should consider solutions related to group buildings, because building and location are mutually contributing in forming a large urban model; and when designer controls just formation of one building in location, he or she creates the shape and situation of that building, a particular relation with the streets, neighborhood, formation of open space among buildings and formation of a particular microclimate around that building.

4.1.1.1 Cooling Solutions

In this section some efficient solutions for cooling in group buildings in hot regions are studied. These solutions present characteristics of urban components with the purpose of providing coolness.

Solution Number 1: Designing wide green passages in direction of cool breezes and radial routes emitted from them in order to control and diffuse cool air in context:

Group buildings affect the model of local winds in two ways. First during night when air flow in the region is quiet, creation of hot islands in urban contexts cause the movement of wind models from regions with low density to regions with high density. These winds are significantly stronger than those blowing in regions surrounding the city. Secondly as denser surfaces in proportion with low dense surfaces produce and reserve more heat in daytime and reserve it for a long period in themselves, so temperature difference between denser urban surfaces and open spaces as cooler of surrounding surfaces at night increases. When warmer and more polluted air flow of city moves upward, a negative pressure is created which results in suction of cool air surrounding the city into the centre. Both these effects,

particularly in hot summer nights, reduce air pollution and warmness in compact urban contexts and create coolness. (Brown.G.Z and Dekay. M, 2000)

Two elements of urban design for forming green ventilating routes are as follows:

1. Natural belt made of plants around urban contexts as a source of cooling

2. Wide passages for air flow to pass from regions with low density to regions with high density

In other words what is intended is a system of green linear routes, boulevards in a convergent system with one centre or more in a radial way. (Figure 4.1)

Washington DC, designed by Enfant Pierre in 1791 is an example of urban planning with linear wide streets from edges to centre. In this example streets lead to squares which are developing knots of the city. Summer wind penetrates into the city from the south and over open space and Potomac River. General rules in designing green spaces and urban passages with the purpose of creating coolness are as follows:

1. Use of wide green streets and open linear parks which are 1 meter or longer in order to make urban spaces cool in quiet nights without breeze

2. Designing ventilation routes, parallel with the orientation of the dominant wind for the air flow to penetrate into compact building masses

3. Designing routes in order to connect surrounding green belts to compact building centres.

4. Designing a green belt occupying 40 to 60% of open space area in touristic resort places

5. Designing routes and buildings in neighboring units, straight to the hot summer wind in order to reduce its velocity in urban spaces and wind diffusion in open spaces with the least size of 400×400 sqm.

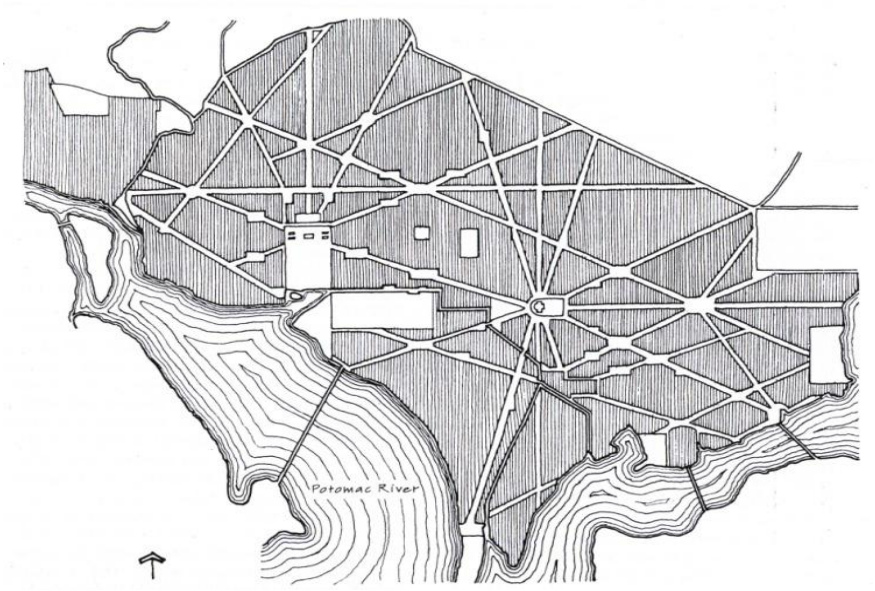


Figure 4.1: Radial routes for guiding cool breeze of the river from the edges into the context in Washington

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 281

Solution Number 2: Designing buildings with purpose of shading on each other and on open spaces

One of significant characteristics of urban contexts in hot and dry regions is high buildings across narrow passages. These passages in comparison with wide passages create more shade; and are suitable for shading on eastern and western parts in north-south streets. (Figure 4.1) The sun is in its highest point in religious noon, so building shading in east-west passages on south parts of other buildings (north part in south hemisphere) is difficult; unless building height in proportion to the width of the passage is very big. In this case, use of horizontal shading elements such as vaults, pergolas and horizontal and canopies is very effective. (Figure 4-2) When building surfaces are shaded, its surface temperature is reduced and the building achieves less heat, so energy needed for cooling is reduced. In hot and dry regions where use of ventilation as a cooling solution in building is rare, buildings should be very compact in order to shade on each other and on neighboring streets.

During the day, the higher parts of the building are warmer than the parts at the same level of the street, because it receives more radiation in comparison with the lower parts. At night, the case is reversed. The parts at the same level with the street get cool more slowly than upper parts, because the surface exposed to the sky is small. Cool weather in the street is collected in layers and then goes to the lower part and moves from the surfaces and slope surfaces to the street. If buildings have fixed height, wider streets increase daily temperature fluctuation. (Givoni, B, 1988)

Figure 4.2: Shading of narrow north-south passages

Site Plan for New Bariz, Egypt

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 84

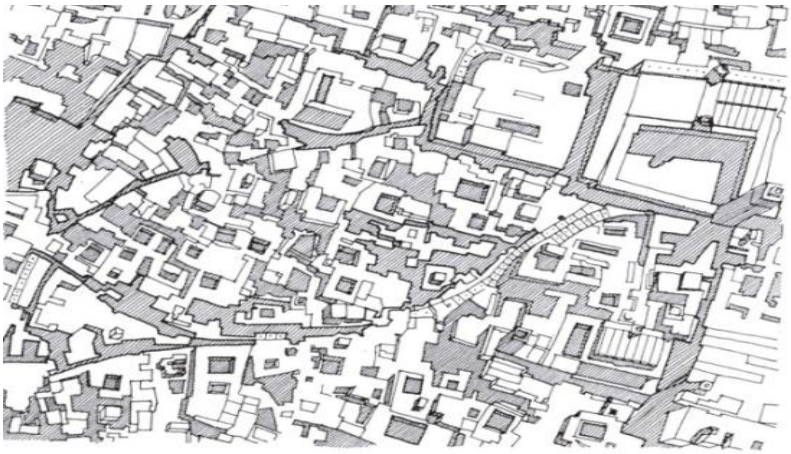


Figure 4.3: Compact designing of Tunisia for shading

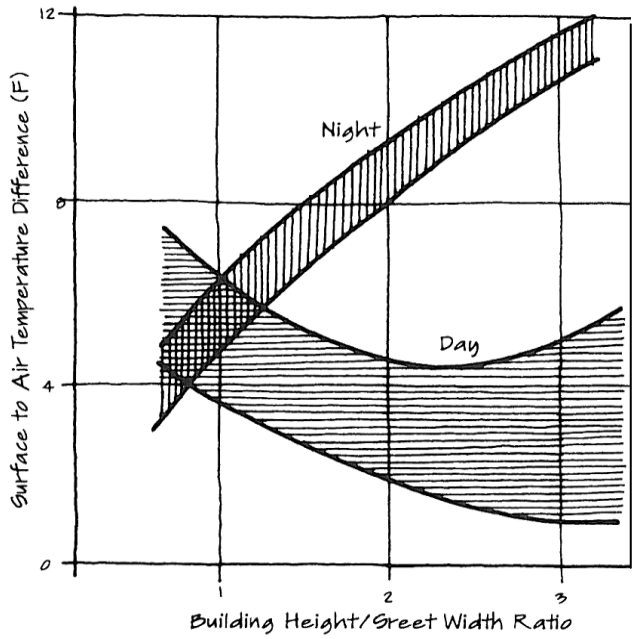
Arial View of Tunis, Tunisia

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 83

Graph 4.1 which demonstrates effect of proportions between cross section of air flow on surface temperature in Bangladesh situated on 23 north latitude, indicates the fact that in passages which ratio of height to width equal to 1 to 1, the highest temperature in summer is 4 degree over than those passages with ratio of 3 to 1. (Brown.G.Z and Dekay. M, 2000)

Those passages oriented from north to south are suitable for shading on buildings. The picture which shows the effect of proportions of north-south streets on shading models indicates that in north-south passages in morning, surfaces facing to the west and in afternoon surfaces facing to the east are shaded. According to the proportion between building height and the width of the passage, larger or smaller part of the street and building frontage will be in shadow, and the amount of shading changes in result of the change in proportion of the passages. So these passages should be narrow and high buildings should be located on both sides and in this way frontage of both sides' shades on the opposite frontage during half of the day.

In other words higher buildings in narrower passages create more shadow. Sun radiation angle in the intended latitude, orientation and time of shading are illustrated in this picture. The amount of shading in street and on opposite buildings is related to factors such as orientation and width of passages, height of buildings and angle of sun radiation. (Givoni, B, 1988)



Graph 4.1: Impact of Cross section on surface temperature

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 84

The diagram of sun radiation angle (P) based on latitude of the region and time of shading is achieved by the use of chart 4.1. Then this angle is drawn from top of the buildings located on eastern edge of the street (frontage to the west) to achieve shade line of afternoon. The significant point is that radiation angle at morning when sun is low is very small, and at noon it increases to 90 degrees. (In northern hemisphere) as eastern and western frontages have little shadow, they receive little heat as well.

Latitude	٦ AM/٦ PM	٧ AM/٥ PM	٨ AM/٤ PM	٩ AM/٣ PM	١٠ AM/٢ PM	١١ AM/١ PM	١٢ Noon
28	**12**	**24**	**37**	**50**	**63**	**76**	**90**
32	**13**	**25**	**37**	**50**	**63**	**76**	**90**
36	**14**	**26**	**37**	**49**	**62**	**76**	**90**

Chart 4.1: Summer radiation angle (P) according to latitude

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 85

In hot and dry regions, narrow passages with better shading are more suitable for pedestrian crosswalk, outdoor living spaces and shops. As building shading is less in east-west passages, these passages may be wider and designed by shading of vaults, canopies and other shading elements for roadway. As one frontage of north-south passages is always in shadow, the use of vaults and covered routes for shading in these passages are not sufficient. Narrow passages may cause increase in pollution, increase in noisiness and decrease in wind velocity. As nightly radiation of heat to the sky and nightly cooling in narrow passages occur rarely, it is essential to make sure about efficiency of nightly ventilation for cooling passages and external surfaces of the building. It should be considered that in location and establishment of the buildings, these shadings should not continue in cold seasons when receiving sun radiation is desirable. (Givoni, B, 1988)

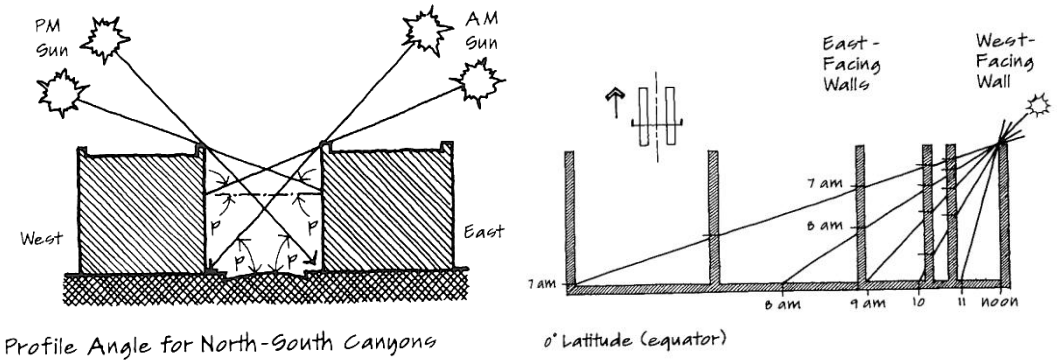


Figure 4.4: Right, ratio of building height to width of north-south passages, in June 21 (summer revolution); Left, radiation angle in north-south passages
Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 85

Solution Number 3: 20-30 degree orientation of main passages, to cool breezes, in order to increase air flow in urban spaces and ventilation of buildings

In hot regions, especially in humid regions, desired ventilation for heat transfer from streets and open spaces and producing passing ventilation in buildings is essential. The primary presupposition for creating passing ventilation in buildings is

availability of enough air flow. Regarding the fact that in compact urban regions, receiving sun heat is more and heat waste through radiation is less, wind can be the essential factor in cooling passages and open spaces. Formation of buildings and streets in relation with summer cool breezes, increases air circulation in city and in this way makes wind access in many buildings possible. (Givoni, B, 1988)

Wind flows with the most velocity in passages parallel with the dominant wind; while in passages which are perpendicular to dominant wind, the wind passes with less velocity and confusion in passages and over the buildings. In passages with cross orientation to the dominant wind, buildings in two lines have positive pressure and in two other lines have negative pressure.

In such buildings, passing ventilation is at most. If passage orientation does not differ much with the orientation of the dominant wind, passing of air flow in city creates a proper air circulation. In general case, in narrow passages, wind velocity decreases; while in wide passages as the result of decrease in friction, wind moves with maximum velocity. In moderate regions where winter heating is as important as summer cooling, for providing south frontages (northern frontage in southern hemisphere) with sun radiation, eastern passages should be enough wide and stretched blocks frontage should have 309 degree to south. (Figure 4.5) In order to increase passing ventilation and air movement in passages, major passages should have 20-30 degree angle to breeze direction. (Brown.G.Z and Dekay. M, 2000)

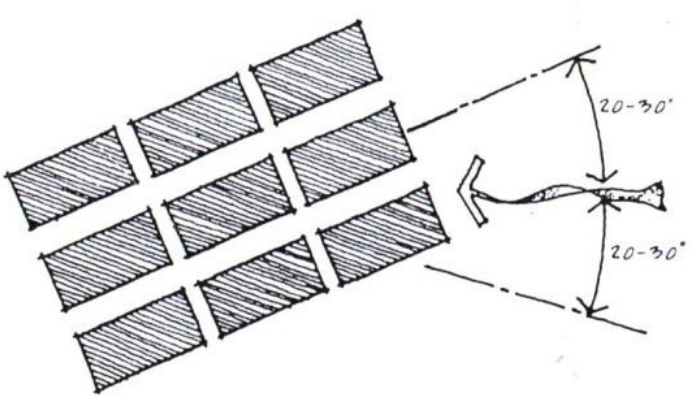


Figure 4.5: 20-30 degree direction of major streets to dominant wind in order to create ventilation

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 115

Solution Number 4: Creating suitable spaces in building for benefiting cool breeze

Each building reduces air velocity in the frontage facing wind; so those buildings in which ventilation is important, if located directly behind each other, for making sure about enjoying air flow, they should be separate from each other about 5 to 6 times of building height. One store buildings in comparison with multistory buildings have a smaller Wind shadow zone and can be situated nearer to each other. Texas building company has designed some beautiful buildings which are compatible with climate; this complex is in the form of separate rooms which are connected to each other through roofs and swinging scaffolds and are surrounded with play living spaces. South Bruke Ranch building is made up of the mixture of three building blocks in the form of U. this building is directed to south east in order to enjoy cool breezes. Each building has windows in opposite parts. According to the spaces between buildings, three distinct relations between them are defined.

1. A case in which buildings are arranged in rows near each other and straight to wind orientation. In this case as the result of little distance between buildings, wind

cannot pass through them and just leads to air movement and creation of a circular fixed and sustainable flow among building spaces.

2. Second case occurs when distances between buildings are more than distance needed for creating a fixed circular air flow but less than total distances of windward and leeward air flows. In this case wind mingles with the air flowing among building distances and a mingled air flow is created among buildings.

3. In third case, distance between buildings is more than total distances in which windward and leeward air flows exist. In this case, wind moves downward with a separate flow model among buildings and is suitable for ventilation too.

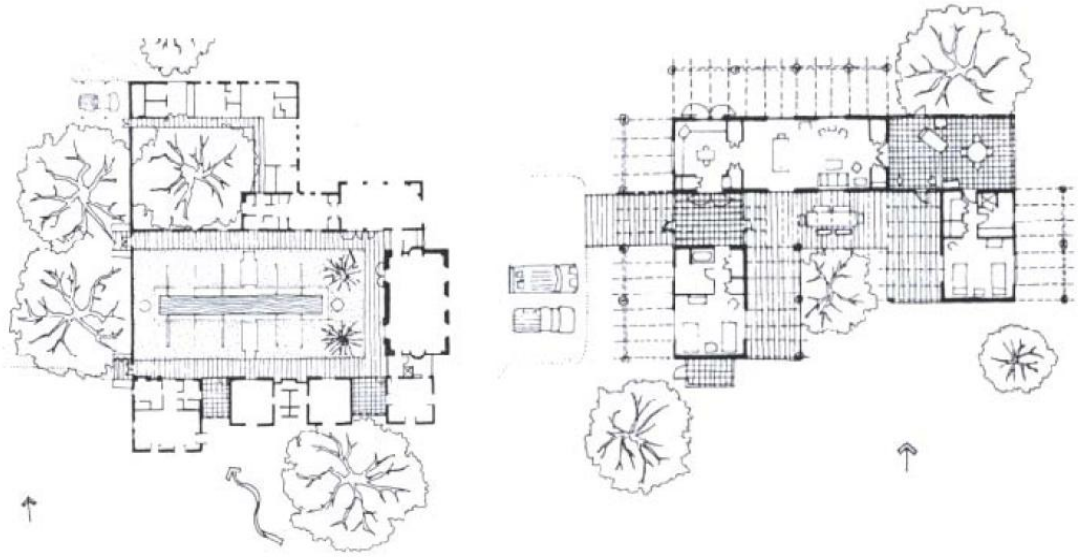


Figure 4.6: Right, Texas Company building plan; Left, South Bruke Ranch building
Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 116

Larger distances between leeward buildings, distance between building ends and their less height reduce reduction in wind velocity. When buildings are designed alternatively, air flow around a building ventilates adjusting buildings and in distances between buildings reduces wind velocity. For determining the effect of building distances and density of building rows on efficacy of ventilation, the ratio of building height and distance between buildings should be inserted in horizontal axis

of Figure 4.7 and after crossing the curve Figure, efficacy of ventilation is estimated according to the straight axis.

These amounts are achieved based on reduction of pressure difference between leeward and windward frontages of buildings as the result of distance reduction. In this diagram, wind direction is straight to the buildings.

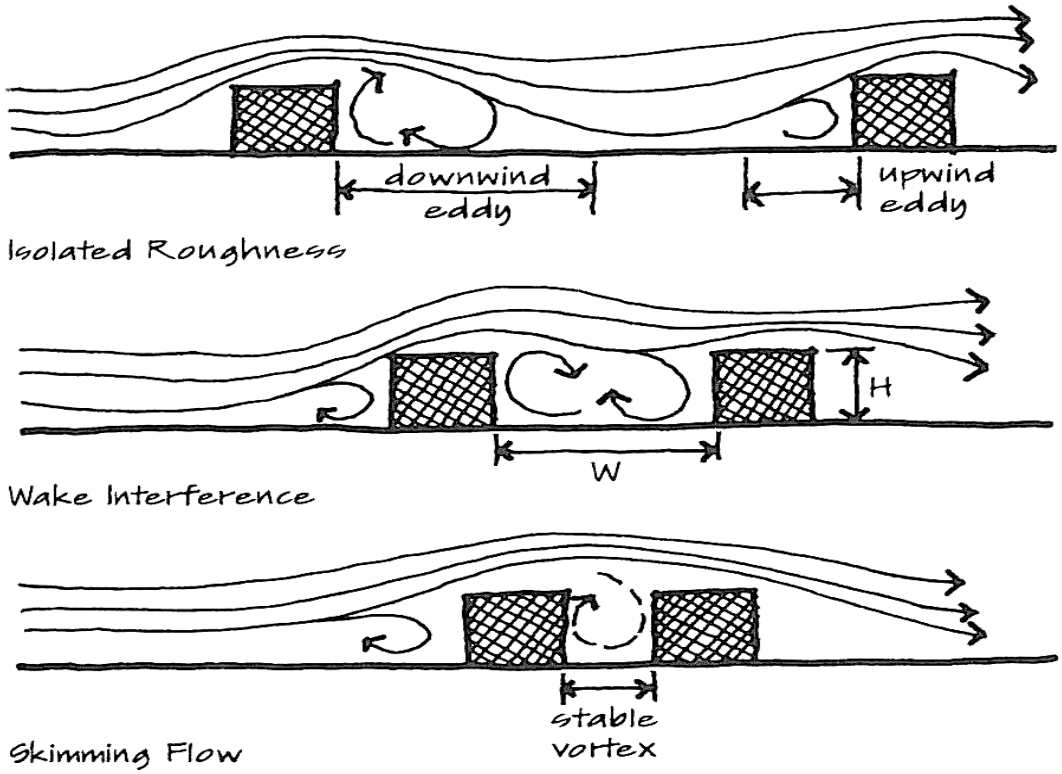
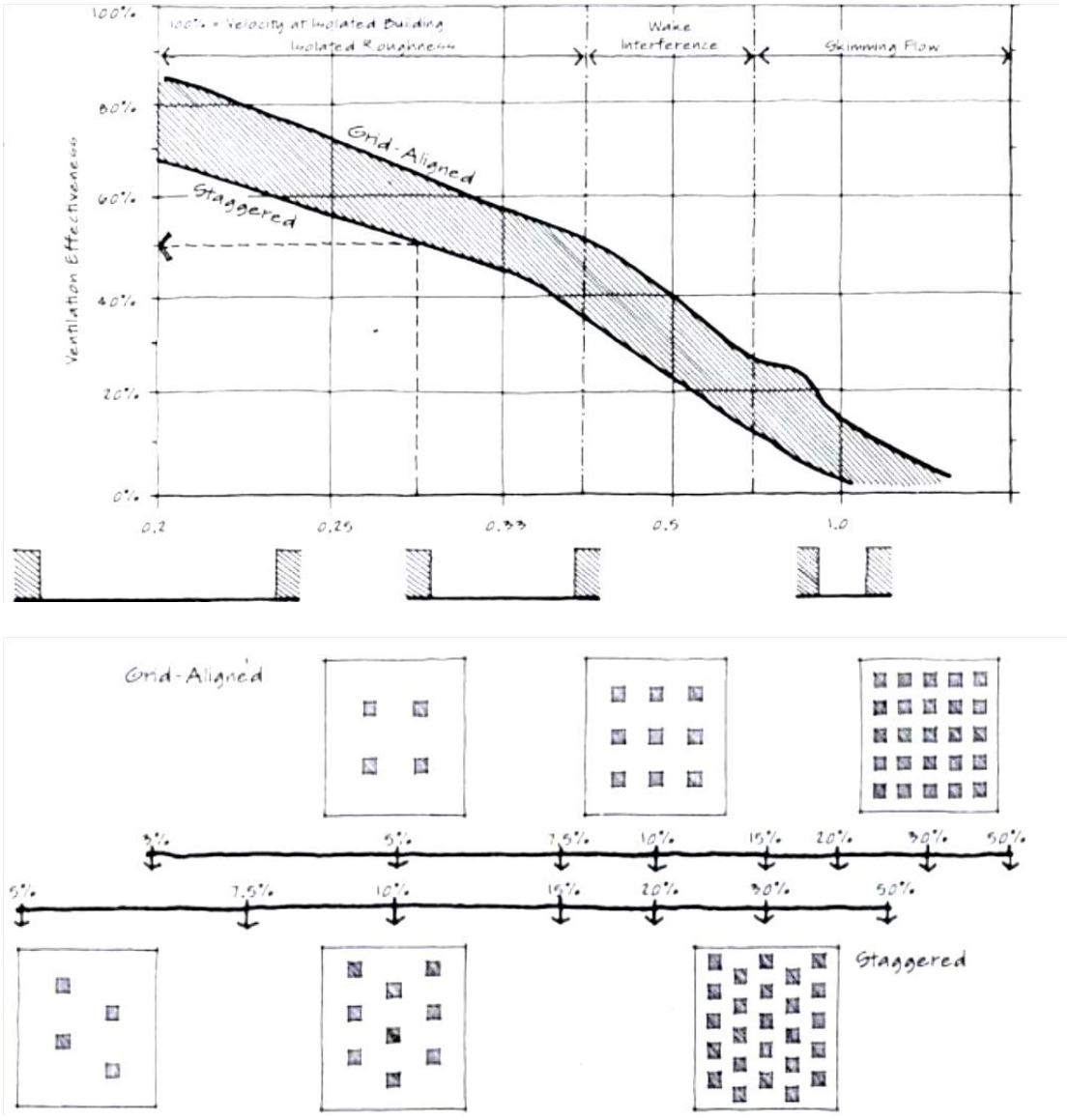


