HELWAN UNIVERSITY
FACULTY OF ENG. & TECH.
DEPARTEMENT OF ARCHITECTURE

PROGRAMMING THE CLIMATIC DESIGN OF THE HOUSE
(Computer Application)

Thesis
Submitted In Partial Fulfillment Of The Requirements For The Ph.D.
Degree Of Architecture
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ABSTRACT

THE purpose of the present study is to create a computer program to execute a programming pattern of climatic design of house, which must be considered during the sketch plan stage of housing design. The general concept of the proposed programming process starts with the input climatic data and terminates with an output of a specified list of climatic design recommendations sorted according to its relative importance.

The proposed thesis includes the sequence of all studies that should be considered through the process of climatic design of house. The sequence of these studies are presented in four chapters. Chapter one provides a general understanding of the climatic conditions and discuss the climatic data representation methods. Chapter tow describes the human thermal balance, biophysical effects of climate and thermal comfort scales. Chapter three describes the thermal properties of building material and elements, and heat

transfer in buildings. This chapter also presents the climate control strategies. Chapter four describes the most of climatic design applications, which can be used to confirm the human comfortable living conditions.

In chapter five the climatic design of house process as a computer program presented according to the programming process stages. These stages are: input stage, evaluation stage, resolving stage and output stage. The concluded programming pattern of climatic design of house and future work possibilities are presented in the last chapter. A complete package of the proposed program and some application examples are presented in tow appendices.

INTRODUCTION

I- FOREWORD

II- STUDY CONCEPT

III- PROGRAMMING PROCESS

IV- THESIS LAYOUT

I- FOREWORD

CLIMATE has a dominant influence on man and architecture all around the world and all through history. As one of the primary function of any building is to protect the occupants against all of the natural environment stresses by counteracting the main disadvantages of the natural environment.

The natural way to confirm this counteraction can be presented by using the natural effectives which are available from the microclimate at the building site in order to confirm the human comfortable living conditions with the minimum need of mechanical heating and cooling costs.

Climates with changing seasons set a difficult task for the designer. The suitable design solutions for one season may be unsatisfactory for the other seasons. For this reason, the basic climatic data of the building site must be considered in the climatic design process.

The climatic data can be assembled and formed in a simple programming pattern, in order to help the designer to formulate the suitable climatic design recommendations for those climatic features which must be decided during the sketch plan stage of housing design .

In our study of the climatic design of house, practical application of computer-aided architectural design may play a useful role. This application will elicits and systematically translates the mission and objectives of human comfort into appropriate climatic design recommendations.

II- STUDY CONCEPT

IN order to develop a general understanding of the potentials for using computer in the filed of climatic design , it is useful to regard climatic design of house as a special kind of problem-solving process.

The types of analysis that may carry out the feasibility study of an architectural design problem are virtually unlimited. However, feasibility analysis techniques can be used to operate a simple programming pattern of the climatic design of house. Some simple feasibility analysis calculations can be carried out manually or with the aid of an electronic calculator. Larger and more complex design analysis necessitate using the computer-aided architectural design through a computer program .

The pattern of feasibility analysis technique for climatic design of house must be built upon the interrelation among the existing climatic conditions at building environment, human comfortable living conditions, and the effects of the climatic design performance which should be considered to confirm human comfortable living conditions.

The proposed study is intended to provide a practical application of computer-aided architectural design in order to help the architect in the climatic design of house process. This application will presented by a created computer program to execute the climatic design of house process. For example this application will handle the tropics region to present a computer program for climatic design of house.

III- PROGRAMMING PROCESS

THE model of feasibility analysis technique for climatic design of house can be processed through the following four major stages:-

1) Input stage (Existing conditions)
2) Evaluation process (Biological evaluation)
3) Generate solutions (Thermal design principles)
4) Output stage (Climatic design recommendations)

The above stages of the climatic design process can be simplified as shown in figure (A).