Figure 4.7: Soft, moderate and rough air flow between buildings according to the distances between them Ratio of height to distances among buildings
Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 117



Graph 4.2 up, effect of ventilation as the result of compactness of buildings; down, effect of ventilation in regions with different compactness

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 117

Solution Number 5: Arrangement of buildings in combination with plants for reducing temperature of surrounding environment

In compact building regions, temperature is higher than surrounding rural regions. This temperature difference is the result of heat introduced by fuel consumption, absorption and reserve of solar heat, weaker radiation of heat to the sky and less nightly cooling and reduction of wind velocity as the result of surfaces friction.

Temperature of surfaces covered with trees is 6-8 degree lower than building masses and this is the result of combination of factors such as evaporation, perspiration, reflection, shading, and reserving coolness. With parks situated in compact urban regions, warm air above thermal islands is replaced with cool air above green surfaces. Savannah, Georgia plan (Figure 4.8) is designed based on a repetitive model of neighboring units which are concentrated around small parks. Each unit consists of 8 residential blocks facing east-west streets. Four blocks at the centre are intended for public places. Open areas in the form of shading parks are distributed on some particular basis in a network shape.

Another similar plan is constructed by Migual Romero Sotelo for Villa El Salvador building in Peru (Figure 4.8). This region is constructed of a repetitive model consisting of 16 building blocks around a public green space. Lokorbuzie in Shandigar is designed as a residential complex in India which has a complex climate with cold winters and cool summers which is similar to hot and humid climate with seasonal winds. As is shown in bottom of Figure 4-8, orientation of main streets toward the dominant wind creates a system of linear open spaces which is crossed at the centre of each big block.

A study on Lafontaine Park in Montreal indicates that plants in blocks near large open spaces have more cooling effects; however these effects are stable in 200 - 400 meters around buildings. In these parts cool air carried by south-west winds flows to the surrounding surfaces.

So those small open spaces which are distributed fairly have more cooling effects than large parks. Passages should be designed in such a manner to guide cool air from parks to buildings. According to studies conducted, based on assumptions, in cities with 1000000population, city temperature decreases just when evaporative

surface area such as plants occupies 10-20% of the total surface area of the city. In case that this surface area occupies 20-25% of the total surface area of the city, the minimum temperature reduces 3.3-3.9 C and maximum temperature reduces about 5-5.6 C.

The diagram representative of cooling amount shows that according to plant cover, temperature reduces by reduction of green surfaces. The curve shows that where 30% of the ground is covered with plant, 66% of cooling is produced through evaporation and perspiration. In general, cooling with the use of plants is dependent on complex effect of shadow and evaporation. Trees reduce temperature and increase humidity.

Cooling effect of plants in hot and cool climate is mostly through evaporation, while in hot and humid climate shading effect is more important. Shading effects of trees reduce cooling energy about by 15-35%. In all kinds of climates, the complex effects of shading and evaporation by trees is helpful in saving cooling energy. With 25% increase in plant cover, we will have 17-57% saving of cooling energy. More use of water for irrigating green spaces is a significant issue in some cities. However if trees consume less water than grass and produce more cooling, it would be better to replace grass with trees. (Brown.G.Z and Dekay. M, 2000)

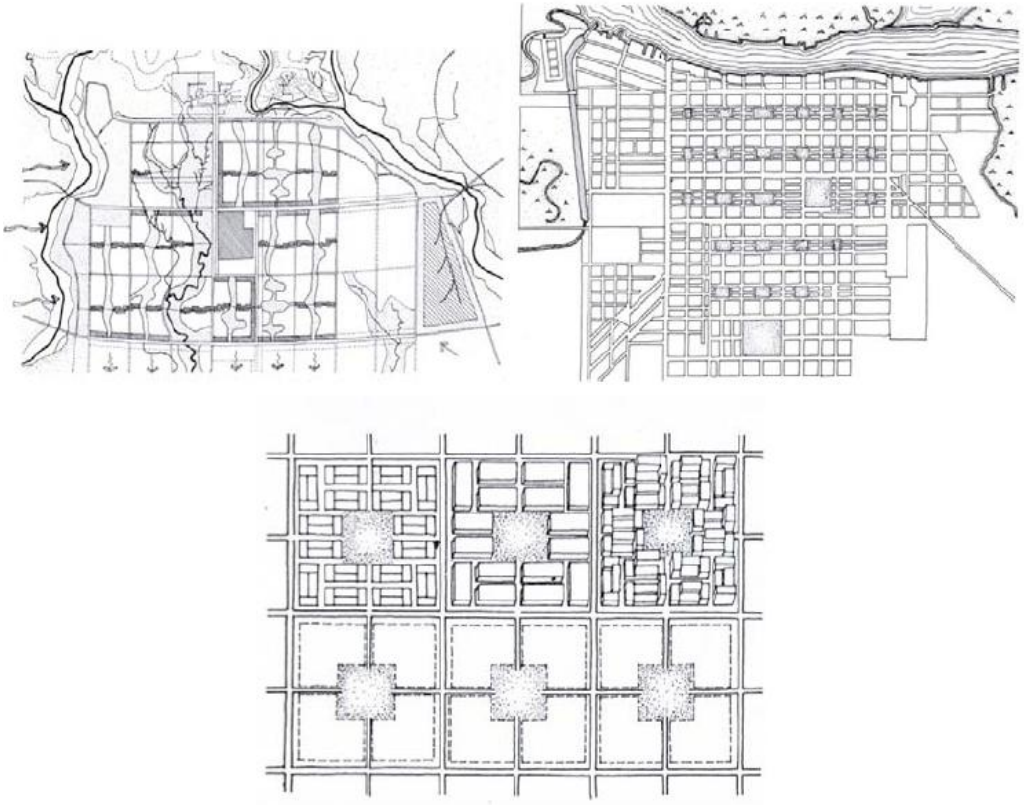


Figure 4.8: Combination of buildings with green space

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 121-122

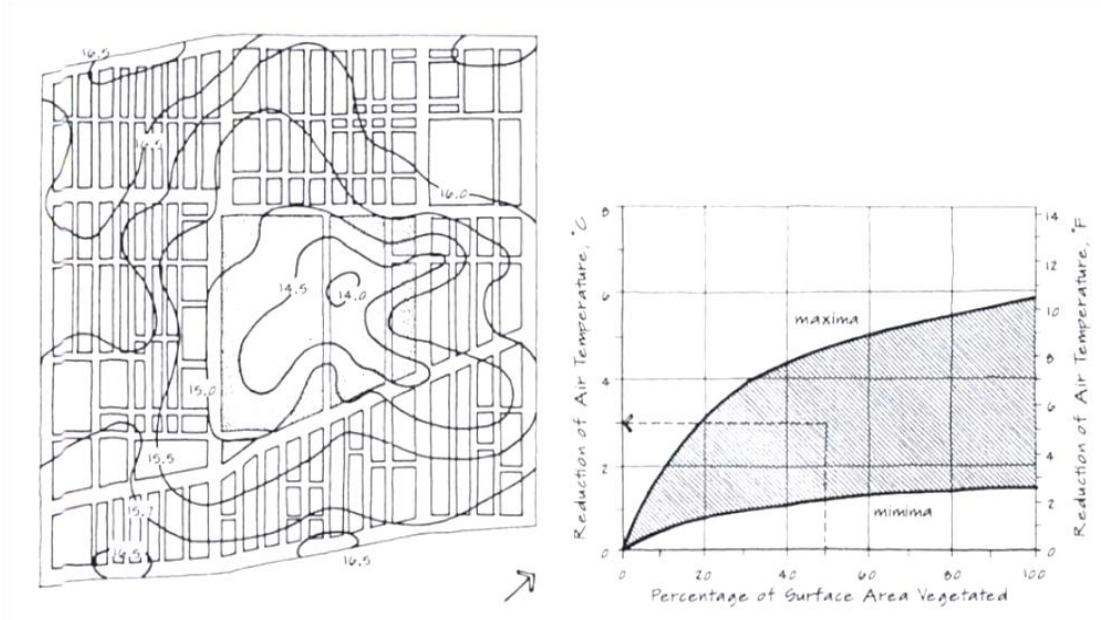


Figure 4.9: Cooling produced by plant cover

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 123

Solution Number 6: Arranging buildings in combination with water for reducing temperature of surrounding environment

In hot and dry climates evaporation can be helpful in reducing temperature. Speed of evaporation in an open surrounded space like the central courtyard is dependent on surface area of water, air relative humidity and water temperature. Some villages in Iran such as Yahya abad and Kosarriz (Figure 4.10) are situated on sides of a water flow brought to the surface by qanats and underground horizontal channels. These water flows appear inside or outside of buildings and in central courtyards on the ground or in depth. Gardens which in addition to providing products help reducing temperature through shading are protected with walls against sandstorms. These gardens include trees, grapes, bushes, and fountains. Central courtyards in houses are situated at the same level with water surface and sometimes 6 meters lower than this surface.

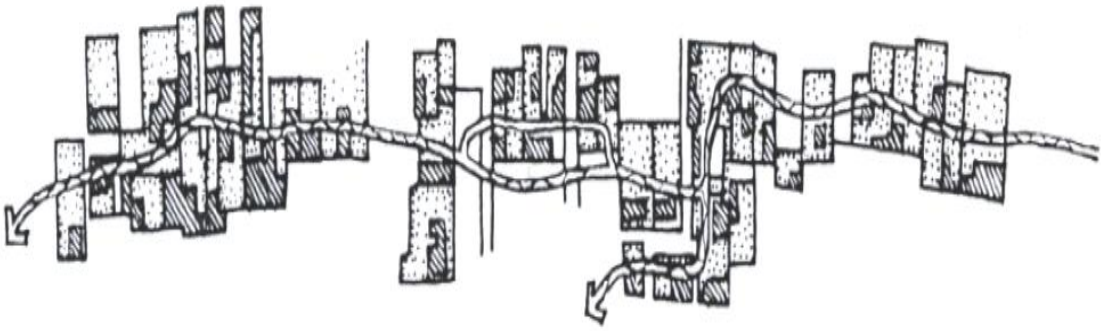


Figure 4.10: City orientation along qanat direction

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 124

When water is brought to spaces surrounded by open pergolas, it is enabled to make surfaces exposed to air cool through radiation. As radiative cooling is dependent on surface area and angle of heat reserving surface, if water flows down a straight or slope surface, effects of radiative cooling are greater for residents. A shaded fountain

is cooler than fountain with no shade. The average temperature of a shaded fountain is near to the average temperature of?. As radiation from water surface is little, most radiation hitting its surface is distributed around. So horizontal surfaces which are exposed to sun radiation and contain water should be in light color.

For evaporation to be effective, cooled space should be separated from surrounding air in order to prevent air confusion. As heat exchange between air and a light layer of water exposed to air is trivial, evaporation area surface of water should be increased by distribution or fountain with small drops. (Brown.G.Z and Dekay. M, 2000)

Solution Number 7: Making Crosswalks witch protected with some vaults in open spaces to protect them from sun radiation(Iran)

In hot climates it is essential for group buildings to be connected with crosswalks. Heat absorption by the materials used in making floors and frontage of buildings, wide angle of sun radiation and severe sun radiation, all contribute providing these conditions. In many hot and dry climates and humid climates, group buildings may be connected with crosswalks and crosswalks be protected with some vaults in streets and open spaces. In hot and dry regions, protection against daily heat and winds with dust is essential. So circulation spaces can be very effective. (Figure 4.11) Isfahan Bazar which is situated in hot and dry climate is a public passage and is considered central part of the city. (Brown.G.Z and Dekay. M, 2000)

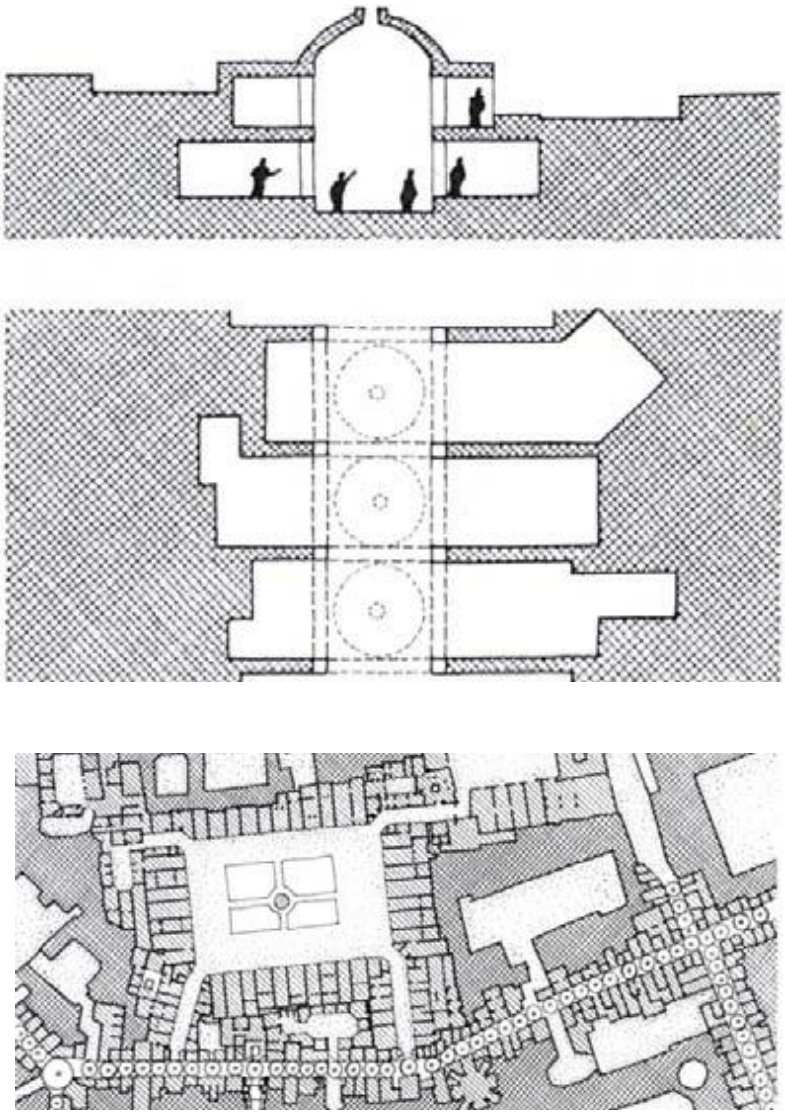


Figure 4.11: Typical Plan and Section of Bazzar

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 133

With a harmonic arrangement and repetition of vaults made up of building materials covered with red coat along linear routes, a desirable shaded microclimate is created. Passages and shops situated in downstairs receive light through small round windows above each vault. Major routes are connected to each other through covered sideways and connect in the form of a network all mosques, public places, water reservoirs, resting places and public baths all over the city. Roofing passages with vaults with aperture provide needed brightness in addition to shading and cooling. They should be designed in proper form and size in order to protect the space below when it needs

shade. When cross angle is bigger than side view angle, lights can be various regarding two angles shown in Figure 4.12 and orientation. Side view angle is the regular angle of the awning which can create a full shadow. When full shadow is not desirable, cross angle would be smaller than side view angle.

As a general rule, for creating a full shadow with fixed roof lights, cross angle in designing the light should be larger than 90 degree as is shown in picture below. Those lights directed to the south and stretched east-west provides shadow all day long except for near the equator when the sun travels its path in north. This indicates that roof lights oriented along east-west are the most effective lights.

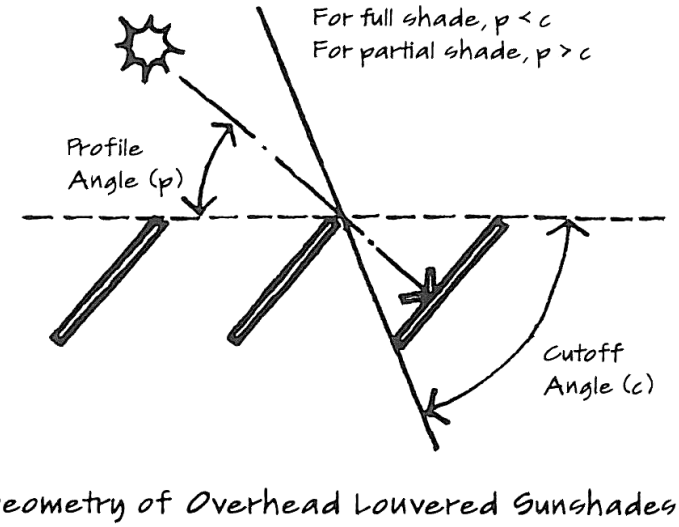


Figure 4.12: Cross angle and side view angle in roof lights

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 134

4.1.1.2 Heating and cooling solutions:

Solution Number 1: Establishment of group buildings in a proper slope for creating a desirable microclimate

In urban spaces and in buildings which are controlled through shell, some elements such as topography, sun radiation and wind in combination with each other from local microclimate which influences macroclimate of the region. Group buildings

being situated in positive slopes (facing south), increase thermal comfort in cold and hot seasons and decrease energy consumption. Compact buildings which are situated in slopes facing south, while providing possibility of benefiting of good winter radiation, shade each other in east and west directions. In summer nights, density difference creates a cool air flow among buildings and back of the walls (Lechner, Norbert, 2001). Mardin in south east of Turkey which is situated in hot and dry climate with moderate winters but cold is situated on a steep slope of 20-25 degree. (Figure 4.13)

Compact group buildings which are surrounded in east and west direction, shade each other while benefiting of good winter radiation in south direction. In summer nights, density difference creates a downward flow of cold air which in low levels is imprisoned among buildings and rare walls. Such cold pools are usually used for sleeping in outdoor.

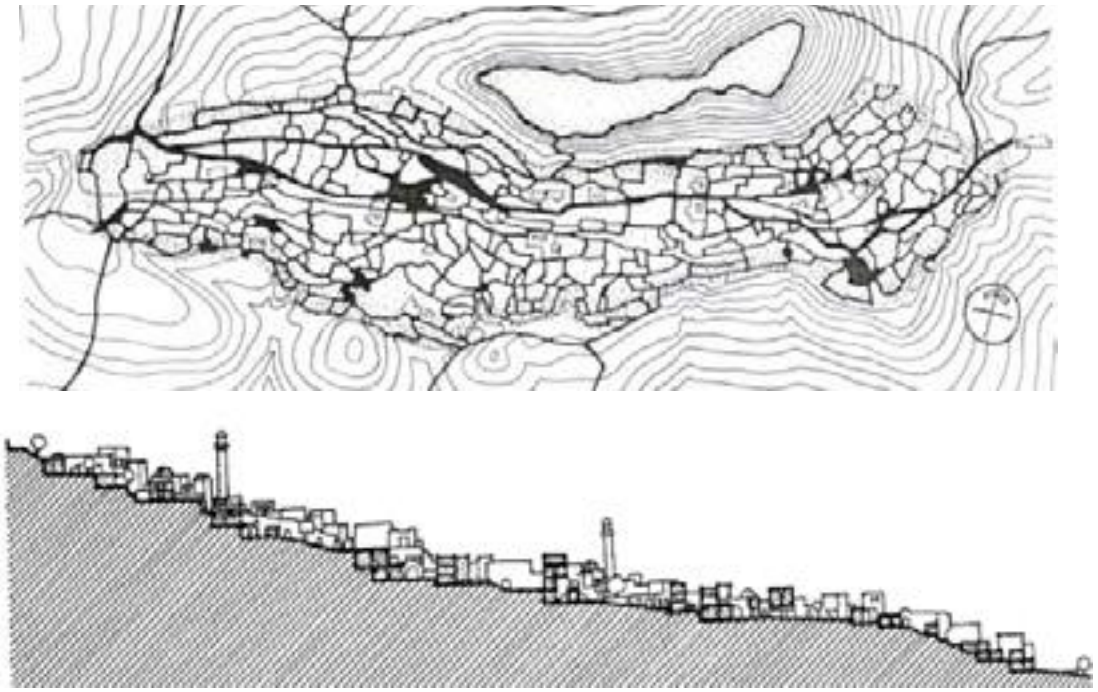


Figure 4.13: Formation of Mardin urban context in Turkey in a slope facing south
Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 86

In order to create proper microclimates in location and enjoying the existing potentials, multiple principles and rules should be regarded. These principles are:

1. Cold air flow due to density and weight is driven downward: cold air flow is denser and in consequent is heavier than hot air. So it is driven downward. Because at nights a layer of cold air takes shape near the ground and rests in low levels. High and convex surfaces make cold air flow while low and concave surfaces collect it.

2. Temperature changes due to the change of height: cooling velocity near the ground is 0.8 c in 100 m height. Higher levels are colder than lower levels. And the air flow which flows down the slope is cooler than the low air which is replaced by it.

3. Sun radiation changes in proportion with the ground relief: ground relief means slope and orientation of a surface in combination with each other in relation to the sun. A surface perpendicular to solar radiation receives the most radiation regarding the unit of the surface area. So slopes facing the south, (north in southern hemisphere), receives most radiation. Slopes facing east enjoy the most morning sunshine and slopes facing west enjoy most afternoon sunshine. However for east and west orientations, slope has little influence on the total daily radiation. Steep slopes – except for slopes facing north (south in southern hemisphere), which receive the least radiation- receive generally more sunshine than flat levels.

4. Large water edges moderate the range of daily and yearly temperature: those locations situated near oceans and large lakes have less fluctuation of temperature in day and night and in winter and summer than internal locations. Maximum temperature of a summer day near water is lower. This non linear effect creates a great difference in microclimate in short distances especially distances less than 20 km from the sea.

5. High mountains create wet slopes windward, while low hills create wet leeward: in high mountain regions where it is colder than low levels, flowing wind drive wet masses quickly upward, therefore the air reaches dew point and this causes raining and coolness in windward slopes. In crossing the ridge, air and temperature decrease, relative humidity decreases and the driest slopes remain leeward. The case is reverse for lower heights. Where the air is transmitted by the severe wind to top of a hill, it provides the possibility of raining on leeward surfaces where air flows are mostly irregular.

The diagram of the combined effect of slope and orientation on yearly radiation (Figure 4.14) shows that ground condition has little effect on radiation in tropical latitudes. And this effect increases as the latitude increases. The amount of received radiation in a location influences the temperature of microclimate, speed of melting snow and the duration of growing seasons, winter season and the cycle of deciduous plants. In moderate latitudes, spring arrives two weeks sooner in a 20 degree south slope in comparison with a flat surface. The needed slope of the location for designing group buildings can be calculated by these diagrams in relation to the climate of the region and regarding the needed radiation for that region. Regarding in what kind of climate the studied region is located and how amount of radiation is needed for providing thermal comfort there, we can use grounds with proper slope in designing. In hot regions where cooling is more needed than heating in a year, designing group buildings on grounds with low slope is a more proper solution. (Brown.G.Z and Dekay. M, 2000)

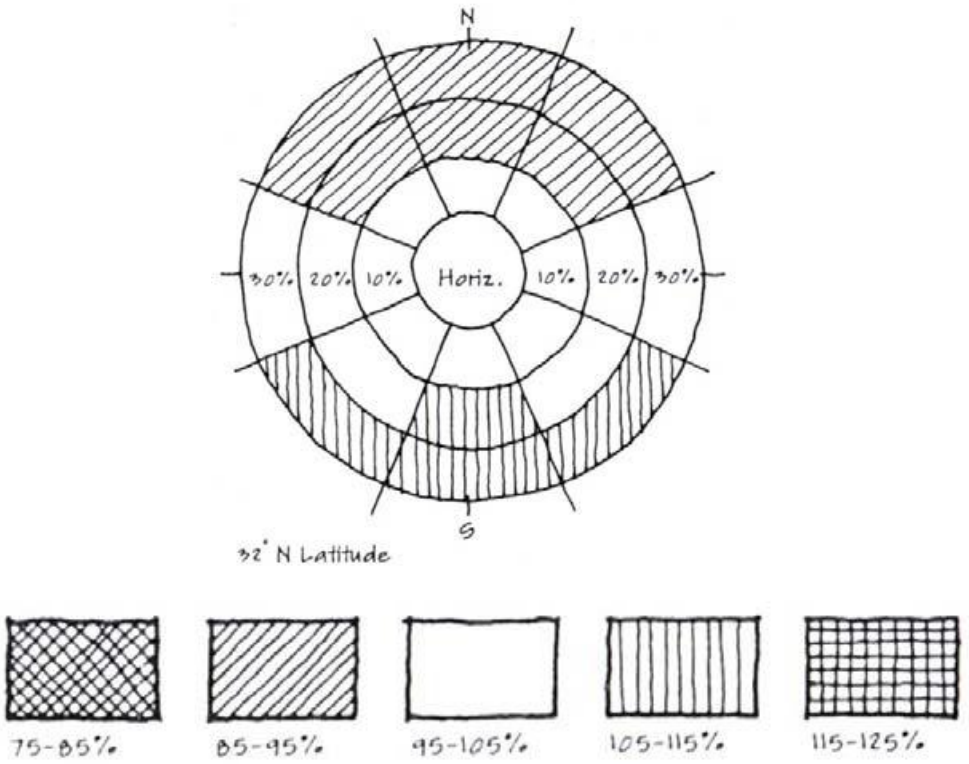


Figure 4.14: The diagram showing the combined effect of slope and orientation on yearly radiation in 32 degree latitude

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 87

Different climates with respect to their particular characteristics have different cooling and heating needs for creating local, proper microclimates and providing comfort conditions. For achieving the optimum designing of group buildings, recognizing these needs and design purposes in each climatic region is essential, because the created microclimate due to being designed in the location has great influences on cooling and heating needs of group buildings. So in different climatic regions, for creating proper microclimates in location, the most proper location for establishing group buildings is different with each other. The general purposes in designing the microclimate of the location in any climatic region and the location of the most desirable microclimate for any region using the shear diagram of the slope, regarding the climate (4-15) is:

- Cold Region: designing purposes in this region is maximizing heating effects of sun radiation and decreasing the effects of winter winds. And in this region in order to increase sun radiation, the low part of the slope facing south (north in southern hemisphere) is a proper site for construction of group buildings. In cold region also for protecting against wind, group buildings should be low enough; and for preventing the collection of cool air at the bottom of the valley, it should be high enough.

- Moderate Region: design purposes in this climatic region are maximizing the heating sun effects in winter, maximizing shading in summer, decreasing effects of winter winds and simultaneously providing the possibility of air flow in summer. The middle part up to top of the slope is the most appropriate site of microclimate in moderate regions for achieving two elements of sun and wind and at the same time protecting against heavy winds.

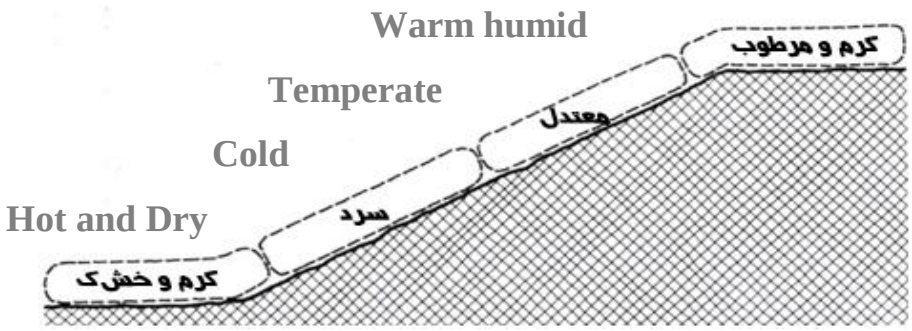


Figure 4.15: shear diagram showing the slope for any climatic region

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 87

- Hot and Dry Region: Maximizing shading and minimizing heat and dusty winds are among the intended purposes in designing touristic resorts in these regions. And the region in the bottom of the slope, due to being exposed to cold nightly air flow, is a proper location for construction of group buildings and the most desirable climate in

hot and dry region. Group buildings in hot and dry regions should be oriented to the east in order to be less exposed to sun radiation.

- Hot and Humid Region: Designing purpose in this region is maximizing shading and wind in group buildings. Top of the slope due to being exposed to cool winds, is the most desirable site for microclimate in hot and humid region. Moreover those buildings situated in this region should be oriented to the east in order to be less exposed to the sun. (Brown.G.Z and Dekay. M, 2000)

Solution Number 2: **Orientation of passages and blocks proportional to light, heat, and shading regarding climatic needs of the region**

Passages orientation has a significant effect on the microclimate surrounding the buildings and accessibility to sun radiation and wind. Wide east-west streets provide better accessibility to sun radiation, while wider streets in the same direction with the dominant winds, increase air flow inside the city.

In high latitudes in northern hemisphere, sun is usually dominant to the south, (dominant to the north in southern hemisphere), while in the middle latitudes, more flexibility is allowed in orientation for solar heating without a significant decrease in achieved radiation. Passages of a north-south roof are appropriate for buildings to shade each other. Proportionate to climate, light and thermal charge of the building, various combinations of solutions may be appropriate (Givoni, B, 1988).

Below Figure (4.16) which shows shading of four- store buildings (18 meters high) on the right side of the streets offer general solutions for different climates. These diagrams illustrate the effect of different orientations of passages on shading models at the time of summer revolution in different latitudes. In designing passages and

building blocks in all climatic regions, paying attention to following points is necessary:

- Cardinal orientation provides cardinal passages with accessibility to more sunshine, while diagonal orientations decrease winter sunshine achievement and increase summer sunshine achievement especially in eastern and western frontages. However for buildings which do not need winter radiation for heating, diagonal arrangement provides fairer distribution of sunshine for most frontages.

Diagonal orientations in comparison with cardinal orientation provide more shadow on street floors most of the day provide shadow at least for one side of the street for most of the day. It should be reminded that in noon, when the sun is in its peak, buildings have small shadows and streets orientation has little effect and in these cases frontages facing the south should be shaded by horizontal canopies and streets, open spaces and external rooms should be shaded by being covered with porches.

Designing building plaques with a spin of 22.5 degree to the north-south axis increases shading the streets and simultaneously is compatible with principles of sun orientation and may be appropriate for moderate climate. By decreasing the spin angle from the main axis, the shadows reaching confronting buildings decrease and therefore buildings should shade each other more. (Brown.G.Z and Dekay. M, 2000)

BUILDING TYPE		RESPONSE		
Internal Loaded Building	skin Loaded Building	1st prioroty	2nd prioroty	COMMENTS
	Cold	Lee	Sun	. Strict cardinal orientation for sun. . Discontinous streets in direction of winter wind. . Space E/W street for solar access for spring and fall .
Cold	Cool	Sun	Lee	. Cardinal orientation for sun . . Discontinous streets in direction of winter wind. . Space E/W street for solar access at solstice.
Cool	Temprate	Winter Sun; Summer Wind	Winter Lee; Summer Shade	. Orient +/- 30 degree from cardinal for sun . . Adjust orientation 20-30 oblique to summer wind . Space E/W street for sola access, if needed Elongate blocks E/W.
Temprate	Hot-Arid	Summer Shade	Winter Sun SummerWind	. Narrow N/S street for shade. . Rotate from cardinal to increase street shading . Space E/W street for solar access if needed Elongate blocks E/W
Temprate Humid	Hot-Humid	Summer Wind	Summer Shade ; Winter Sun	. Orient street 20-30 oblique to summer wind. . Modify orientation by rotating from cardinal to increase street shading. . Space E/W street for solar access if needed Elongate blocks E/W. .Wide street for wind flow
Hot-Arid& Tropical-Arid	Tropical	Shade all seasons	Night Wind Day Lee	. Narrow N/S streets for shade. . Elongate block N/S, If E/Wfacades shaded. . Wider auto street run E/W
Hot-Humid &Tropical	Tropical Humid	Wind all Season	Shade	. Orient streets 20-30 oblique to predominant wind . Respond to secondary wind direction. . Maximize street right-of-ways for wind flow, but not paving

Chart 4.2: Orientation and design of passages and stretching of residential units with emphasis on climate

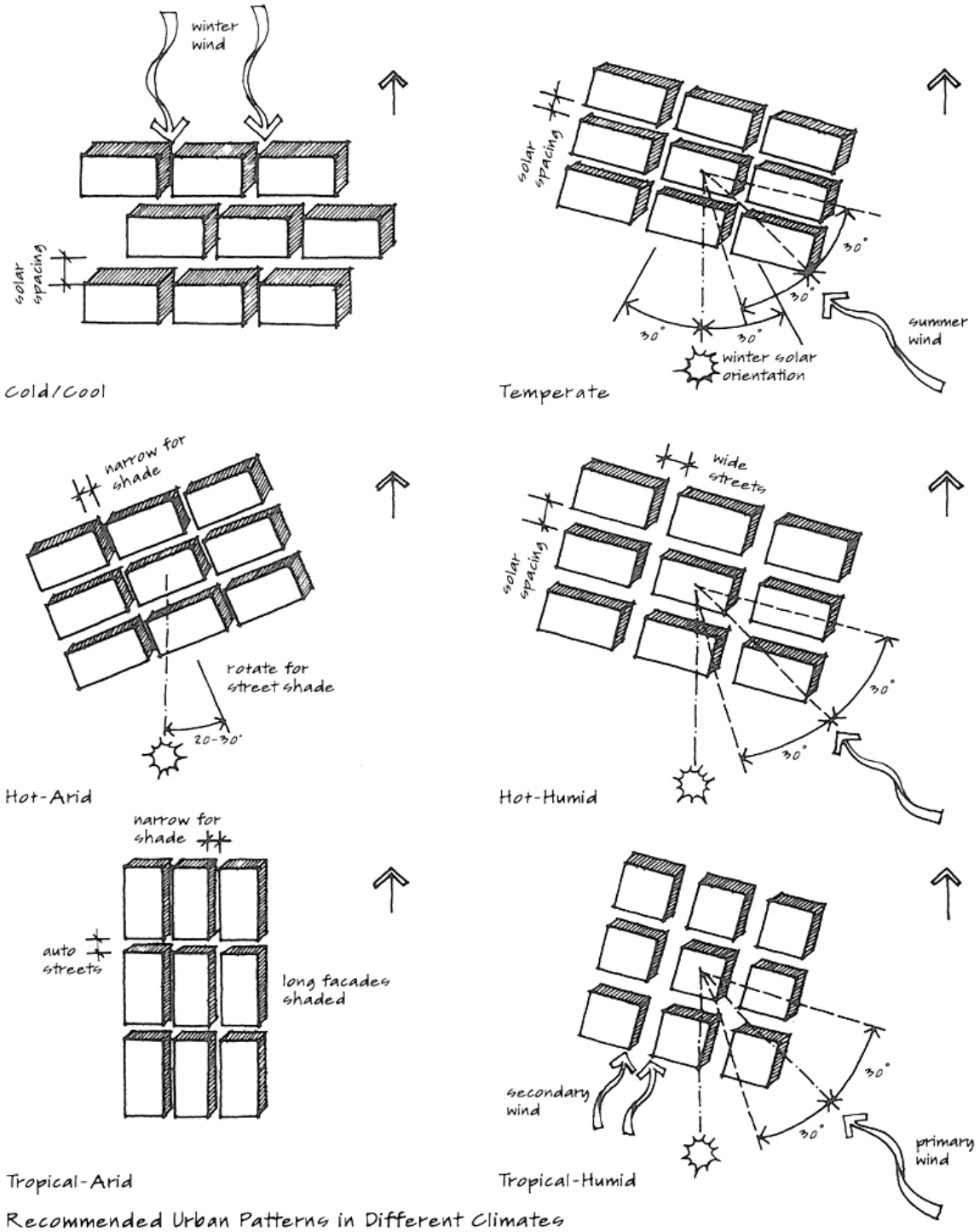


Figure 4.16: Orientation of passages and building blocks and their stretching in different climatic regions

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 102

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Solution Number 3: Using natural or artificial windbreaks for protecting buildings and open spaces against undesirable winds

Windbreaks can be used for protecting buildings and outdoor spaces against hot and cold winds. In cold climates, windbreaks can decrease heat waste in buildings through decreasing air flow above the buildings and decreasing convection and air penetration. A high windbreak in comparison with the use of four trees around the building will decrease air penetration by 30%. This decreases energy cost by 15%. According to the studies, use of retaining wall against wind flow, can decrease wind flow by 15% of velocity of dominant wind in urban complexes. If we prevent wind entry into outdoor spaces which have accessibly to the sun, people can feel comfortable dependent on their clothes and activities in very low temperature – 4 or lower.

When wind does not flow vertically, the surface area of protected place decreases. As the velocity of wind penetration to the building is proportional to wind pressure, designing windbreaks for maximizing decrease in wind velocity is more important than decrease of distance covered by the windbreak. When disturbing wind flows from a dominant direction, windbreaks in the form of L similar to those in garden houses of Japan can be exploited. But when disturbing wind has an unstable direction, a more covered shelter may be needed. In Pantelleria in Italy, for protecting lemon trees against disturbing unstable winds, a high wall is constructed all around them. (Figure 4.17)

Decrease in wind intensity behind windbreaks made up of trees, is dependent on height, density, shape of cross section, width and length. Among these factors, height and density are the most important. The diagram showing decrease in wind velocity

by the use of trees shows that decrease in air velocity in a surface area 5 times bigger than the height of the leeward obstacle is 62-78%, with the use of a windbreak with average density and in a surface measuring 9-10 times bigger than the height of obstacle is 2-21%, and in a surface 10-15 times bigger than height of obstacle is 13-23%. Decrease in air velocity using obstacle is dependent on their porosity and height. The maximum decrease occurs in a surface which is 2-7 times bigger than the height of the obstacle, in leeward part of the obstacle, when wind flow is perpendicular to the obstacle.

Graph 4.3 which shows average velocity of wind in belts with various perm abilities indicates that while very dense windbreaks are more effective in decreasing velocity in short distances behind the obstacle, Their effect is less than more porous windbreaks in far leeward distances. In hot and dry regions in addition to thermal comfort, windbreaks protect against dust and sand. As these particles are light, they are easily moved with air flow around the building.

Central courtyards which are at most two times stretched than the height of buildings are properly protected against dust. Windward walls should be at the same height with the building and their distance from the building should be less than 6 meters. Sands due to being heavier can be prevented by shorter walls of 1.7 meters. Figure 4.18 illustrates reconstruction of Byker in Newcastle upon Tyne in England which is established on a slope facing south west by Ralph Erskine with a perspective facing the center of Newcastle. Erskine surrounds northern part with a narrow, continuous building and creates a retaining wall in order to prevent northern winds from sea and noise from road and railways to the center of city.