The computer could be programmed to execute this programming pattern for climatic design of house. This pattern can be transferred into a computer program, which is capable of storing data in an internal memory of the computer, and of following stored sets of instructions to operate upon data in order to produce desired results.

A common computer programming language such as the C. programming language can be used to executes the climatic design of house process.

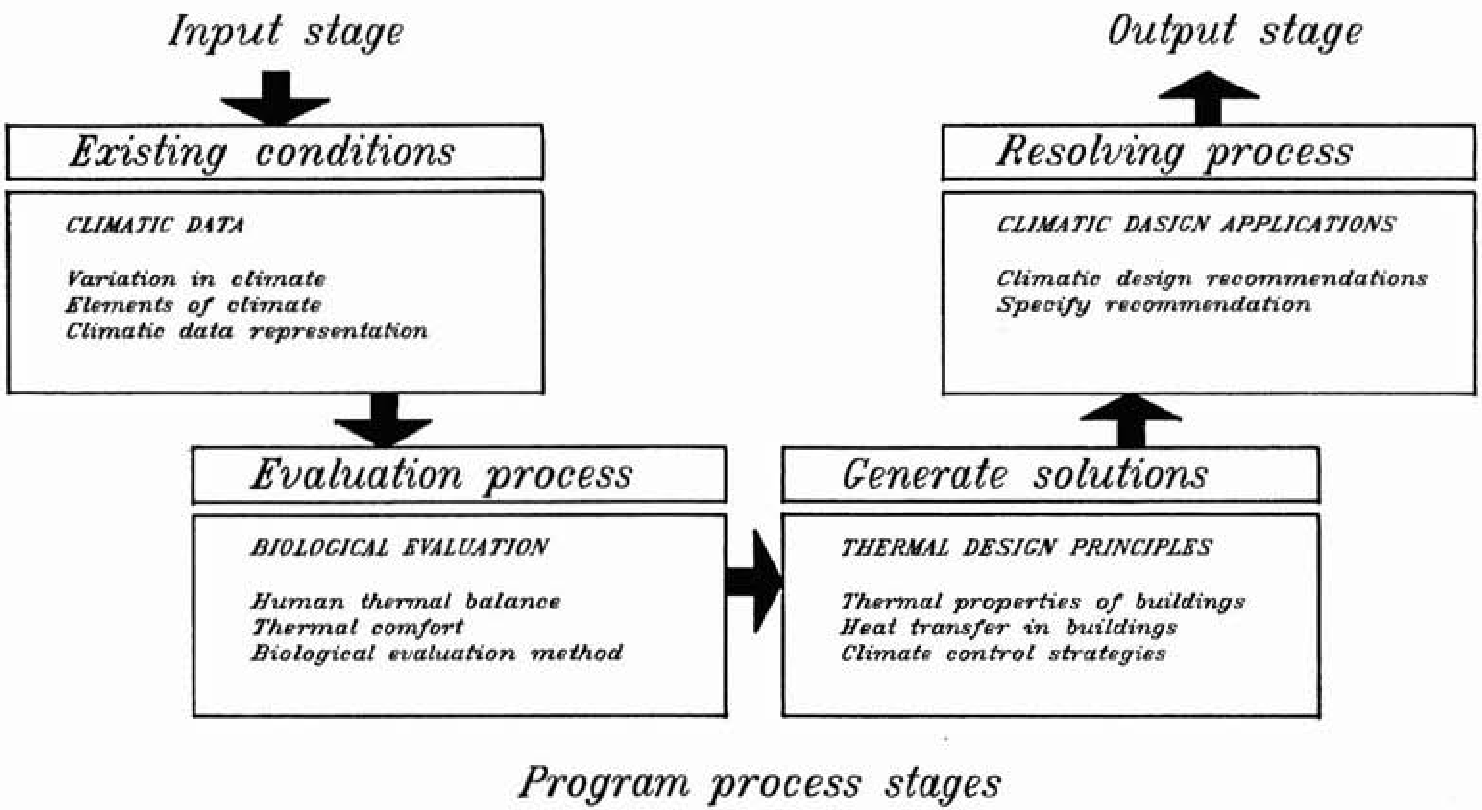

FIGURE (A)

The general form of climatic design of house program

IV- THESIS LAYOUT

THE proposed thesis includes the sequence of all studies which should be considered through the process of climatic design of house. The sequence of these studies are provided as follow:-

Chapter 1, THE BASIC CLIMATIC DATA

This chapter provides a general understanding of the climatic conditions and discuss the climatic data representation methods .

Chapter 2, BIOLOGICAL EVALUATION

This chapter describes the human thermal balance, biophysical effects of climate and thermal comfort scales.

Chapter 3, THERMAL DESIGN PRINCIPLES

This chapter describes the thermal properties of building material and elements , and heat transfer in buildings . This chapter also presents the climate control strategies .

Chapter 4, CLIMATIC DESIGN APPLICATIONS

This chapter describes the most of climatic design applications, which can be used to confirm the human comfortable living conditions.

Chapter 5, CLIMATIC DESIGN PROGRAM

This chapter presents the climatic design of house process as a computer program, written by a computer programming language.

Chapter 6, CONCLUSION AND FUTURE WORK

This chapter presents the concluded programming pattern of climatic design of house and the future work possibilities.

Appendix A

This appendix presents the complete package of all files which created to perform the climatic design of house program.

Appendix B

This appendix presents some applications of the proposed program for some locations in Egypt (for examples).

Chapter 1
THE BASIC CLIMATIC DATA

1.1- INTRODUCTION

1.2- VARIATIONS IN CLIMATE

1.2.1-Latitude effect

1.2.2-Altitude effect

1.2.3-Land and water effect

1.2.4-Winds effect

1.2.5-Atmospheric impurities effect

1.3- ELEMENTS OF CLIMATE

1.3.1- Solar radiation

1.3.2- Air temperature

1.3.3- Relative humidity

1.3.4- Wind

1.3.5- Precipitation

1.4- CLIMATIC DATA REPRESENTATION

1.4.1- Graphic representation

1.4.2- Numeric representation

1.1- INTRODUCTION

THE climate of a specific region can be determined by the pattern of variation of several climatic elements. The aspects of climate are including averages, changes and extremes of temperature, the difference between day and night temperatures (diurnal range), humidity, sky conditions, incoming and outgoing radiation, rainfall and its distribution, air movement and other special features.

The daily and yearly variations of climate conditions are influenced by some natural modifiers. These modifiers and its effect have to be considered in the analysis of the climatic data.

The combinations of the climatic elements have to be considered as the primary phase of the programming pattern of climatic design process. The designer should be interested specifically in those aspects of climate which affect human comfort.

In order to use the climatic data as an existing conditions phase of the programming pattern for climatic design of house, it should relate to a period of at least 10 years since, shorter periods will exhibit variations from the long term average. However, a five year period, although less reliable, may still provide useful information if no other data is available. These data should recorded in the form which help the architect to get a good understanding of the climatic conditions of the building site.

This chapter is intended to provide an overview of climatic variations and the elements of climate. Also at the end of this chapter the climatic data are represented in graphical and numerical forms. The numerical form will be used as the input data of the climatic design of house program.

1.2- VARIATION IN CLIMATE

THE earth receives almost all its energy from the sun in the form of solar radiations. Thus, the sun is the most dominating influence on climate. The regions which are exposed full-face to the sun radiations for a long period of the year are hot. Conversely, the regions which are exposed to the sun radiations for a shorter period of the year are colder.

The modifying effects of microclimatic conditions must be considered in the climatic analysis. The variation in microclimatic conditions at any location are dominated by incoming solar radiation. The amount of this solar radiation are influenced by many natural modifiers. Also manmade forms affects the microclimatic conditions.