(Brown.G.Z and Dekay. M, 2000)

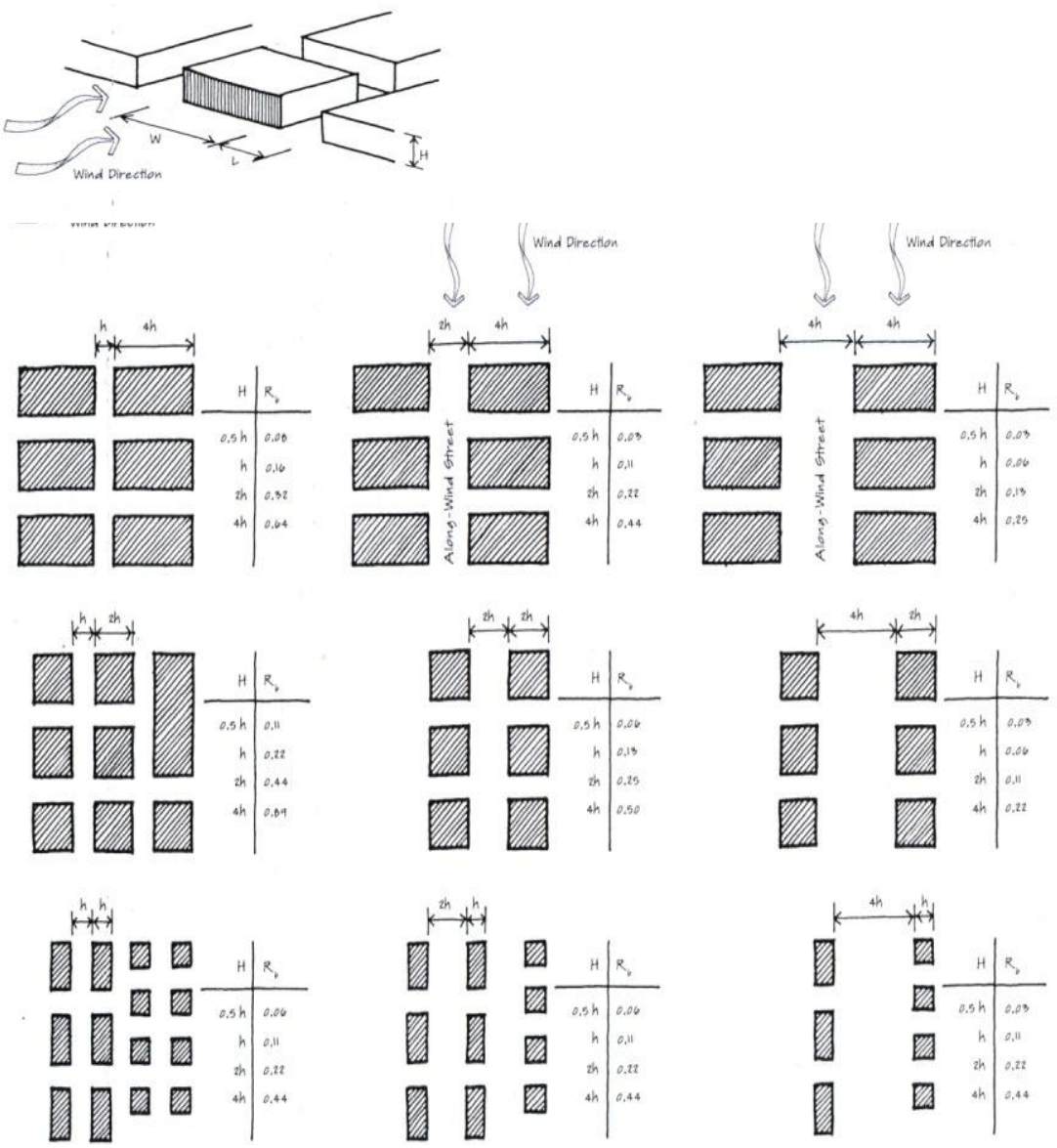


Figure 4.17: Blockage ratio in group buildings according to their organization

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 108

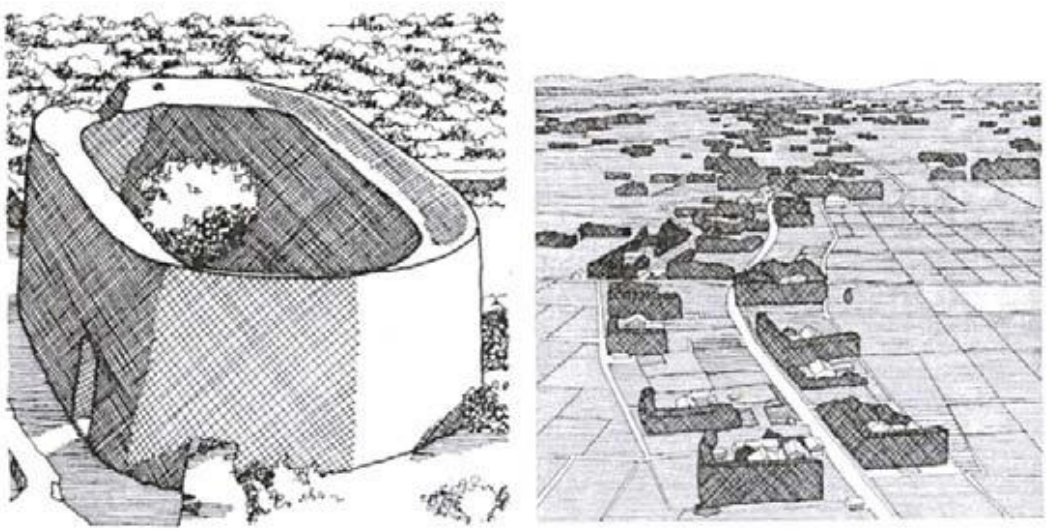
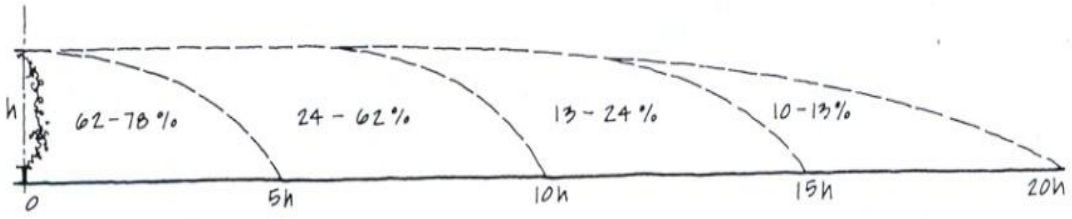


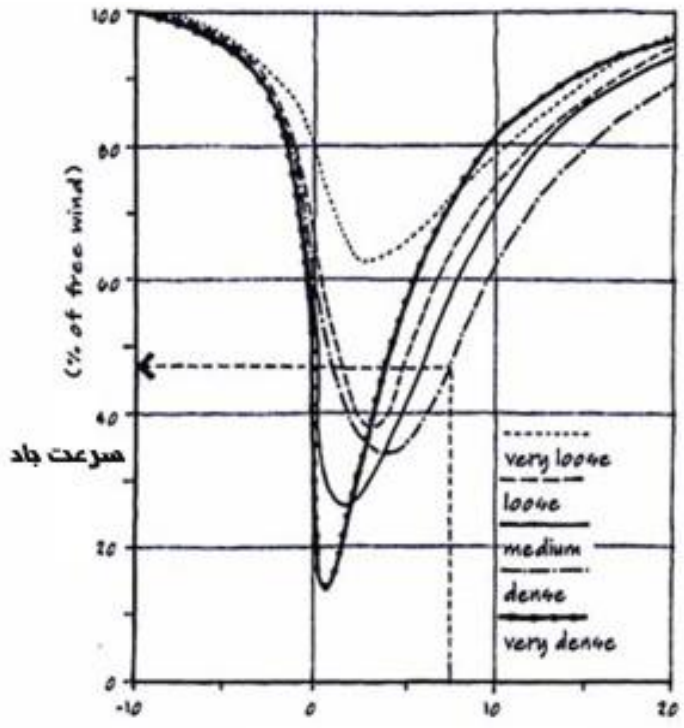
Figure 4.18: Right, L form windbreaks in Japan; Left, protecting trees in Italy

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 130



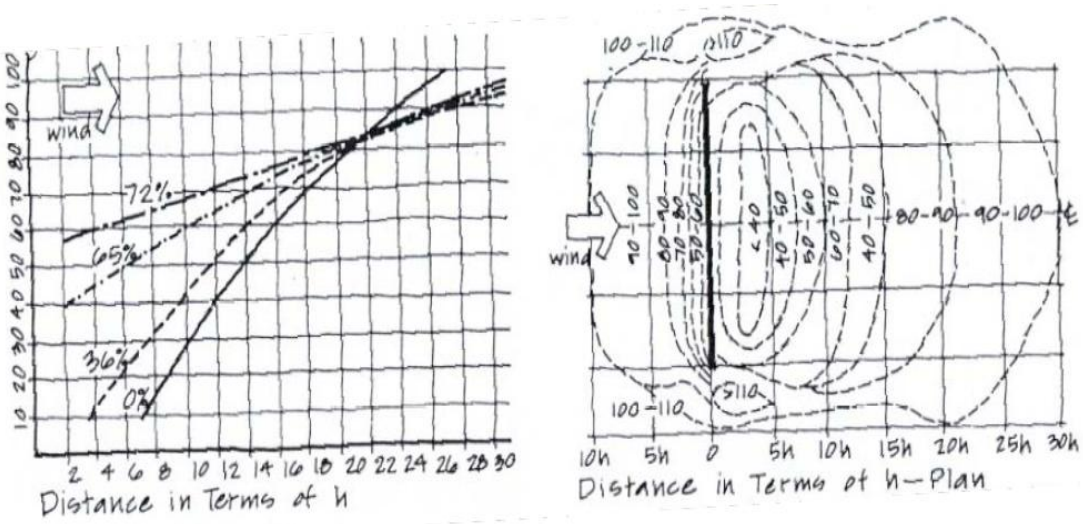
Graph 4.3: Decrease in wind velocity behind obstacles made up of trees in various distances

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 108



Graph 4.4: Average velocity of wind behind windbreaks according to amount of porosity and permeability

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 109



Graph 4.5: Right: Distribution of wind around the windbreak in various distances, Left: Decrease of wind velocity using obstacles

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 109

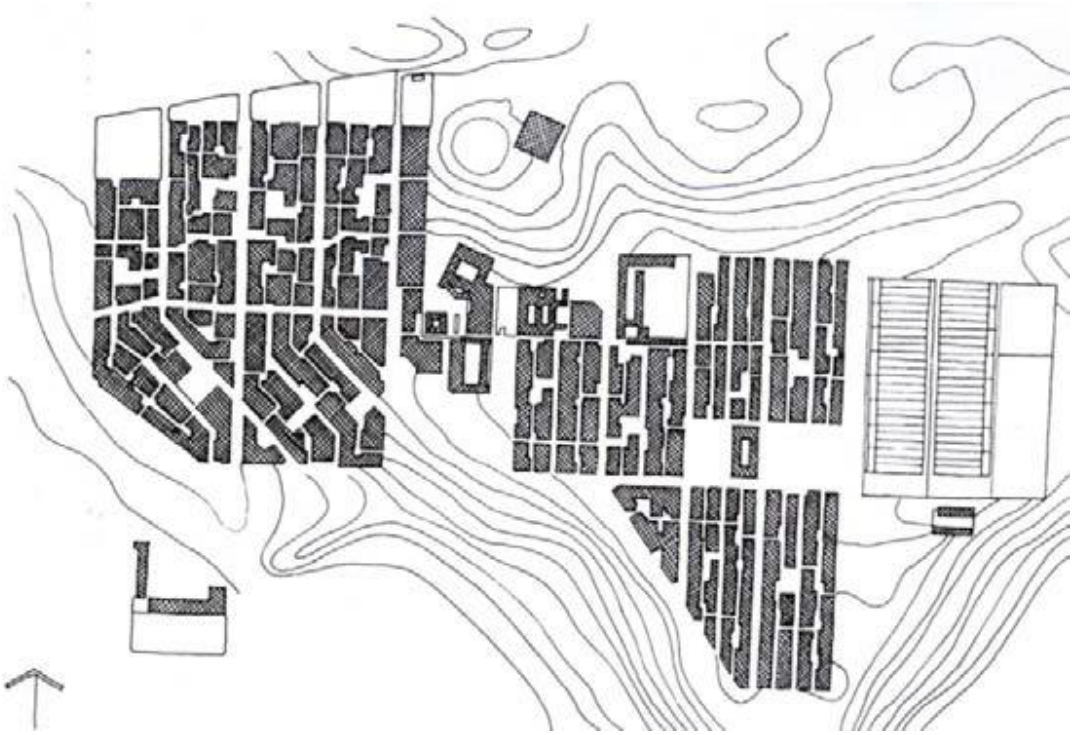


Figure 4.19: Reconstruction of urban texture of Byker in Newcastle in England

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 84

4.1.2 Building

In this section cooling and cooling-heating solutions applied in designing are studied in building.

4.1.2.1 Cooling Solutions

Solution Number 1: Designing the plan and a diffuse and permeable cut, for passing ventilation, chimney ventilation or both

Ventilation is one of important means of cooing in hot periods. The reason is that ventilation not only moves heat, but also increases comfort by increasing evaporation from the skin. However in hot climates and in temperate climates at night, air convection is totally slow; and at this time chimney ventilation is an efficient and important solution. It is possible that for different rooms of a single building, a combination of these solutions be used. For example, while passing ventilation is

used through operable windows in windward part of the building and in the rooms of upstairs, chimney ventilation is used in leeward part and the rooms in lower parts with little accessibility to wind. (Brown.G.Z and Dekay. M, 2000)

Both ventilations (passing ventilation and chimney ventilation) work better in particular situations. Theses ventilations can be easily used with different kinds of organization of rooms. When a special design is formed with the purpose of developing both ventilations, both the plan and building section should be open to wind flow. The best case for developing passing ventilation in the building is when the building is as deep as a room and is stretched in parallel with the dominant wind. This is possible for all buildings, except small buildings with limited sites. Chimney ventilation is dependent on height difference between opening entries of air and exits. Therefore in rooms and high chimneys, this difference is the maximum. The combined effects of chimney ventilation and passing ventilation are dependent on total driving measures of both air flows. If air pressure changes with the square of velocity then the effect of combined cooling would be non-linear. (Givon,B, 1988)

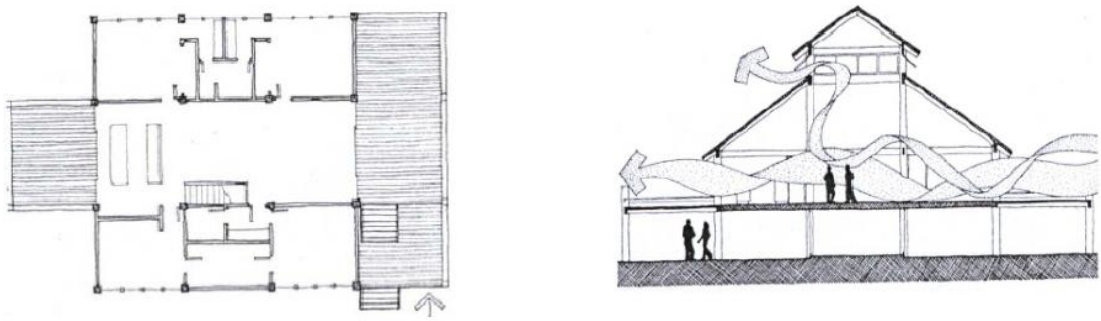


Figure 4.20: Logan House Plan and Section, Tampa, Florida,

Rowe House Associate

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 146

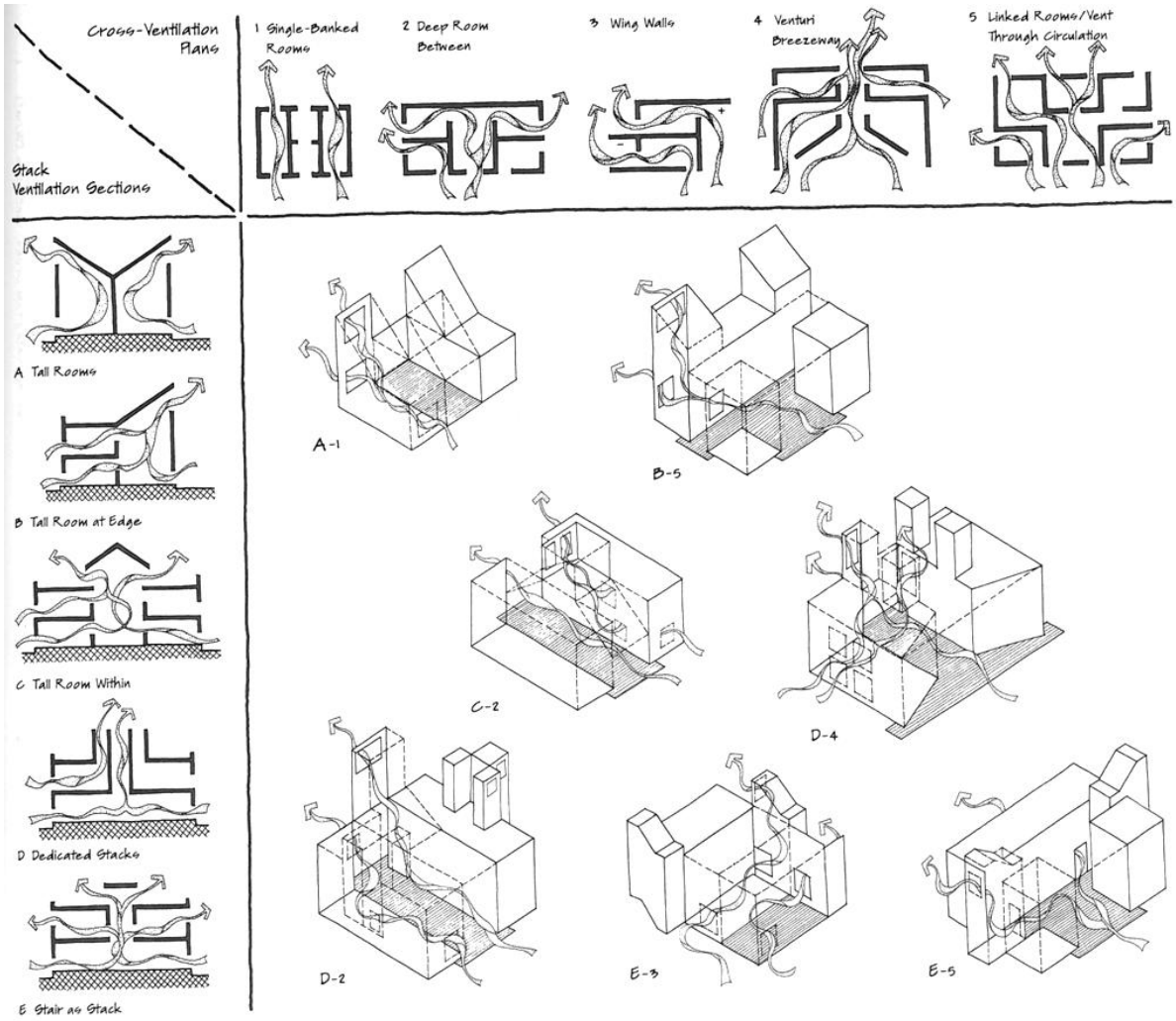


Figure 4.21: Organizing rooms for developing passing ventilation, chimney ventilation or both

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 147

Figure 4-21 illustrates the manner of using passing ventilation and chimney ventilation and their combination in the building. Horizontal axis presents some solutions for organizing the rooms for developing passing ventilation, and the vertical axis presents the solutions for developing chimney ventilation. In the main body of the construction, combined solutions for developing both ventilations are presented. In Logon house in Florida which is designed by Rowe Holmes group, (Figure 4.21), rooms are categorized for using a central chimney, but three central

spaces are open to each other and to outside space and some entries for arriving air into the building are established. (Brown.G.Z and Dekay. M, 2000)

Solution Number 2: Developing the maximum distance between the operable windows of downstairs and those of upstairs in order to increase chimney ventilation

When there is air flow and outdoor temperature is lower than indoor temperature, it is possible to use passing ventilation for providing cooling. But it is possible that sometimes for example at night, there be no wind flow, or in some climates there be a very quiet air flow or urban spaces prevent accessibility to the wind. In such cases, chimney ventilation which needs no wind for circulating air in the building can create similar cooling effect. In spaces which are cooled through chimney ventilation, hot air moves upward to exit from the upper windows and the arriving cool air replaces it.

The air circulating in the room carries some heat. The amount of this heat is proportional to the height difference of the entrance window and the exit window, their sizes and temperature difference between outdoor and average temperature of indoor above the room. When using the ventilation chimneys, the effective height of the room increases. The exits on the roof for vertical ventilation of the building are in different forms. These forms vary from a tool such as roof exits to vertical ventilators which are part of the building. Conventional methods for mutual ventilation through the roof include vault ventilator, calottes on the roof and ventilators on the upper edge of the roof.

Function of any vertical ventilation can be improved by the use of fan. It is significant to pay attention to this fact that in winter, any kind of vertical ventilation

has negative effect on the residents' comfort. Therefore all ventilation exits should be blocked by appropriate windows and if possible, thermal isolators should be fixed on the windows. Two general rules should be considered in designing the vertical ventilation:

A. The exits should be placed in the highest points

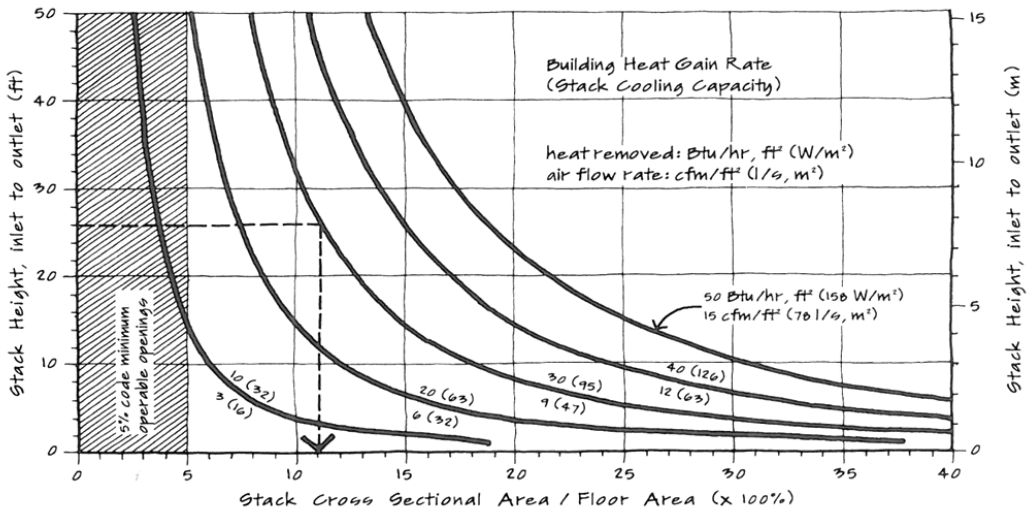
B. The exit should be in a shape that has minimum resistance to the ascending air flow.

If we have both the amount of ventilation and transported heat, then through the graph 4-6, the height of ventilation chimney and surface area of cross section of the chimney are acquired. The vertical axis represents the height of chimney (from the center of the entrance window to the centre of the exit window), and the horizontal axis represents the ratio of surface area of the cross section of the chimney to the surface area of building floor which is in need of cooling. The curves represent the amount of achieved heat. This graph is useful when temperature difference between indoor and outdoor is 1.7 C. When temperature difference is higher than this, the surface area of the cross section of the chimney can be a fraction of the acquired amount in the graph.

When surface area of entrance and exit is the same, chimney ventilation would be maximum. Designing the exit as large as the entrance is difficult in practice. Increasing the sizes of entrance is more effective than increasing the sizes of exit in increasing air flow, but the amount of increase is not proportional to the added surface area.

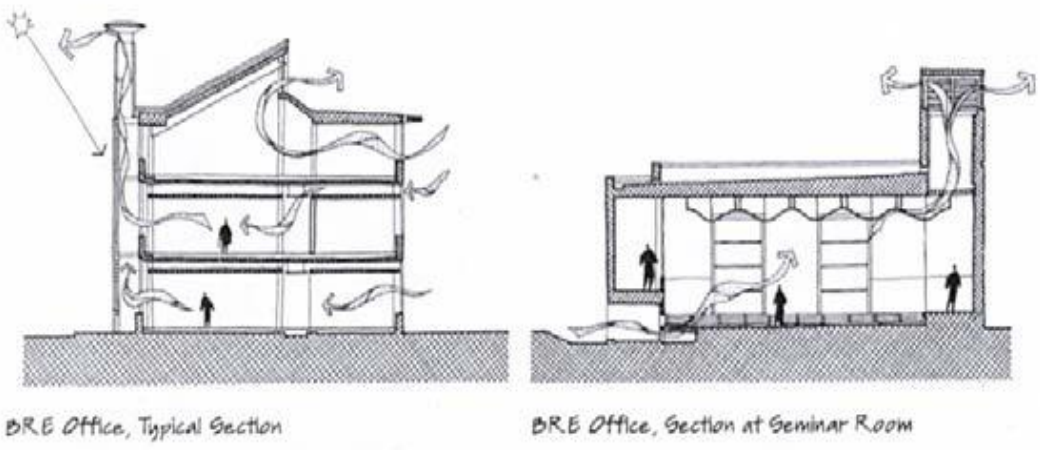
This is performed in the building of official institute of building research in Garston in Russia by Feilden Clegg. Five chimneys which guide air flow from the bottom to

upstairs are situated in south line of the building. Along the south, between the entrance and exit, there is an intermediate space. The entire south front is made up of glass to warm up the exiting air and increase temperature difference with the arriving air. When natural air flow is insufficient, the fans fixed in chimneys contribute to ventilation. Natural ventilation, in addition to providing cool and fresh air, is effective in providing light and acoustic issue by mixing external noise and daily light or preventing formation of sound insulators between rooms.



Graph 4.6: Sizing Stack-Ventilation

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 187



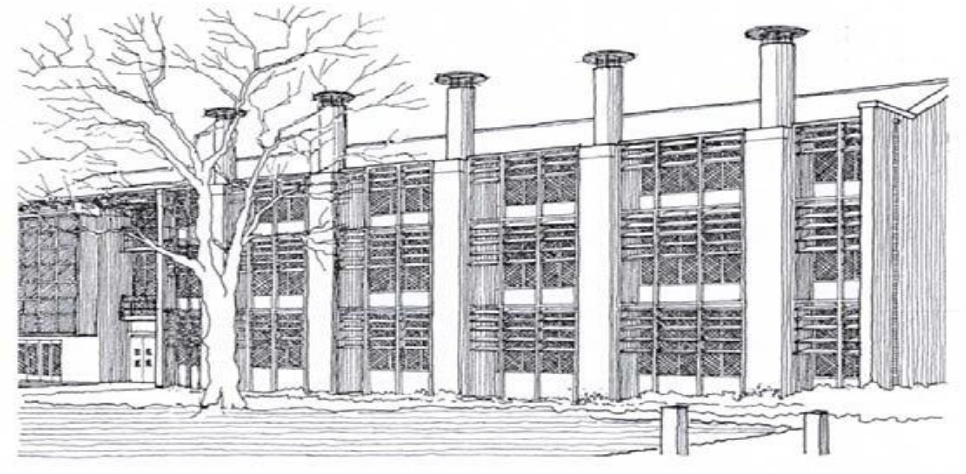


Figure 4.22: Chimney ventilation in, Garston, Russia

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 185

In Queens building in Engineering Faculty of Demon for in England which is designed by Short and Ford architects, (Figure 4.23), some especial chimneys which function as discriminating acoustic regions are used. In lecture hall which is dark and needs ventilation, entrance openings of absorbing sound in the wall are fixed under the chairs. Air flows through these openings and exits through two chimneys above the roof. (Brown.G.Z and Dekay. M, 2000)

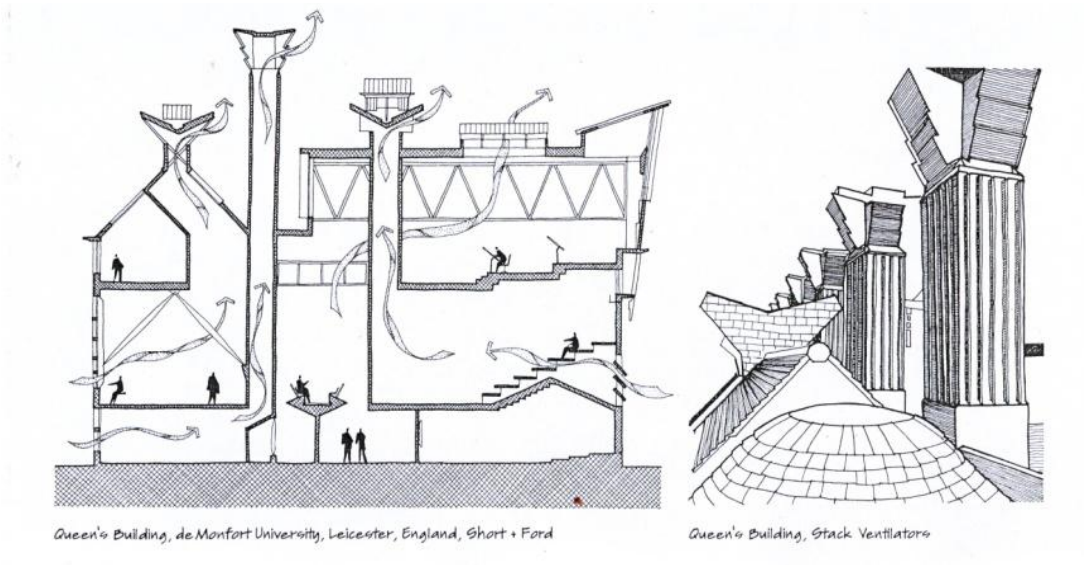


Figure 4.23**:** Use of chimney ventilation in Queens building, in engineering faculty of Demon for in England

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 186

Solution Number 3: Receiving breezes passing above the building by the use of wind breaks

In compact and high urban regions which windward buildings prevent wind from contacting with leeward buildings, windbreaks can receive cooler air flow without dust which passes above the roof and then guide it to lower spaces. As in high parts there is no obstacle, windbreaks can receive air flow from all directions. Windbreaks should be designed according to the change in direction of local winds. Orientation and number of openings of windbreak are determined by the amount of cooling needed for the building in different months and by direction of local winds. Then according to these, one-row, two-row or multiple-row windbreaks are used. If orientation of cool winds is always stable, Egyptian three-row windbreaks are suitable. (Brown.G.Z and Dekay. M, 2000)

If wind orientation changes in 90 degrees angle, Pakistan windbreaks are suitable for receiving wind. In case that wind vacillates in two opposite directions, using Iranian two-row windbreaks is a proper solution. If the graph, representing the direction of the wind flow, shows various winds with almost a similar distribution in different directions, Iranian four-row windbreaks can receive wind in different directions. Figure 4.24 shows the amount of received wind in four kinds of windbreaks according to the wind direction. The amount of received air is defined according to the ratio of amount of air flow in the tower for creating proper velocity of wind and surface area of cross section of the tower. How much the amount of received air (CE) is bigger and quicker, the amount of ventilation and convection is more, the cross section of the tower is less.

The graph shows that efficiency of Egyptian and Pakistan windbreaks is more than Iranian windbreaks. The reason is that most often wind flows from directions which windbreaks are oriented toward them. Iranian four-row windbreaks notwithstanding their little efficiency, this efficiency does not change with change in wind direction.

For the windbreak to be situated over turbulence level and wind be able to enter the opening, this opening should be at least 2.7 meters higher than surrounding buildings. The sizes of needed openings for transmission of thermal energy in the building by the windbreak, as a fraction of the surface area of the floor, assuming temperature difference of 1.7C between inside and outside the building are achieved by the below graph. In this graph, the vertical axis represents wind speed in m/h and the horizontal axis represents the ratio of surface area of the entering window to the surface area of the exiting window for the air flow.

If temperature difference between inside and outside is smaller than this, larger openings are needed and if it is bigger, smaller openings are needed. The graph is formed based on 0-40 degree angle between wind direction and operable windows of the windbreak. For designing multiple-row windbreaks, operable windows of all direction should be large enough in proportion to thermal charge of the building. The sizes of openings for wind should not be larger than the surface area of the cross section of the windbreak, but the sizes of exiting window should be almost two times bigger than the sizes of entering openings. (Brown.G.Z and Dekay. M, 2000)

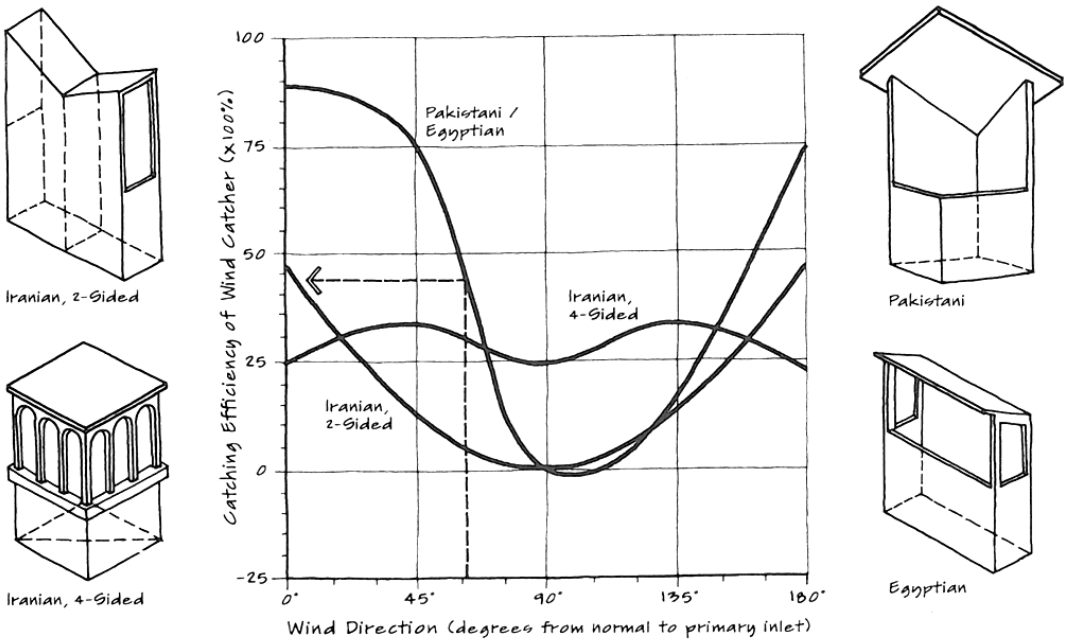
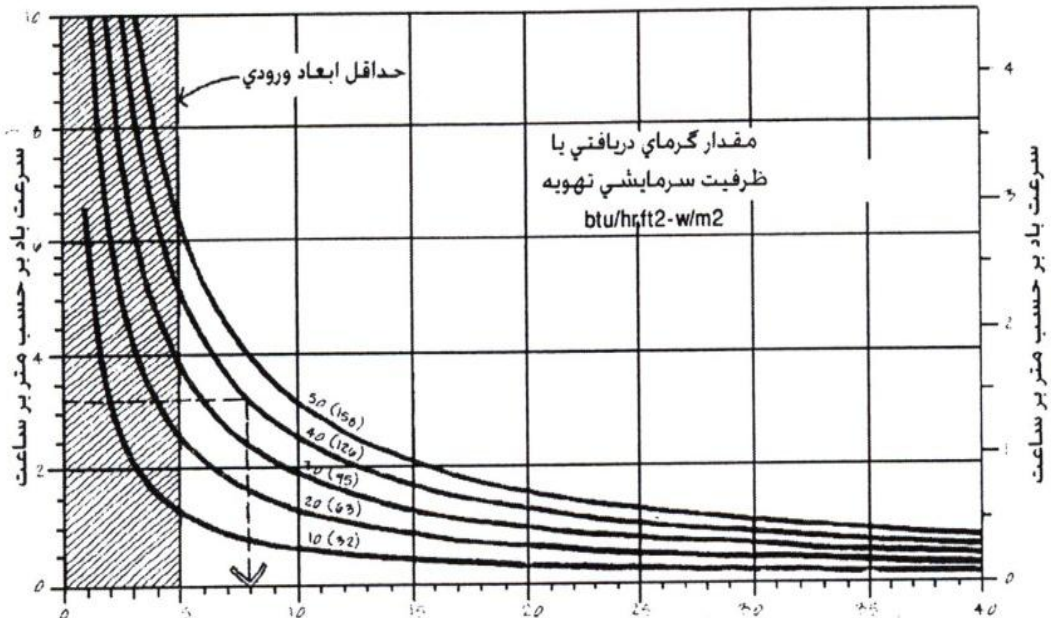


Figure 4.24: Catching Efficiency for Difference Wind Catcher Design

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 189



Graph 4.7: The sizes of openings of the windbreak for cooling

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 190

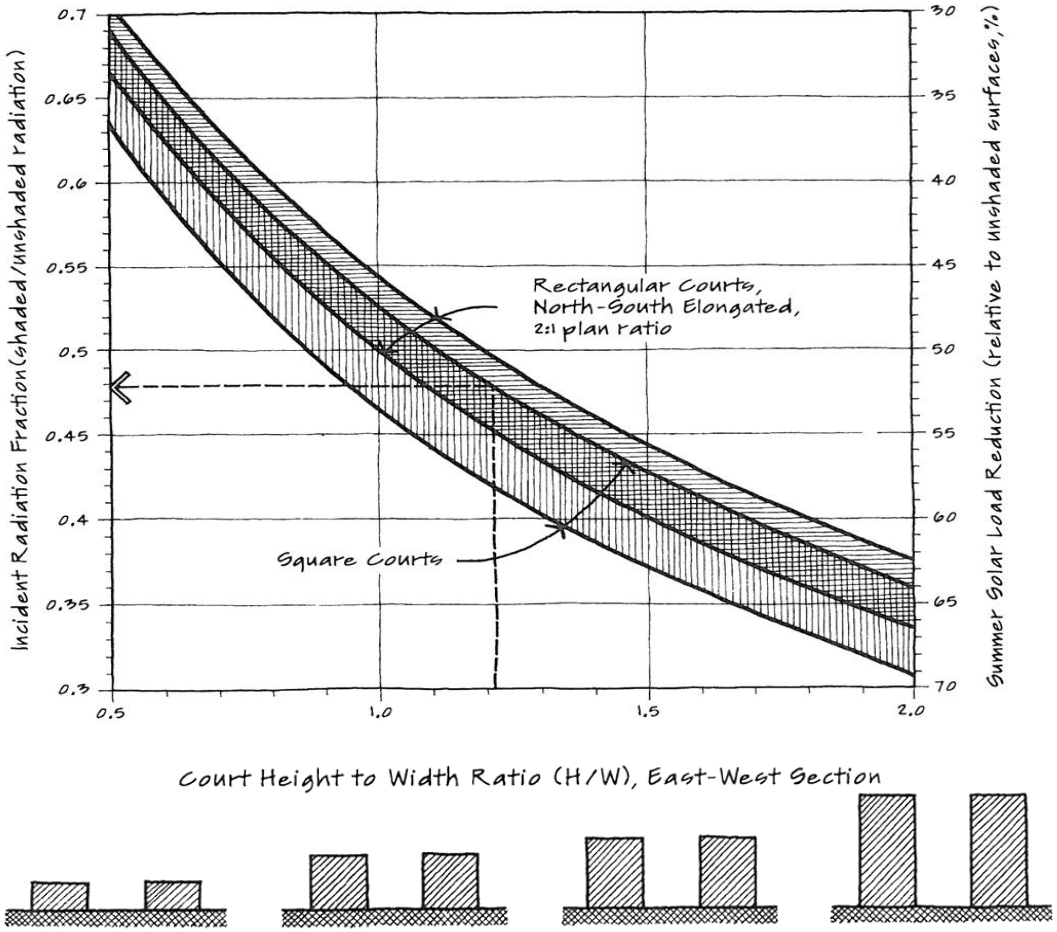
Solution No. 4: Using Water Edges for Cooling Arriving Air Flow to the Building

In hot and dry regions, evaporation reduces temperature significantly. The amount of evaporation and the resulted cooling is proportional to the surface area of water, wind velocity, relative air humidity, and water temperature. In this case, designer has a good control on surface area of water and its situation to wind direction and spaces in need of cooling. In moderate atmosphere, humidity and wind, 1 sqm of water, as the result of heat exchange between air and a light external layer of water, can produce 200 w cooling. Increase in heat exchange between air flow and water accompanies the increase in evaporation and humidity. The courtyard can function as a cold trap and would imprison the produced coolness and then uses it for cooling the air flow passing from the building. In addition, for increasing surface area of water, it is possible to use irrigating water by geyser and fountain and changing water to tiny drops. (Brown.G.Z and Dekay. M, 2000)

Solution No. 5: Developing narrow yards with high walls for imprisoning cool air

In hot and dry regions with much temperature fluctuation, the houses of central yard are one of old and efficient forms for cooling. These yards with high walls, especially when stretching east-west, at morning and afternoon with low sun radiation, are totally in shadow. And always, some part of the building can shade yard floor and confronting walls. In courtyards with high walls, wind flowing above the building, does not disturb air flow in the courtyard. At night, the roof and the courtyard especially the floor, radiate heat directly to the nightly cold sky. The air surrounding these surfaces is cool and replaces the heated air near the earth. Cool air in the courtyard, makes cool the adjoining surfaces which are warmed in result of

reserving daily heat. During day, the courtyard is more moderate than totally open external spaces. The reason is that surfaces and the air imprisoned by them are cooled proportionally.



Graph 4.8 Effect of ratio of height to width of the courtyard on shading the floor

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 211

For comprehending the effect of ratio of yard height to its width in reducing sun radiation on the floor and yard walls, we can use graph 4.8. Overlapped region determines two kinds of courtyard: a square yard and a rectangular yard with ½ ratio stretching north-south. The bottom of the curve represents moderate regions and upper parts represent tropical regions. The curve is used for regions in the latitudes bigger than 40 degree. In yards stretching east-west, there is less shadow and more sun light on walls and floor. (Brown.G.Z and Dekay. M, 2000)

4.1.2.2 Cooling-heating Solutions

Mutual cooling-heating solutions in building, is discussed here in this section. As mentioned before, these solutions are influential in reducing thermal charge of the building, especially in hot and dry regions with long, hot summers and very cold winters.

Solution No. 1: Determining the yard situation regarding direction of radiation and wind direction in order to provide appropriate seasonal conditions

The buildings, by protecting against the sun and wind, create different micro-climates around themselves. Room situation in relation with external space, is affected by sun and wind direction. The picture shows combined effects of sun and wind direction in determining the situation of mid-open spaces and courtyards in three different conditions – sun radiation perpendicular to wind direction, radiation parallel with wind direction, and radiation opposite to wind direction - according to the micro-climate of the region. (Givoni, B, 1988)

According to this graph, situation of mid-open spaces in summer in hot and dry regions is as follows:

1. In a case that direction of wind and sun radiation are oblique to each other (90 degree or less), mid-open spaces and courtyards should be situated in eastern part of the building in order to be able to enjoy cool breezes.

In case that direction of cool breezes and direction of sun radiation is the same, it would be better that mid-open spaces, external rooms and central courtyards be situated in southern part. In this case they can enjoy proper southern light while passing cool breezes. (Brown.G.Z and Dekay. M, 2000)

2. In case that direction of cool breezes are in opposite to the sun radiation, it would be better for the courtyards, mid-open spaces and external rooms to be situated in northern part in order to produce shaded spaces and enjoying cool breezes.

In hot climates, cooling is essential most often, but in moderate climate, sometimes it is necessary for the courtyards and mid-open spaces to be warmed up by sun radiation. Therefore in moderate climate, external rooms and mid-open spaces should be designed in a way that provide both winter heating and summer cooling; or more than one mid-open space be designed in order that residents be able to move their daily and seasonally. In humid climate, for providing cooling, mid-open spaces should be situated in a position that while enjoying cool breezes, be shaded. In this climate, making draught is more important than shading the buildings. In hot and dry climate, shading is the primary issue and wind may be very hot, accompanying dust. However enjoying cool breeze at night is desirable. (Givoni, B, 1988)