The main natural variations in climate are caused by the effects of the changes in altitude, latitude, land and water relationship, winds and atmospheric impurities. The following sections discusses the effects of these changes on climate.

1.2.1- LATITUDE EFFECT

The total amount of received solar radiation to a horizontal surface through a clear sky, depends mainly on the distance from the equator. As one moves away from the equator, the angle that made by the sunshine with the surface of the earth, and the intensity of its heating, decreases; while increases during the summer, when the angle is greater.

The amounts of the received solar radiation at the ground surface through a clear atmosphere at various latitudes are shown in figure (1-1).

Maximum intensity of solar radiation is received on the earth surface normal to the direction of radiation. On 21 June the areas along latitude 23.5 deg. North are normal to the direction of sunshine and the longest daylight period is experienced. At the same time the areas along latitude 23.5 deg. South experiences the shortest day and a minimum radiation. On 21 December this relationship are reversed. This relationship is shown in figure (1-2).

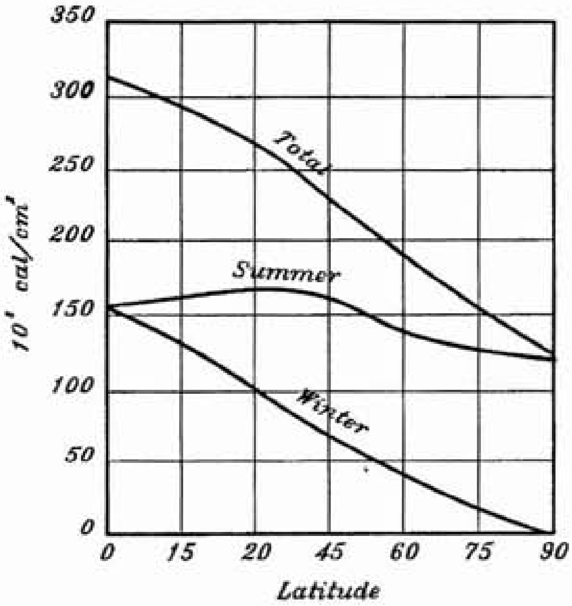

FIG. 1-1 (*)

Radiation received at the ground in clear atmosphere at vairous latitudes

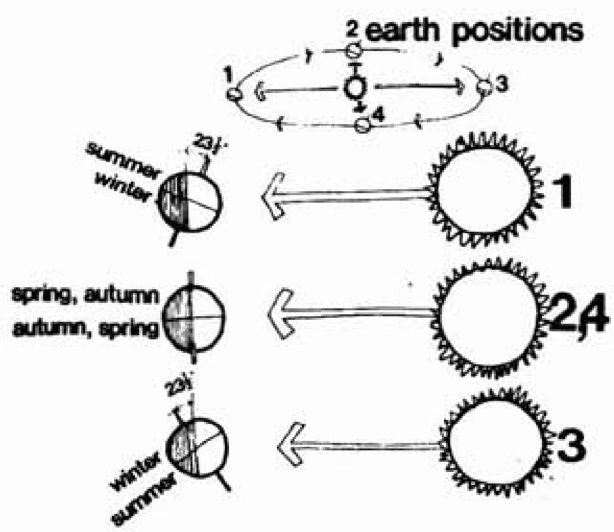

FIG. 1-2 (**)

The earth-sun relationship

(*) DESIGN WITH CLIMATE Vector Olgyay P. 10

(**) SUN/EARTH Alternative Energy Design for Architecture R.L. Crowther P. 45

1.2.2- ALTITUDE EFFECT

Changes in altitude will accordingly cause changes in climate, since, the air temperature near the ground is expected to follow the same general trend with altitude. Also local contours create wind shadows in some spots and expose others to the full effect of free air movement.

In clear atmosphere, temperature decreases with height at the rate of 0.65 deg.C. per 100 m. Because altitude reduces air temperature, the assumption is sometimes built on that the tropical uplands can be regarded as similar to regions of low elevation at higher latitude.