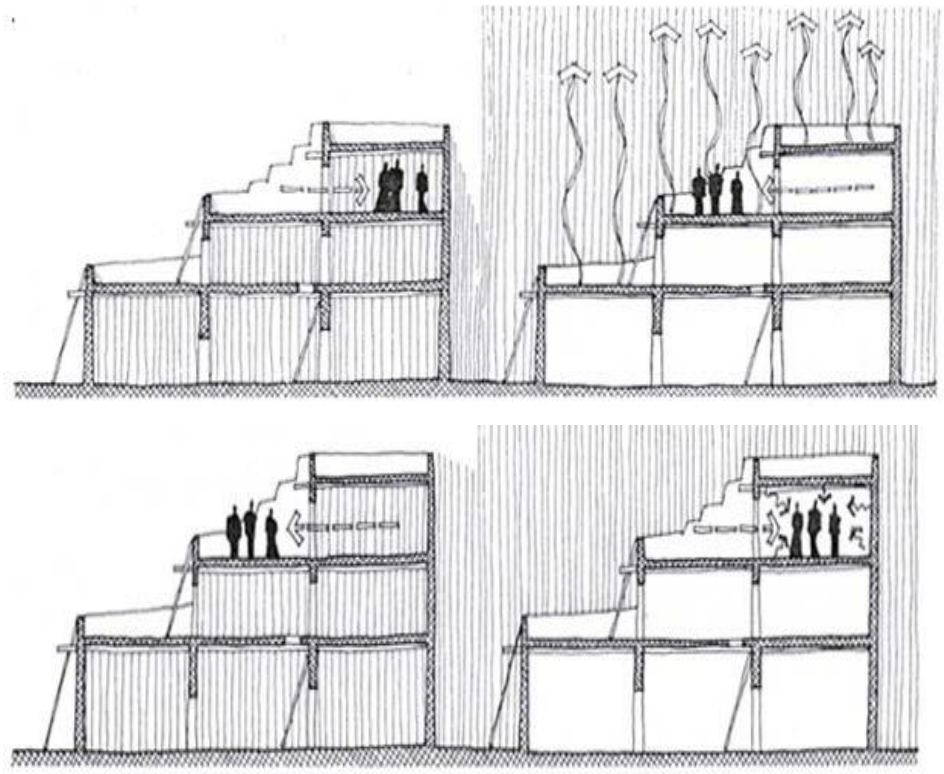


Figure 4.25: Use of terrace in Pueblo Acoma in New Mexico

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 136

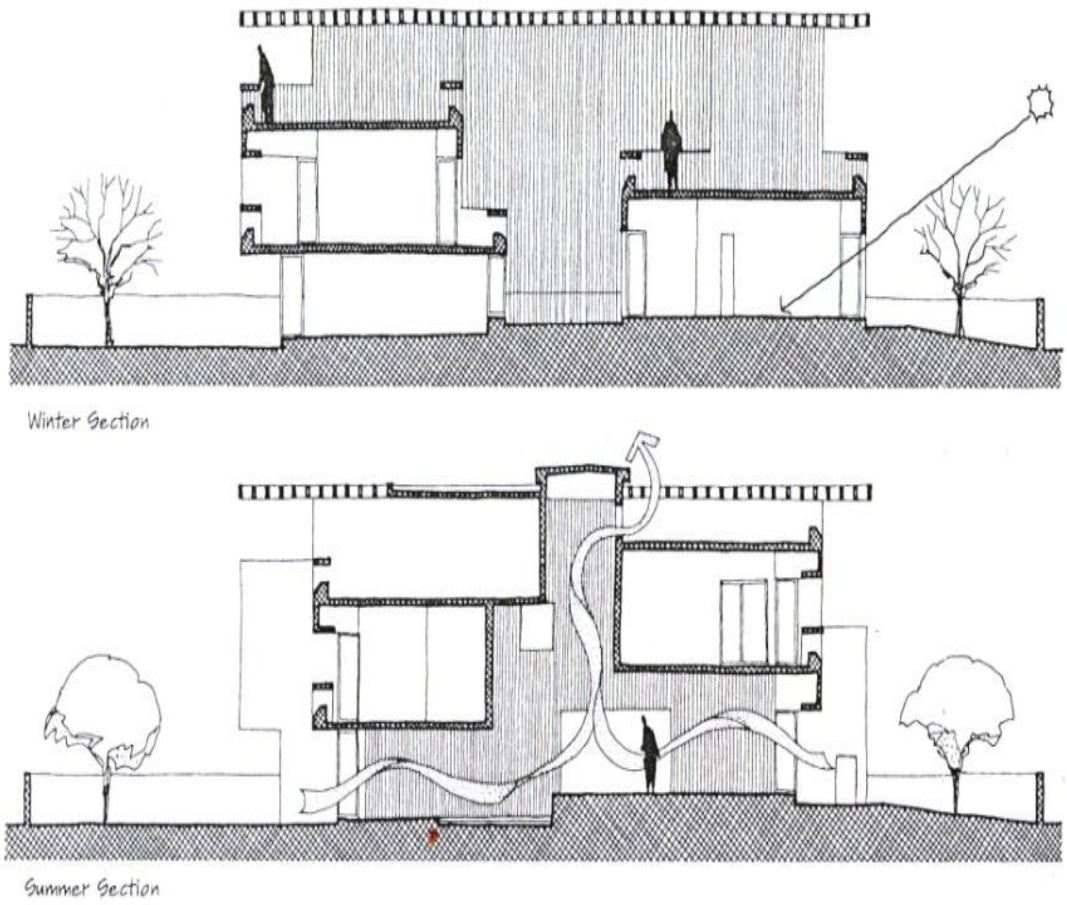


Figure 4.26: Parekh house in Ahmadabad-India

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 136

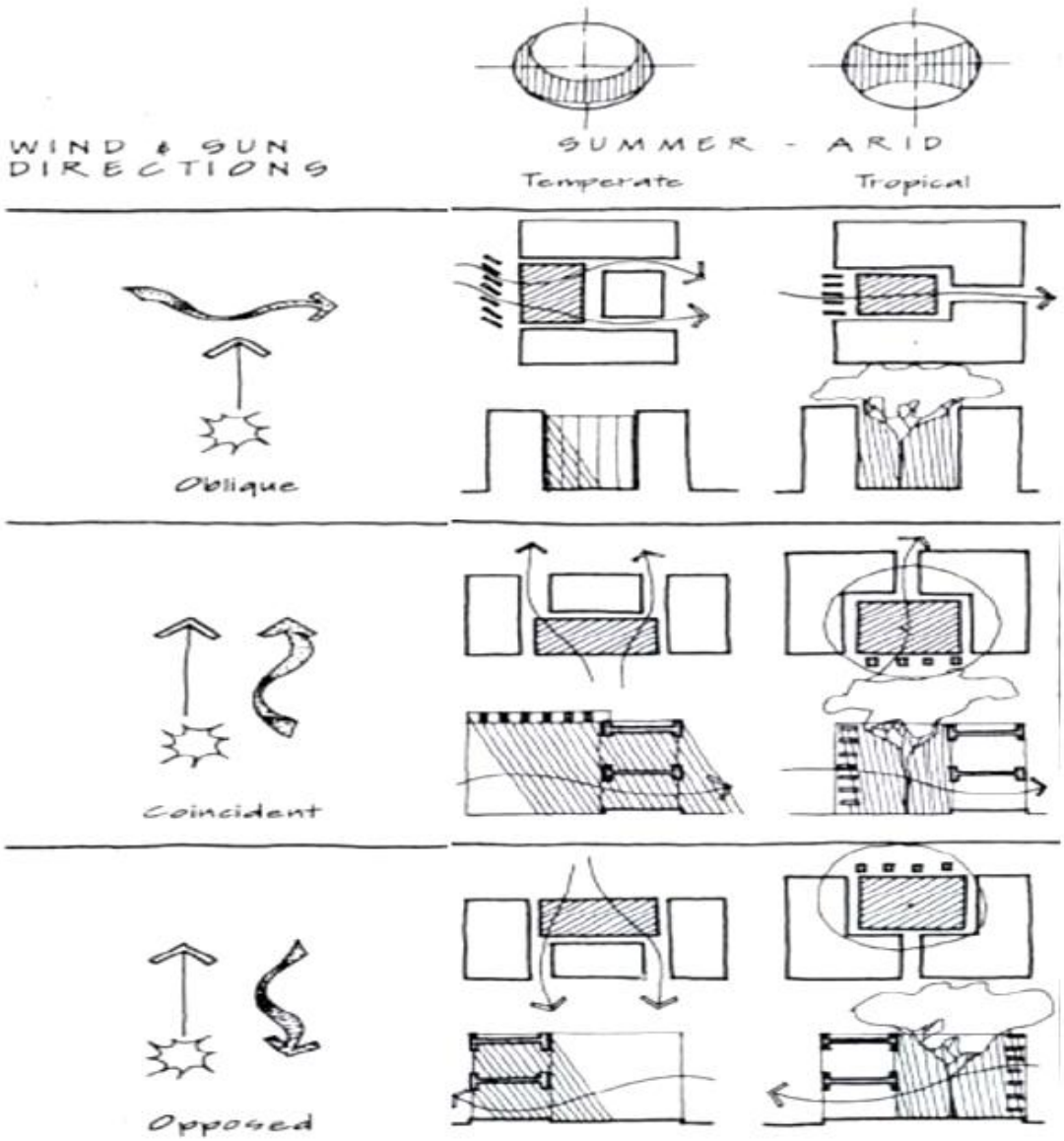


Figure 4.27: Situation of mid-open spaces and courtyards based on micro climate

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 140

Abdolvahed Alvakil, in designing Hamdi house in Cairo, Egypt, has used half of the space as mid-open space which functions both as an arriving space and as a courtyard. This courtyard in three parts is surrounded with wooden reticular windows and in the fourth part with resting space of the building. One important part of the courtyard is the basin and an open fountain. In summer morning and afternoon, high walls shade the courtyard. At noon, the residents, due to hot shining sun take refuge to the or internal spaces that are more protected. The windows provide the

possibility of cool nightly ventilation and due to being reticular prevent dust from entering into the building. (Brown.G.Z and Dekay. M, 2000)

Solution No.2: developing group rooms for decreasing surface area of building shell and receiving and wasting thermal energy

The surface area of the building depends on the amount and volume of surrounded spaces in the building; and it can be in the condensed forms such as cube, stretched forms such as rectangular or other forms. The heat exchange through the building shell by convection and radiation, in stretched buildings is more than condensed buildings with the same volume. Therefore, huge buildings with a particular ratio of surface area of the shell to surface area of the floor can have the same amount of heat exchange as smaller buildings with the same ratio (ratio of surface area of the shell to surface area of the floor). Those buildings with surface area larger than their volume, receive more sun radiation through the ceiling, walls and the floor. This case is suitable for winter heating when the building is stretched to the south. But for summer cooling, especially when the main parts face east and west, is very inappropriate.

About cases that control of receiving and wasting heat through the shell is very important; we can design the rooms in group forms and nested .This design is used in conventional buildings. In these houses the rooms are situated around a central heating source. In this house, many windows and largest of them are installed in southern part for receiving sun radiation. The fixed sources of heat such as the kitchen are situated in coldest part of the building which is the northern part. Heat exchange through the shell is dependent to factors such as isolation, surface area of the building, and temperature difference between indoor and outdoor. The ratio of surface area of the building shell to the surface area of the floor in buildings with

weal isolation is very significant. As illustrated in Graph 4.9, increase in the ratio of S/F (Skin area/Floor area), the heat exchange through the shell increase as well. But in buildings well isolated, this change is very slight.

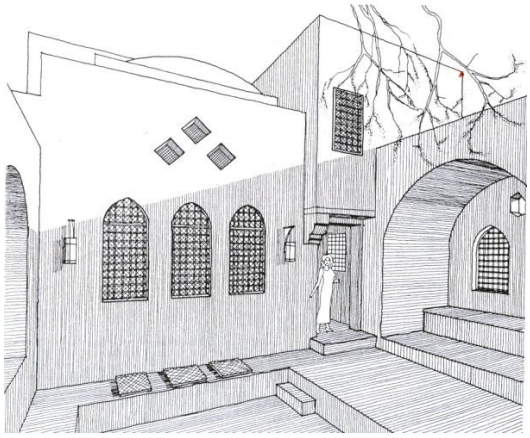
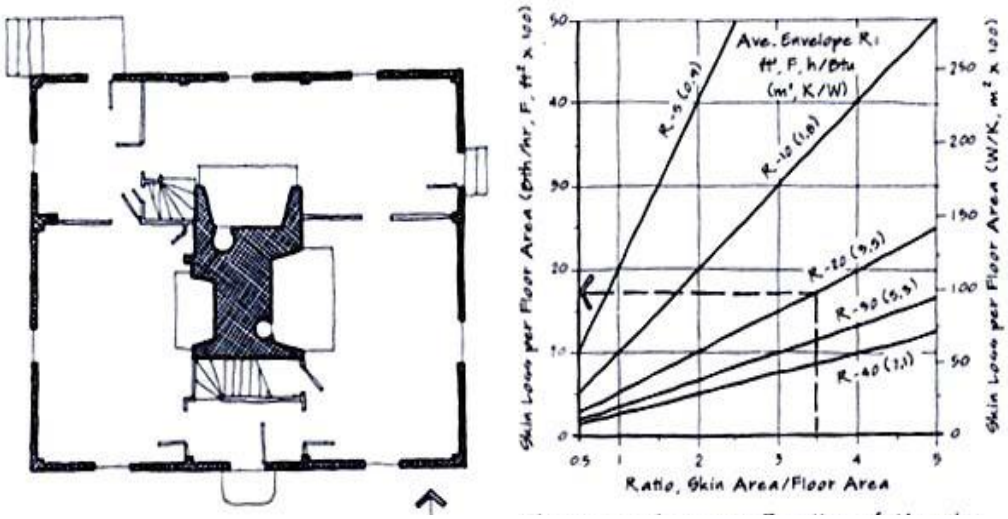


Figure 4.28: Hamdi house in Cairo in Egypt, Abdolvahed Alvakil

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 141



Graph 4.9: the effect of increase in S/F ratio on heat exchange through the shell

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 145

Solution No. 3: Designing plan in order to absorb or release the produced heat in indoor

Putting thermal sources in middle parts of the house may prevent the thermal energy to spread evenly in all parts of the building. However by the use of other methods,

the above said system can be improved. For example, in ventilation system of hot air, one can install channels for returning air below the window and in this way eliminate cold air flow on the floor and below the window. About other thermal sources, installation of thermal isolation and reflecting surfaces behind them can increase functioning of the system.

In many buildings, particular parts of the building produce much heat due to concentration of equipments or people in them. Those buildings which heating needs are dominant in them benefit theses thermal sources indoor for providing the required heat. For distribution of heat in the building, the sources of indoor thermal energy can be placed where that makes the northern part as well. In warmer parts with dominancy of cooling needs, heating parts should be separated from other parts of the building. In Stratford Hall which is situated in hot and humid climate of Virginia, the kitchen which is the permanent source of heat is situated in a separated part (Figure 4.29). Two other examples for spaces producing internal heat are kitchens of restaurants and engine houses.

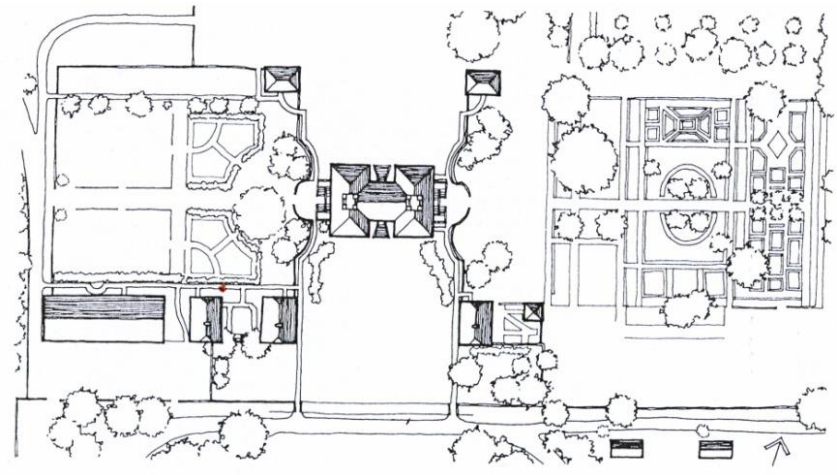


Figure 4.29: Stratford Hall in Virginia

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 161

Solution No. 4: Vertical separation of internal spaces into two parts of cold and warm

In order to provide people with comfort, we can divide indoor to two parts of cold and hot. If there are some parts in the building which are used less than other parts or have seasonal use, then we can separate them from hot parts of the building and therefore provide comfort with less consumption of energy. Even the permanent residential places need not have the same temperature. Using the walls resistant to heat exchange and the doors which are completely caulked are essential for dividing cold and hot parts. Hot air always moves upward, so the parts of building situated in upstairs are warmer than lower parts. This temperature difference can be used for creating the parts suitable for different activities with different temperature requirements. In this method, lower parts are used as entrance of cool weather and reserving it and upstairs as the sitting room and other spaces.

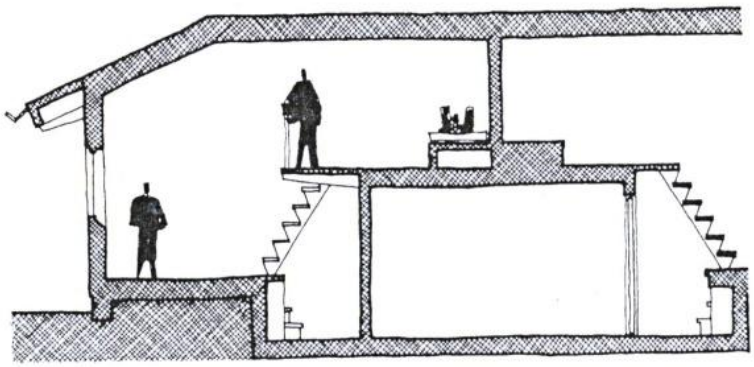


Figure 4.30: Ski Lodge house in Sweden

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 161

In hot climates, these principles are used in reverse. The rooms used all day long, are placed in downstairs which are cooler than other parts of the building. Bedrooms are situated near the ground floor. These rooms have high roofs for the hot and light air to move upward and exit through the upper windows and prevent accumulation of

hot air in residential spaces. The windows in addition to function as exit of hot air flow do not make any problem for privacy due to being situated in high parts. (Brown.G.Z and Dekay. M, 2000)

Solution No. 5: rooms exposed to sun and wind for increase of receiving natural heat and coldness

For ventilation of rectangular houses, it would be better for the bigger axis of the house to be perpendicular to the direction of desirable winds. If the angle between the building and wind is bigger or smaller than 90 degree then ventilation will be more effective. However as direction of the dominant wind usually deviates from its main direction, a 90 degree angle is appropriate. If direction of the dominant wind is not clear, the building should be designed in a way that ventilation would be possible through both directions. In this case, a square plan with windows in four sides of the building would be appropriate. (Givoni, B, 1988) The maximum amount of ventilation happens when air entrances and exits are large and wind direction is perpendicular to the surface of operable windows. Changing direction of operable windows up to 40 degree does not decrease ventilation in comparison with the case that operable windows are perpendicular to the direction of dominant wind. When a construction is deeper than a room, 20-45 degree direction to the dominant wind, makes two regions with positive pressure and two regions with negative pressure. When windows cannot be fixed leeward, then landscaping and extra partitions are used around the construction for creating regions with positive and negative pressure.

This leads air flow to parallel windows. In winter that the sky is clear and the sun is low, more radiation hits the southern side. (To the northern side in southern hemisphere), in addition to the amount of reflected radiation from glass surfaces, is effected by the angle of sun radiation hitting the surface. Closer angle causes more

reflection. The effect of orientation of glass surfaces on heating depends on the ratio between the amounts of radiation received and shell wastes and the amount of nightly radiation from the glass. If glass surfaces are directed to south-east or south-west with a 30 degree angle, decrease of efficiency would be less than 10% of optimum amount in practice. This increase is the result of glass orientation to the south. The maximum decrease in efficiency happens in southern side for windows with direct receiving and in cloudy, cold climates. Therefore, decrease rule in this case is +-15 those climates with long hot and cloudy seasons are less sensitive to orientation, because they have more amount of scattered radiation. So decrease amount can have +-40degree turning. For having maximum radiation, the angle between transparent surfaces and the horizontal surface can be equal to latitude of +-15degree. (Givoni, B, 1988)

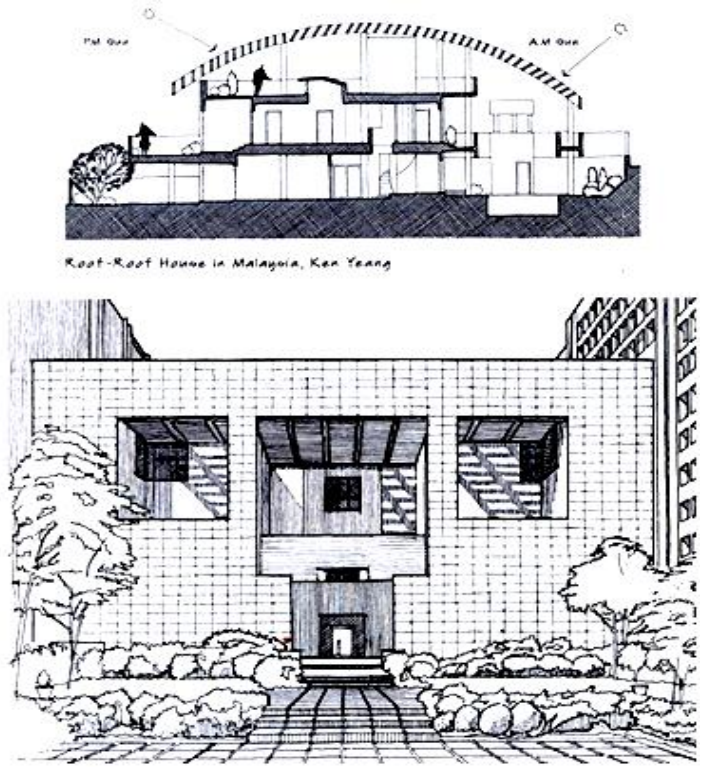


Figure 4.31: Top, using arch roof for shadowing and reflecting radiation. Bottom, Consulate Building of England in India

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 165

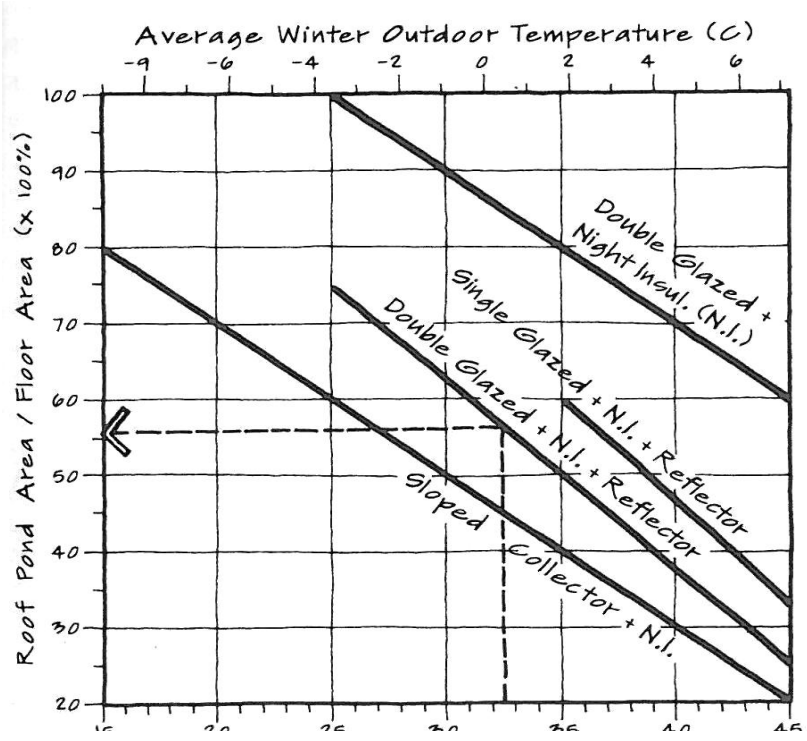
Solution No. 6: Designing underground floors in order to protect the building against external heat and coolness

Soil is not an appropriate isolator. Resistance of soil as a thermal isolator increases with increase in thickness. However we should be careful that thermal energy flow in winter passes through a semi radial path to pass the underground walls and reaching the surface. A considerable amount of thermal energy of buildings located at underground wastes through the walls and the floor. In summer these internal surfaces are good sources for heat. Just when humidity increases in summer, and collection of water drops near the walls and floor changes to an essential problem, isolation seems necessary and essential. (Watson, D, 1372, 1998)

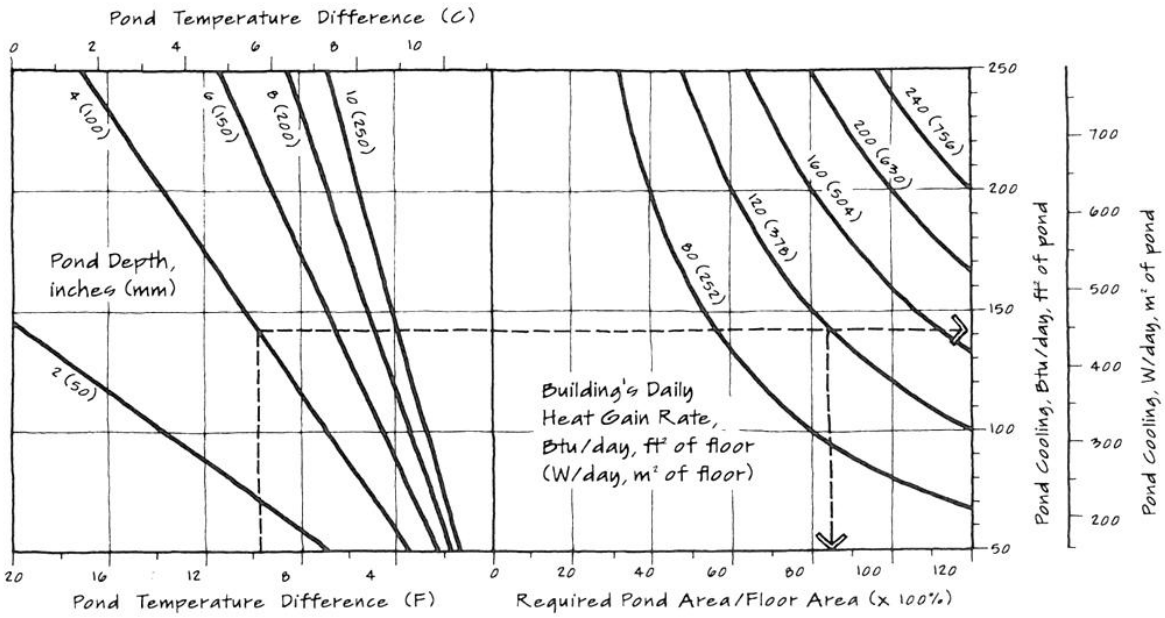
Using the ground as a shelter decreases heat absorption and waste by two ways. One way is increasing resistance against flowing heat through the walls, roof and floor. The other way is decreasing temperature difference between outside and inside of the building. In depth more than 6m underground, daily temperature fluctuation is trivial. Using the ground as the shelter is possible in three forms: being located in underground, making ramp around the building and on the slope of the mountain or heel. In all these forms, the ground may cover part of the walls, or entire walls and roof. The amount of consumed energy and the effects resulted from building ground shelters, must be compared with necessary costs of constructions, humidity isolation, and other costs related to the reservation of the building. The needed light for these buildings may be provided through roof lights, or a central yard or atriums, or windows with indirect light located in one or two facets.

This issue in underground buildings is important for sufficient ventilation for transferring of heat and humidity. In order to determine the resistance of the walls

made up of the ground in a specific depth by the use of the graph, we should enter the depth to the left part of the graph, and then we follow the vertical line to reach to the diagonal lines to determine the type of slope. Then we follow the vertical line to cut the diagonal lines and specify the type of the soil. Then we follow the vertical line to the horizontal axis to determine the resistance of the wall in a determined depth. Then we calculate the average of resistance in top and bottom of the wall or we can calculate resistance in a specific depth. Figure 4.40 shows different designing solutions for providing light and ventilation. In case that there is not direct access to the wind, we can use windbreaks or chimney ventilation. (Watson, D, 1372, 1998)



Graph 4.10: Calculating the area of the basin in proportion to the area of the roof for winter heating



Graph 4.11: Calculating area of the basin in proportion to the area of the roof for summer cooling

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 177

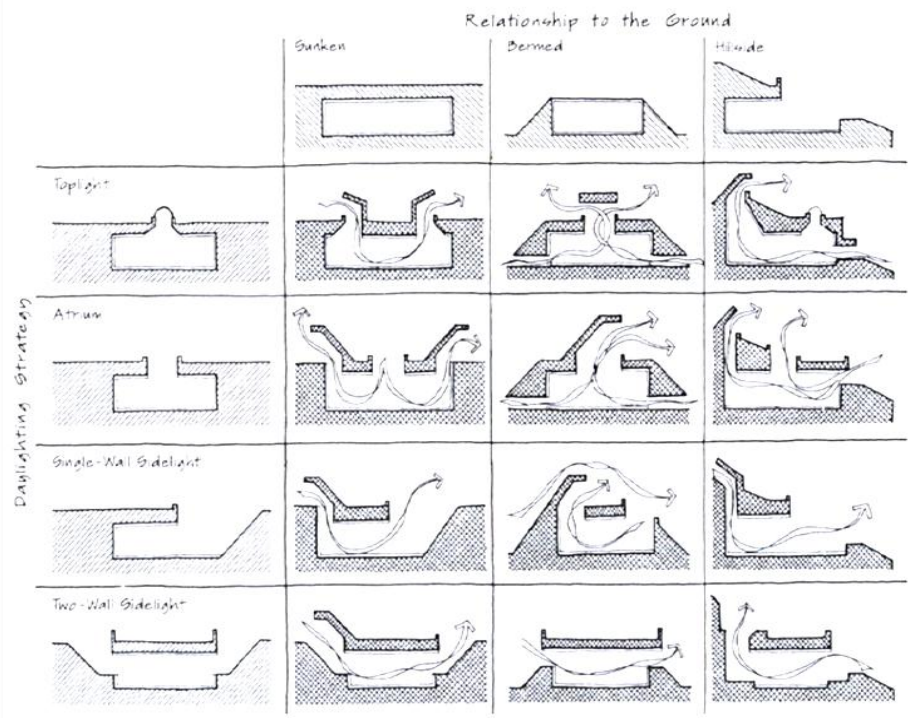


Figure 4.32: Solutions for Providing light and ventilation in different types of ground shelters

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 203

In Cooperative Homesteads project, Frank Loyd Right enjoys the second way namely situation of ramps in one part of the building. Heels and gardens on the ground are used for protecting the building against the winter winds and isolation.

Figure 4.33: Cooperative Homesteads Project, Frank Loyd Right

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 204

Solution No. 7: Designing wide yards with short walls, for enjoying the cool breezes, and yards surrounded with high walls, for protecting against unpleasant winds

The amount of enjoying wind flow in central yards depends on the proportion of the height of the building and width of the yard along the wind direction. The velocity of wind in central yard generally increases with the increase of length of the central yard and decreases with the increase in the height of the windward facet. Wind moves upward after hitting the windward facet, and then moves down the yard again. Generally, wind velocity in the yard increases in proportion to the length of that yard facet which is along the wind, and increases as the height of windward facet increases. (Givoni, B, 1988)

In designing the building of Developing Entrepreneurship Assembly, in Ahmadabad, India (Architect: Bimal Patel, Figure 4.34), the possibility of yard to have access to wind is from upward y directing the open main space to the seasonal

humid winds of southwest. These buildings are located in a 45 degree angle to the wind direction and they have access to wind. (Brown.G.Z and Dekay. M, 2000)

For determining the dimensions of the central yard for enjoying the wind, the chart 5-4, illustrates the average velocity of the wind in the yard for three regular wind angles (0T, 22.5, 45). We should remember that when creating large yards for enjoying summer cool breezes, the yard would have less shadow in summer. Therefore other ways for shading such as plants, covered porches, and shading parts in the building can be used. In hot climates where ventilation is desirable, a central yard with a 45 degree angle to the dominant wind would be effective both for producing air flow in the yard and passing ventilation for the building. Operable windows to the central yard, increase wind velocity in the yard, but have less effect on the average wind in the central yard, unless an operable window be installed in the windward facet, and one or more operable windows let the wind exit to the yard. (Figure 4.35) Therefore wind velocity in a narrow yard, increases much in proportion to the amount it is surrounded. In hot and dry climates, long, narrow yards are more appropriate for shading. The buildings are completely surrounded during the day and are protected against hot, sandy winds. The combination of open and shaded yards can be used for decreasing air flow from one side to the other side.

4.1.3 Building Components

Designing solutions in term of building components, relate to those components which form the rooms, central yard and buildings. They include building shell, walls, roofs, floors and operable windows, door and windows and roof lights. Designers due to small dimension and details for designing usually pay attention to these components in the last stages of designing. Building dimension is very important in

providing energy system and building light and should not be ignored. For example, the location and materials of group buildings, shape and space of the room in the building may be designed for collecting solar heat. Therefore designing solutions for the building which is influential for building models should be considered in first stages of designing. Here in the present thesis, the most important solutions of designing building components for sustainable coolness and the manners of their use in designing touristic residents are studied. (Brown.G.Z and Dekay. M, 2000)

Figure 4.34: Entrepreneurship Improvement Society, Ahmadabad-India

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 207-208

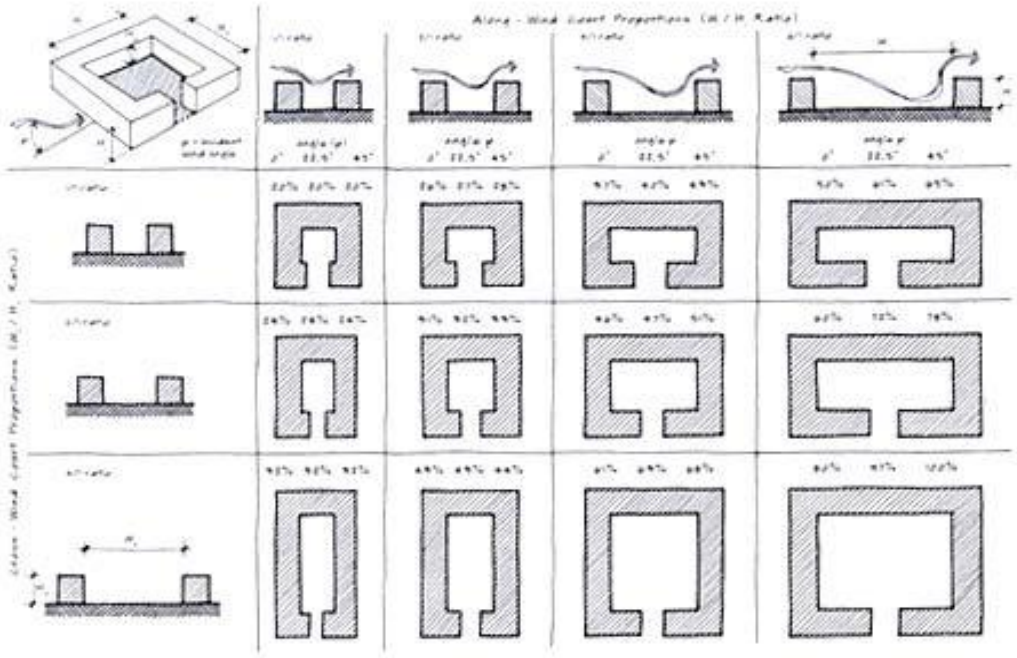


Figure 4.35: Determination of Central Yard Dimensions for Ventilation

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 209

4.1.3.1 Cooling Solutions

In this section, cooling solutions regarding the structural components are studied. In hot regions these solutions are very functional in cooling the building.

Solution No.1: Using double shell components for preventing heat to penetrate into the building.

In summer, when sun shines to the external surfaces of the building, some part of absorbed thermal energy is transferred inside through conduction. In this case, temperature of surface of materials is higher than their surrounding temperature and therefore received thermal energy increases. Double shell system, is an executive solution for cooling the building in hot climates and in external part of the building in hot summers. This solution is frequently used for eastern and western facets. (Figure 4.36) External shell shades the roofs and opaque internal walls or windows.

While the air flows in hollow space between two shells, it transfers the extra heat outside through the external shell. Efficiency of hollow space between shells in decreasing thermal energy depends on absorption capacity of the external shell, the amount of radiation of hollow space and the amount of ventilation in hollow space. An ideal system has an external shell with high reflectivity, and an external surface with low absorption capacity, and an internal surface with low capacity of heat release. As the internal temperature of external shell increases in result of increase in temperature of external shell, ventilation of hollow space is very important.

Chart 4.5 illustrates the efficiency of double shell roofs and walls.

In selecting materials for internal and external shell of the building, their apparent characteristics should be considered. In external shell of the building, those materials with low absorption capacity and high heat release are preferable to those with similar absorption capacity and low heat release.

The reason is that, materials with high capacity for heat release would reflect absorbed heat very quickly. One exception in this case is those plant covered surfaces which are reflected against sun radiation. The example is those ivies growing on the surface of awnings. Though the leaves absorb much of solar radiation, the extra heat is disseminated as the result of hollow space among the leaves, evaporation and perspiration. Just on the black surface non metal and polished metal, the amount of absorption and dissemination is not dependent on the wavelength. (Brown.G.Z and Dekay. M, 2000)

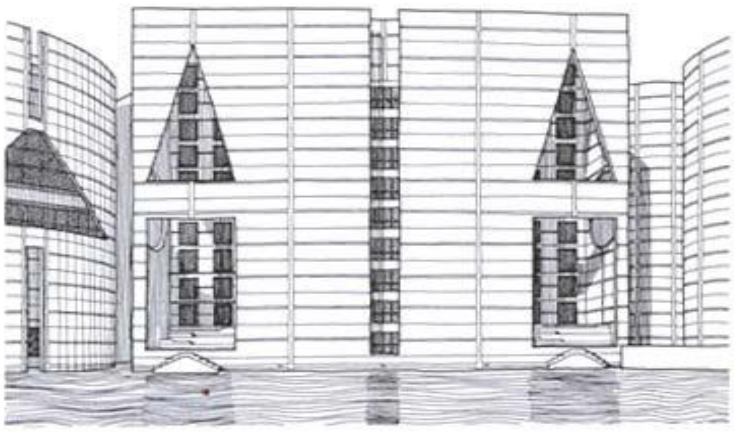


Figure 4.36: Double shell walls in official building in Bangladesh Source from:

Wind & Light Brown.G.Z , Dekay. M, 2000, P 225

DOUBLE SKIN TYPE	Efficiency
Roof	
Typical poorly vented attic	0.2
Typical well-vented attic	0.45
Canvas louvers, horizontal, white outer, Gray inner, fully vented	0.8-0.98
Walls	
Canvas sheet, continuous, white, vented top/ bottom	0.65
Canvas sheet, continuous, dark, vented top/ bottom	0.30
Canvas sheet, staggered, vertical on east-west, Gray, 50% vented	0.89
Canvas sheet, staggered, vertical on east-west, Gray, fully vented	0.95-1.0
Sheet metal, louvers, galvanized, vertical on east-west, Gray, 50% vented	0.88-0.98

Chart 4.3: Tested Double-Skin Construction

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 227

Solution No. 2: Designing operable windows in order to increase air movement in occupied spaces

Proper organization and arrangement of operable windows can be useful in ventilation of the room and would increase air flow around the residents and cool them. Besides hot weather flow in room, if the speed of ventilation is proper, it can cool the residents. When temperature of surrounding air is higher than comfortable zone, ventilation through convection would properly cool the residents. Air velocity inside the room is determined by wind velocity. Average velocity of air flow inside, is proportional to wind velocity outdoor, the angle between wind and operable windows, and situation and size of the operable windows. (Givoni, B, 1988)

For operable windows, with 2/3 width of the wall, air flow average velocity in those rooms with just one operable window in one of the walls, would be 13% to 17% of outdoor air velocity. This difference is smaller in those operable windows with a surface area of 33% to 100& of wall surface. For two operable windows in a small wall, velocity average is over than 22% of outdoor air velocity. The reason is that one operable window functions as the entry and the other one as the exit. If some vertical partitions are placed among the operable windows, then when wind hits the wall obliquely, air velocity average would increase more than 35%. When operable windows of the room are located in two walls, velocity average of sir indoor is more than 35% to 65% of the air outdoor, because always one operable window is located in a high pressure part.

The amount of air flow and the amount of air transferred is under great influence of sizes of operable windows. The location of operable windows and internal partitions n plan and cut would be influential in the direction of air flow across the room

(Figure 4.37). Therefore air flow velocity across the room changes. Though the operable windows in opposite walls would cause air flow with maximum velocity, the operable windows in adjacent walls, and the opaque direction of wind to the window, will augment air turbulence. An important issue is that, the air flow should flow among the residents and make them cool. Is the operable windows are installed near the ceiling or the floor, then the maximum velocity of air flow does not happen for the residents and it would be usually in 0.3-0.8 high from the floor. If the operable windows are installed in middle part of the wall, or some of them are installed up and the others are installed down, then maximum air velocity happens for the residents.

Chart 4-4 illustrates the average air velocity of indoor in the form of percentage of wind velocity outdoor. The wind flows in 45 degree in proportion to the vertical axis of the window. (Brown.G.Z and Dekay. M, 2000)

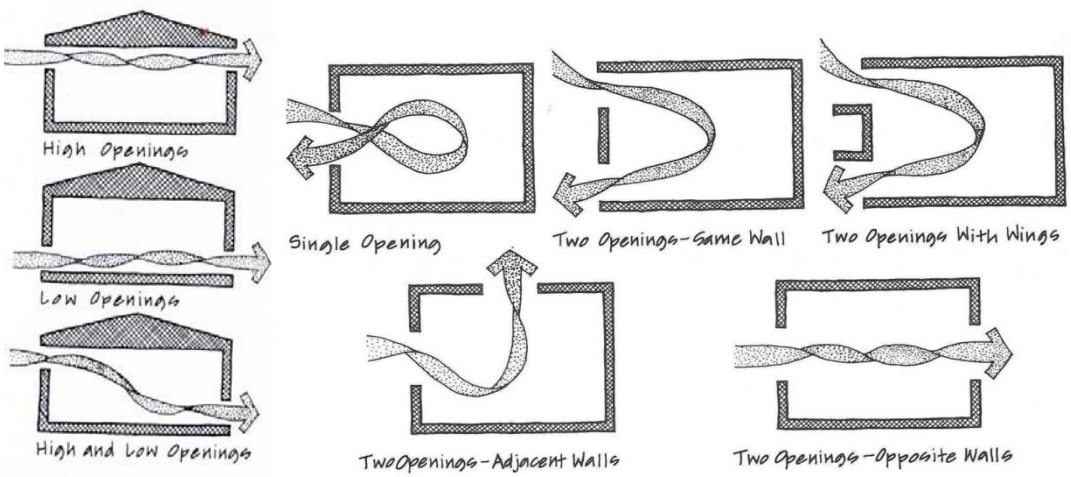


Figure 4.37: Influence of Operable Windows on Plan and Influence of Height of Entrance and Exit, in determining wind direction inside the building

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 242

Window height as a fraction of wall height	1/3	1/3	1/3
Window width as a fraction of wall width	1/3	2/3	2/3
Single opening	12-14%	13-17%	16-23%
Two openings in the same wall	……	22%	23%
Two opening in the adjacent walls	37-45%	37-45%	40-51%
Two opening in opposite walls	35-42%	37-51%	47-65%

Chart 4.4: Average velocity of wind inside the building in the form of a percentage of air velocity outside

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 242

Solution No. 3: using perforated awnings for shading the glass and decreasing daze

In the buildings in need of shading on the glass surface and reduction of internal heat produced by the electronic light, these awnings are applicable. However we should be careful that these awnings block the sight to the sky and reduce daylight in internal space of the building. Further studies; predict light reduction equal to 50%, resulted from external partitions, with a 45 degree angle to the building. Accuracy in designing apertures and roof lights, and partitions, make shading possible and at the same time prevent light reflection to the internal space of the building.

Horn & Mortland in designing Sunshine school in California, have used roof lights (Figure 4-38), the lights are installed firmly near the building for shading against sun radiation. Moreover, the open suspending roofs provide air flow in the awnings and

reduce heat transfer from the inside. For reflecting daylight, lights (patios) should be in bright color, because the reflected light from the awnings is the main source of daze. In selecting materials for the last surface of the last surface of the awning, the important point is that we should select those materials which reflect light not thermal energy. One example is polished metals. The shading parts, under the awnings should be in bright color. (Brown.G.Z and Dekay. M, 2000)

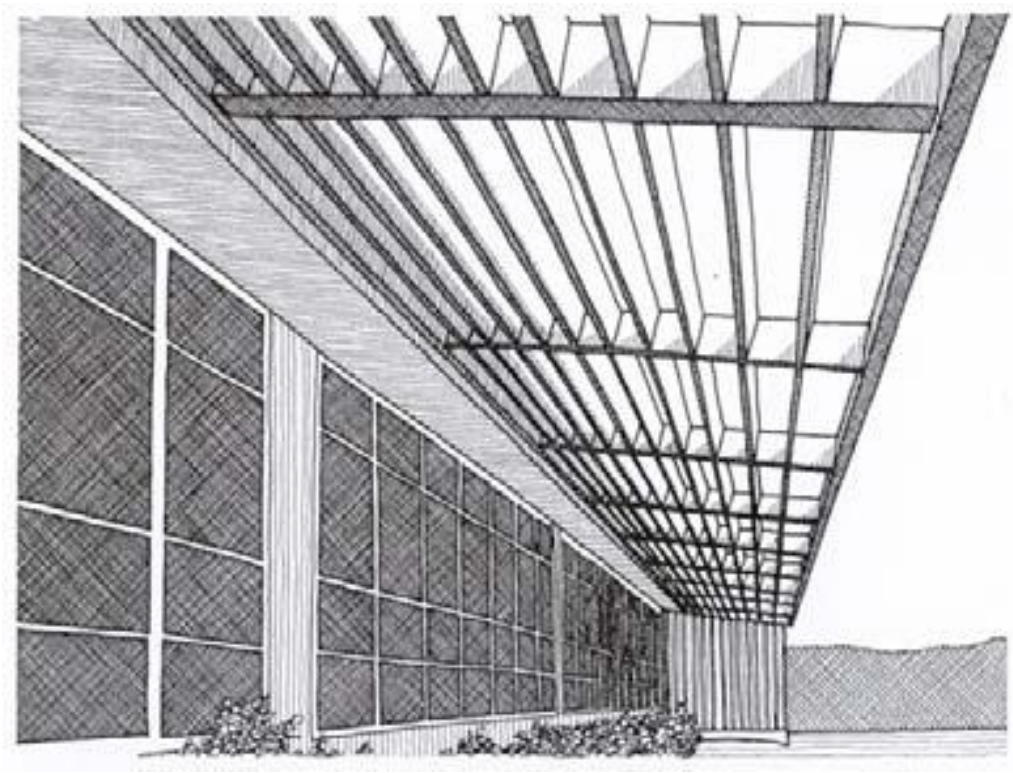


Figure 4.38: using different awnings

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 260

Solution No. 4: Using external awnings

External awnings, horizontal, vertical or a combination of horizontal and vertical called egg-box, are used for shading the windows. According to the sun direction in summer, in northern hemisphere, horizontal awnings in hot months, shade the southerly windows. They also create shading in cooler months. When there is sun in

the sky, this problem may be removed by making seasonal adjustable awnings such as the provisional tents. Deciduous grape trees create effective shading both in spring when they are leafless and in summer when they are green. Horizontal awnings create effective shading in southern facet of the building. (Givoni, B, 1988)

Depth of the awning determines the length of the shadow on the wall of the window. Depth of the awning changes in proportion to the height of the glass. They are deep on the ground-floor and those floors with glasses stretching from the roof to the ceiling, and they become shallow in up floors where the door threshold is almost high. The blind arcades made up of clay, are full of holes in order to be able to reflect the penetrated light and distribute the heat absorbed by the use of shading. In summer the sun is situated in upper position than in winter. Therefore, horizontal awnings are able to produce full shadows in summer, and receive sunlight in winter and contribute to the heating of the building. The size of awnings may change without any change in their shading characteristics. This change is in result of the proportion between the awning depth and the distance between the remaining fixed components. As the awnings are exposed to the direct sunshine, one should be careful that this characteristic does not cause daze or heat transfer into the building. The proper size and the distance between the shading components are dependent on the windows direction and the time of the year or day that shadow is needed.