The intensity of solar radiation received on the earth's surface increases with the height above sea level. The variations of direct solar radiation intensity related to the sea level are shown in figure (1-3). Table (1-1) is a guide to the magnitude of some of the variations in climate which may occur with increasing altitude.

TABLE 1-1[*]

Variation in climate with increasing altitude

Climatic variation	Effect of 100 m increases in altitude
Annual mean temperature	0.5 deg C decrease
Monthly range	0.25 deg C decrease
Daily range	Significant increase
Relative humidity	Slight increase
Solar radiation	0.25% increase
Rainfall	Up to 100 mm increase
Wind speed	Significant increase

Note: The values given are indicative only and may not apply in all situations.

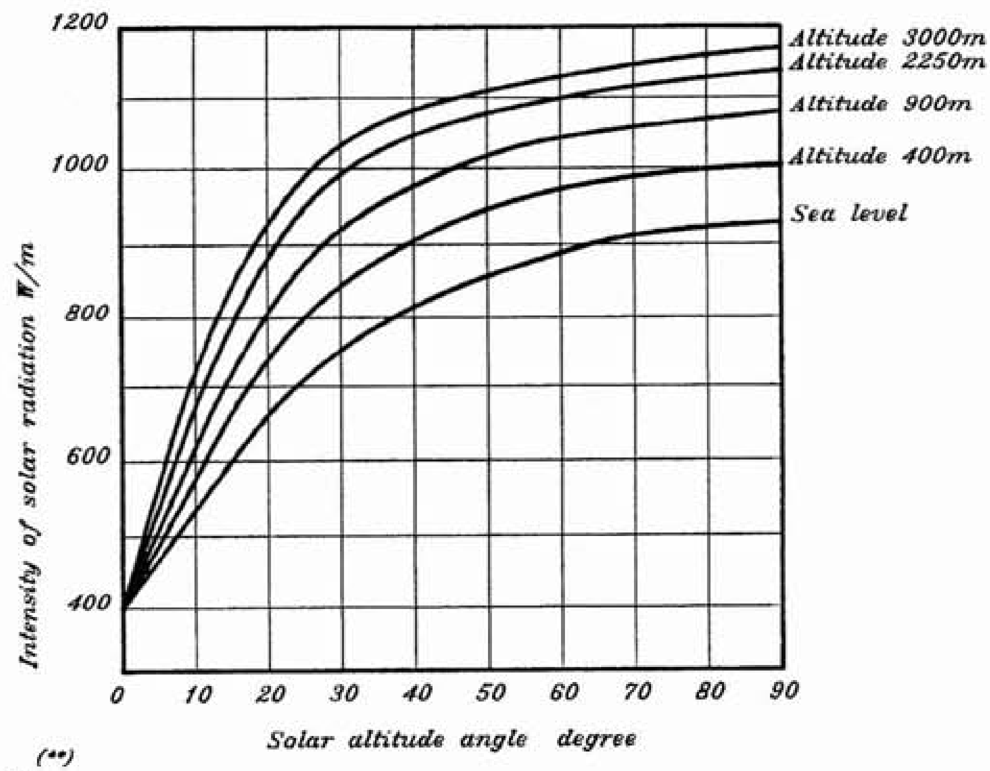

FIG. 1-3[**]
Variation of direct solar radiations intensity related to the sea level

[*] HOUSING, CLIMATE AND COMFORT Martin Evans P. 13
[**] MANUAL OF TROPICAL HOUSING AND BUILDING Part 1, Climatic design P. 6

1.2.3- WIND EFFECT

The effects of the geographical and seasonal variations on air temperature would suffice fairly well if air stayed in the same place. But air is constantly moving across the surface of the earth.

The winds bring air whose temperature depends upon what happened to it at various places during its journey. The air coming from the ocean is generally more equable and moist, while that coming from land is more extreme in temperature and dry. On the other hand, the air coming from polar regions is cold, while that coming from equatorial regions is warm.