For achieving the times in need of shadow, we can use the diagram showing the sun direction. If the glass surface is completely in shadow, the distributed light in the sky and earth, and reflection from the shading components, contribute to the providing of light and heat as much as 20% of the sun radiation. The sizes and distance between the simple awnings are attained by the use of the chart. The amount attained by the use of charts for creating the efficient sizes of horizontal awnings, are attained

according to the latitudes by the use of the graph. For determining the length of the horizontal awnings, the first chart is used for the southward windows and the second chart is used for the eastward and westward windows. Using the time and the date of needing the shading, P is attained is attained through the relevant longitude. The height of the window in need of shading (Y) is multiplied in P (Chart 4-5), and then the depth of awning (X) is achieved. (Brown.G.Z and Dekay. M, 2000)

Solution No. 5: Using internal awnings between two cups of glass of double surface windows

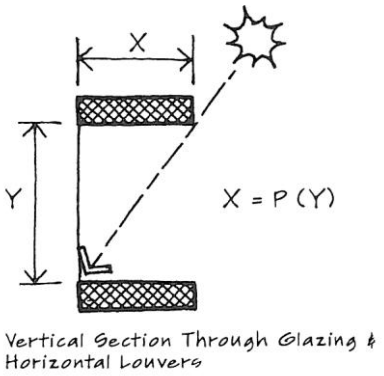
While the external awnings are very effective in preventing sun radiation, they get dirty very soon and their maintenance is difficult. Controllable awnings are installed either behind the glass surface or between two or three layers of the window glass and reduce sun radiation in summer. These awnings can reflect light into the building, reduce daze, be protected against pollution and hostile climate. If these obstacles are put between the glasses, shadow coefficient (SC) would be low, because the achieved radiation is moved in the window before entering the space.

The low shadow coefficient prevents heat absorption. Shadow coefficient for the awnings which are located between some glass layers, is between the low shadow coefficient of external awning and the high shadow coefficient of the internal awning. For example a double surface window with an external obstacle with light color would have a shadow coefficient equal to 0.14, with the obstacles between the glasses would be 0.33, with the obstacles in the window, and would be 0.58. The awning components include horizontal or vertical patios, moving obstacles and the internal curtains. Depending on the color, cover, angle and the final covering, the general shadow coefficient changes. The empty space between the glass layers may

be used for transferring the extra heat between the glass obstacles in summer or for transferring the heat to the rooms for heating them in winter. The absorbed solar heat in the empty space is attained and then for driving out the heat, the chimney effect is used. (Brown.G.Z and Dekay. M, 2000)

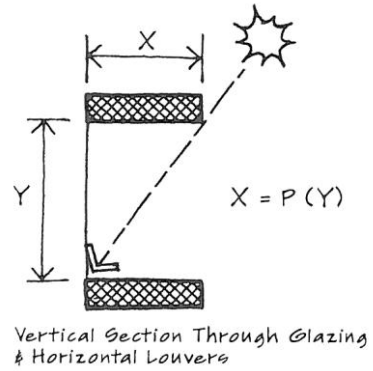
Latitude North lat.	8AM/4PM De	Nov/Jan	Oct/Feb	Sep/Mar	Agu/Apr	May/Jul	Jun
32	3.26	2.48	1.32	0.62	0.37	0.21	0.15
36	4.31	3.09	1.53	0.73	0.45	0.29	0.22

Latitude North lat.	9AM/3PM De	Nov/Jan	Oct/Feb	Sep/Mar	Agu/Apr	May/Jul	Jun
32	2.01	1.68	1.08	0.62	0.37	0.21	0.15
36	0.42	1.98	1.24	0.73	0.45	0.29	0.22



Latitude North lat.	9AM/3PM De	Nov/Jan	Oct/Feb	Sep/Mar	Agu/Apr	May/Jul	Jun
32	4.46	3.75	2.68	2.04	1.63	1.40	1.32
36	5.79	4.54	2.96	2.14	1.65	1.40	1.31

Latitude North lat.	8AM/4PM De	Nov/Jan	Oct/Feb	Sep/Mar	Agu/Apr	May/Jul	Jun
32	1.91	1.74	1.42	1.18	1.00	0.89	0.85
36	2.23	1.97	1.54	1.24	1.02	0.90	0.85



Latitude North lat.	8AM/4PM De	Nov/Jan	Oct/Feb	Sep/Mar	Agu/Apr	May/Jul	Jun
32	54	56	64	73	84	93	97
36	53	56	63	71	82	90	94

Latitude North lat.	8AM/4PM De	Nov/Jan	Oct/Feb	Sep/Mar	Agu/Apr	May/Jul	Jun
32	44	46	53	62	74	85	89
36	43	45	51	60	71	80	85

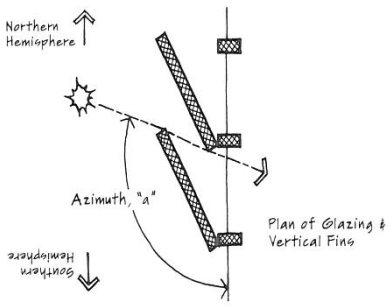


Chart 4.5: Values of P for East or West-facing horizontal louvers

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 260

4.1.3.2 Cooling-Heating Solutions

In this section, cooling-heating solutions of designing regarding the building components are studied. These solutions if applied properly would be very effective in reducing thermal energy of the building.

CONSTRUCTION TYPE	Shading Coefficient
1/8 Clear Glass, in & out	
Venetian Blinds Between (light/medium)	0.33/0.36
Venetian Blinds Inside (light/medium)	0.58/0.62
Louvered Sun Screen Between	0.43
Special Shaped Mirrored Louvers Between	0.25/0.59
Opaque Roller Shade Inside (White /Translucent /Dark)	0.35/0.40/0.71
Draperies Roller Shade Inside Open weave/dark color Semi-open weave/medium color Closed weave /light color	 0.62 0.52 0.42
1/4 Heat Absorb. Glass Out, Clear Glass In	
Venetian Blinds Between (light/medium)	0.28/0.30
Venetian Blinds Inside (light/medium)	0.36/0.39
Louvered Sun Screen Between	0.37
Opaque Roller Shade Inside (White /Translucent /Dark)	0.22/0.30/0.40
Draperies Inside Open weave/dark color Semi-open weave/medium color Closed weave /light color	 0.47 0.41 0.35

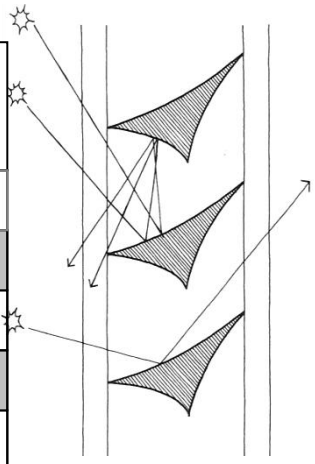


Chart 4.6: Shadow coefficient for double shell glasses with internal awnings and awnings between glasses

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 270

Solution No. 1: **Designing the building shell with enough thickness in order to make a thermal insulator**

For installing thermal insulator in the building components, there are three basic methods. These methods are as follow:

1. Fixing the insulator inside the building shell while making an empty space
2. Fixing the insulator on the building shell
3. The insulator and the building structure are united without framing

In case of using light insulation in empty space of framing components of the wall, the final thickness may be less than the thickness of the walls made up of materials on which the thermal insulator is fixed. When the insulator is fixed on the wall such as insulation of the external surface of the building, the shell materials are apparent and the building structure does not need to get thicker in order to be in compatible with the thickness of the insulator layer. Two above mentioned methods may be used in combination; in this case, some part of insulation is fixed on the surface of the building shell and some part is fixed among the framing components in framing structures.

A fixed layer of insulator especially in wall with metal pillars would reduce thermal bridge. The reason for using insulator layers in buildings which control through the shell and get cool sustainably, is the temperature difference between indoor and outdoor and reducing heat absorption. In case that cooling solutions such as flowing ventilation and chimney ventilation are used, indoor temperature is a bit higher than outdoor. Therefore for reducing heat flow resulted from temperature difference, there is no need of using insulation in the building.

There is just need to controlling the heat resulted from sun radiation. In case that the walls and roof are protected by shading radiation obstacles, the insulation would be very effective. In non residential buildings, winter heat waste is nullified by the inside thermal energy. Therefore in these buildings, cooling needs are more than heating needs. (Brown.G.Z and Dekay. M, 2000)

Solution No. 2: **Choosing proper color for external surfaces of the building**

In hot climates, the color of external surfaces should be light in order to be able to reflect sun radiation. As the heat transfer from the building shell depends on the temperature difference between indoor and outdoor temperature, the temperature increase of the external surfaces by increasing radiation absorption would reduce waste of thermal energy through the building shell. Dark surfaces absorb thermal energy and increase the temperature of their surroundings. In those cities with hot summers, the influence of reflection increase on reduction of radiation absorption and outdoor temperature is? In moderate climate is 50% and in cold climates is 30%. The reflecting surfaces reflect the received radiation both in summer and in winter, therefore increase thermal charge of the building. In hot climates, the advantages of light color in summer are more than its disadvantages in winter. The reason is that in summer the sun is in high position and the reflective roofs are more effective and has little effect on reducing heat receipt in winter (Chart 4.7).

Solution No. 3: **Using thermal materials, with proper size for reserving heat and coolness**

There are three main approaches, regarding determining the surface area and thickness of thermal materials. The first approach is using the heat reserving systems such as trombe wall, basins on the roof, and green house space, in which the surface

area of the receiving heat part is equal to the surface area of the reserving part, and considering their thickness, is very essential. The second approach concerns direct receive in which the surface area and thickness of the receiving and reserving surfaces are different. In those systems operating with direct method, as the reserving materials are located in a stationary space, temperature of air and materials does not change much. Therefore, such systems are dependent on the large heat transferring surfaces made by light building materials. The third approach is the method which uses water for reserving thermal energy. In this case, size of water tanks may get smaller according to the amount and surface area of water surface. The reason is that heat transfer through convection is easier by water than building materials.

Water, in comparison with building materials, reserve more thermal energy and is a proper solution for reserving heat in the buildings with light framing structure. This method is used in Bart Prince House in New Mexico. In this house, water is reserved in high, transparent pillars located on the south facet. (Givoni, B, 1988)

As the water tanks are transparent, some part of light passes through them and therefore these pillars have low absorption coefficient. **(SRI/Solar Reflectance Index)**

Roofing Material	Solar Reflectance	Infrared Emittance	Temperature Rise	SRI
Asphalt				
Premium white	0.36	0.91	59F (33C)	41
Generic white	0.25	0.91	70F (39C)	27
Grey	0.22	0.91	73F (41C)	23
Light brown	0.19	0.91	76F (42C)	19
Medium brown	0.12	0.91	83F (46C)	9
Dark brown	0.8	0.91	87F (48C)	4
Black	0.5	0.91	90F (50C)	0

Metal				
Steel, galvanized Aluminum Siliconized polyester, white	0.61 0.61 0.59	0.04 0.25 0.85	55F (31C) 48F (27C) 37F (21C)	46 56 71
Tiles				
Metal, white Clay, red Concrete, red Cement, unpainted Concrete, light brown Fiber cement, earth brown	0.67 0.33 0.18 0.25 0.42 0.26	0.85 0.9 0.91 0.9 0.9 0.9	28F (16C) 62F (34C) 77F (43C) 70F (39C) 53F (29C) 69F (38C)	82 41 23 31 49 28
Coatings				
White polymer Light yellow Gray Dark blue Aluminized	0.7-0.85 0.79 0.40 0.12 0.61	0.86-0.91 0.91 0.91 0.91 0.25	55F (31C) 48F (27C) 37F (21C) 48F (27C) 48F (27C)	88-107 99 47 9 56

Chart 4.7: Influence of materials with different colors on the amount of reflection of sun radiation and temperature increase

Source from: Wind & Light Brown.G.Z , Dekay. M, 2000, P 22

More distribution of solar reservoir (SSF) leads to more thermal reserve. When SSF is lower than 30%, sun heat during the day is much and heat waste is low and there is little need for reserving thermal energy. If SSF us between 30% to 70%, we should use more thermal materials fir reserving thermal energy and consuming this energy at night. SSF over than 70% is very rare in moderate climates. In such climates thermal reservoir is much more needed than daily reservoir.

In trombe wall and water roofs, thickness of the wall and the roof determines the amount of thermal energy reserved and released. Water walls, should be 230-350 mm tick. If ticker than 305 mm, SSF increases in proportion to the wall volume. Trombe wall which is made up of heavy materials if ventilated should be 255-355

mm tick, and if not ventilated, it should be 305-405 mm tick. Thickness of trombe walls which cannot be ventilated, affect the time needed for heat transfer through the wall and entering inside. Thicker walls have lower temperature vacillation and therefore extend comfort zone. (Brown.G.Z and Dekay. M, 2000)

Solution No. 4: Using thermal insulator in external surfaces for fixing the temperature of indoors

Building materials are usually used as external materials. For increasing efficiency of thermal materials in reserving heat or coolness, they should have surfaces exposing to air indoors. Therefore there should be isolation between the materials and external air flow. For accessing an external surface of building materials, usually an extra layer of building materials is put as a cover on the external surface. The thickness of trombe walls not being ventilated is efficient for the time of heat transfer through the wall and entering indoors. Thicker walls will create lower temperature vacillation and therefore extend comfort zone.

1. Wall: If the wall is a part of external shell of the building, the thermal insulation in the building would be in the form of thermal insulation inside and outside. Thermal insulation inside: for heavy and semi heavy walls the insulation is made of building materials or concrete. This kind of insulation may be made up of different materials including polystyrene, polyurethane, and mineral wool. Thermal insulation outside: is usually used for residential buildings; it can be used in heavy and semi-heavy walls with building materials or concrete.

2. Roof: In designing the roofs, limiting temperature imbalance in external part of the roof should be done by minimizing the thermal poles. If in building the slope roof, the method used for thermal insulation of the wall is used, observation of the

relevant regulation is necessary. It should herby be mentioned that, due to the damp insulation on the external layer of the roof, condensation risk in thermal insulation of these roofs are very serious. Therefore necessary preparations should be done to prevent water steam penetrate into the thermal insulator layer.

3. Operable Windows: operable windows are devices through which the residents can find access to other spaces. The examples are doors, the windows to the roof, etc. These windows if not isolated properly, change to places for wasting energy, so we should pay attention to them. In designing the operable windows these issues should be considered: caulking the operable windows is very important in limiting energy waste. It is necessary that the soft components used for air locking the joint fixed and movable parts be resident against ice cycles, ultraviolet radiation and other damaging environmental factors. Moreover, regarding the transparent operable windows, in addition to observing the above mentioned points, isolation is done by using multi walls for the transparent part and using thermal isolating materials for construction the whole or some part of the operable window and the frame. As the metal profiles are used widely in making the operable windows, we can use some methods for limiting the influence of thermal bridges.

4. Floors: for isolating the building floor, if the floor is located on the open spaces such as underground floor, pilot, parking and the like, the technique would be like the one used in isolating the roof. A small difference is no need to the humidity isolator in one side of the isolator as the result of no condensation in the isolator, or the difference between the types of floor making on the roof. For the roofs on the ground, most often the thermal isolator is just necessary for the surrounding edge of the floor. The humidity isolator is necessary for the parts which humidity penetrates

into the isolator. In case those Yonolit isolators or other impenetrable isolators are use regardless of the insulation layer. (Brown.G.Z and Dekay. M, 2000)

Solution No. 5: **Using proper glass for providing brightness, heat and shadow in the windows**

For making balance in daily light, absorption of winter heat and summer shadow, all types of glasses can be used. Transfer of thermal energy through the windows is made by the following methods:

1. Conductive and radiative transfers through the window
2. Receiving solar radiation
3. Receiving or losing thermal energy through air penetration

Transfer of thermal energy through conduction depends on thermal conductivity coefficient of the window which is equal to the amount of heat transferred through the materials. The lower thermal conductivity coefficient means the better isolation. Glass has a lower thermal conductivity coefficient in comparison with other building materials. In the buildings having shell control system (SLD), windows can control heating and cooling charge of the building. So the thermal conductivity coefficient of the window should be decreased in order to control external climatic situations.

In the buildings with sustainable solar heating, reduction of thermal conductivity coefficient is very important in reducing heat waste in winter. This thermal energy which is absorbed by the glass surfaces which receive solar heat can be reserved in building materials and be used at night. In hot climates, the glasses should be able to absorb thermal energy. The low thermal conductivity coefficient of the window is a helping factor. (Brown.G.Z and Dekay. M, 2000)

4-2 Conclusion

Creating sustainable habitats in hot and dry climates needs using sustainable and super sustainable designing methods regarding texture building and constructional details. Due to the special conditions of hot and dry climates, in these climates designing methods for providing comfort are based upon the methods of producing sustainable cooling. Therefore knowing about the sources and different methods of producing sustainable cooling which was studied and discussed widely in the present chapter is one of the primary tasks for designing in these regions. Regarding group buildings, designing wide green passages and linear parks windward, compact designing of the buildings, creating cool leeward passages, designing a texture in harmony with the plants, designing the texture in harmony with water, creating green belts out of plants, creating sheltered passages, etc. would provide cooling conditions. Meanwhile using topography of the location and slope micro climate, creating compactness and moderate distribution within the texture, creating sporadic urban models in hot climates for enjoying cooling breezes, and compact urban models in cool climates with the purpose of reducing winter winds, using natural or artificial wind guards, would result in summer cooling and winter heating.

Solutions such as using vertical and horizontal awnings, designing plans, open and penetrable cuts, creating wide operable windows in leeward and windward facets, creating maximum distance between downstairs and upstairs operable windows in order to increase reception of breezes passing over the building, using thermal materials, using evaporative tower, using water edges, creating narrow yards with high walls are all useful in cooling the building without using expensive machines. We can also create summer cooling and winter heating by creating summer and winter spaces, locating the yard regarding the sun and wind, decreasing building

shell area, using internal thermal energy, dividing internal space to two warm and cold parts, using retaining spaces against undesirable heat and coldness, orienting the rooms toward the sun and wind, using water roofs, designing the building in depth of the earth and designing short and wide yards, for enjoying cool breezes and yards surrounded with high walls for protection against wind while enjoying at the same time sun radiation.

Using building materials in two separate layers, organizing and adjusting the operable windows, using light reservoirs, using awnings providing light, using external and internal awnings, are among cooling solutions. Designing the building shell with enough thickness, color of external surfaces, using thermal materials, using thermal isolator in external surfaces, using multipurpose operable windows for providing light, thermal energy and ventilation in internal spaces, using windows for moderating temperature of air flow before entering the building and reserving thermal energy before exiting the building, using proper glass in windows in order to adjust the amount of light, heat amount received in winter and shadow in summer are among cooling-heating solutions of designing different parts of the building in hot and dry climates.

CHAPTER FIVE

5. CONCLUSION

It seems that nowadays, sustainable development and the related concepts are properly compatible with the purposes of architecture and modern urbanization and can be offered as efficient factor for realizing the aims of sustainability. The structure of neighborhoods and resort and tourist complexes as the sustainable micro cities are built upon people interactions, public transportation and welfare services which provide accessibility to the services, facilities and transportation centers and therefore supply the most essential practical needs namely providing the services, goods and movement.

Regarding the before said discussions we can briefly say that a resort tourist complex is sustainable when it is able to supply all the physical needs of its residents with high density, optimum compactness, mixed applications, public transportation, low traffic jam, disparate transportation with motorbikes, with a hierarchy of facilities and services as well as open and green spaces. In order to provide security needs, such a complex should be quiet, far from environmental, vocal pollutions and exempt from social disorders; the open green spaces should be carefully designed and the distances and privacies between the buildings and sites should be properly observed. In order to fulfill the need to communication and belonging, collective and location sense should be observed in designing the resort and tourist complexes and emphasize social communication in case of not leading to disintegration of the texture. In order to fulfill the need of being respected, designing resort tourist

complexes should be in a way to grant the residents partial independency and self sufficiency. It is necessary also particular identity and conceptual image in the residential units exist.

It should be possible for the people to interfere and supervise the process of designing and constructing resort tourist complexes and contribute in creating visual-formal qualities, designing the elements and details of resort, tourist complexes. In this way their need of creativity would be fulfilled. At last, the sustainable resort tourist complex should be designed in a way that fulfills aesthetical needs. It should be designed in a way that identifying characteristics distinguish it the natural potentials of the location are reserved.

The study intended to show sustainable suggestion in designing sustainable touristic resort complexes with emphasis on static cooling in hot and dry climate and at last as PHD thesis I wish to design a complex which all this studies could help me trough it.

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