The winds distribution and its characteristics, over any region, are determined by several global and local factors. The principal determinants are the seasonal differences in the atmospheric pressure between places, the rotation of the earth, the daily variations in heating and cooling of land and sea, and the topography of the given region. Also the man made forms has an considerable effects.

1.2.4- LAND AND WATER EFFECT

A given amount of direct solar radiation will heat dry earth to a higher temperature than it will heat water or wet earth. This is because dry soil is heated about twice as easily as the same volume of water. Water, moreover, loses some of its heat again by evaporation. The direct effect of costal influences is unlikely to be felt more than 30 km from the coast. The difference between coastal and inland sites will tend to be much greater in dry climates.

By day, when solar radiation heats the land more than the sea, the breeze will develop as the hotter air over the land rises and the cooler air from the sea flows inland to replace it. By night, as the land cools faster than the sea, the breeze is reversed. Table (1-2) summarizes the variation in climate between coastal and inland locations.

TABLE 1-2(*)

Variation in climate between costal and inland sites

Climatic variation	*Effect of 10 km distance from the coast*
Diurnal temperature range	*2-4 deg C increase*
Annual temperature range	*3-6 deg C increase*
Relative humidity	*Usually lower*
Cloud cover	*Usually less*
Solar radiation	*Greater due to lower humidity and cloud cover*
Wind speed	*10-30% drop in on-short winds*
Rainfall	*Usually less*

Note: The values given are indicative only and may not apply in all situations.

(*) HOUSING, CLIMATE AND COMFORT Martin Evans P. 13

1.2.5- ATMOSPHERIC IMPURITIES EFFECT

As solar radiation passes through the earth's atmosphere some of its energy is reflected by the surface of the clouds, and other part is absorbed by atmospheric ingredients such as ozone, water vapor and carbon dioxide, while a certain amount is scattered in all directions by the air molecules themselves.

The absorption amount, which absorbed by the atmospheric impurities, is about 15 percent of the energy which come out of sunshine passing directly through the atmosphere to fall vertically on the surface of the earth. Concerning sunshine falling obliquely on the surface of the earth, and thus passing through greater thicknesses of atmosphere, the absorption percentage will be greater. The depletion is greatly increased by impurities in the air , such as dust and smoke, and by high water vapor content.

1.3- CLIMATIC ELEMENTS

After reviewing the variation in climatic conditions and how the natural modifiers affects the local climatic conditions, these climatic conditions should be determined by basic climatic elements, which affect man's heat balance.

The designer has to understands the local climate at the building site in order to define the appropriate climatic design performance which help to confirm comfortable human living conditions. Before considering human comfort and housing design requirements the climatic data of the building site should be analyzed with the yearly characteristics of their constituent elements.

The main principal climatic elements which must be considered in the climatic design process are solar radiation, air temperature, relative humidity, wind and precipitation.

1.3.1- SOLAR RADIATION

Solar radiation is an electromagnetic radiation emitted from the sun. The solar spectrum is broadly divided into three regions: The ultra-violet, the visible and the infrared. The intensity of solar radiation at the upper limits of the atmosphere varies according to the earth's distance from the sun and the solar activity. The average intensity on a surface perpendicular to the solar rays is 1.94 cal/cm²/min (or 1353 watt/m²) and this value is called the solar constant.[*]

The intensity of the direct solar radiation depends upon the solar altitude, the amount of water vapor, the incidence angle, dust particles and man-made pollutants which the atmosphere contains.

Figure (1-4) shows the solar radiation path through the atmosphere. A part of the incoming solar radiation is reflected by clouds, and part is absorbed by atmospheric ingredients such as ozone, water vapor and carbon dioxide, while a certain amount is scattered in all directions by the air molecules themselves.

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[*] MAN, CLIMATE AND ARCHITECTURE B. Givoni P. 2

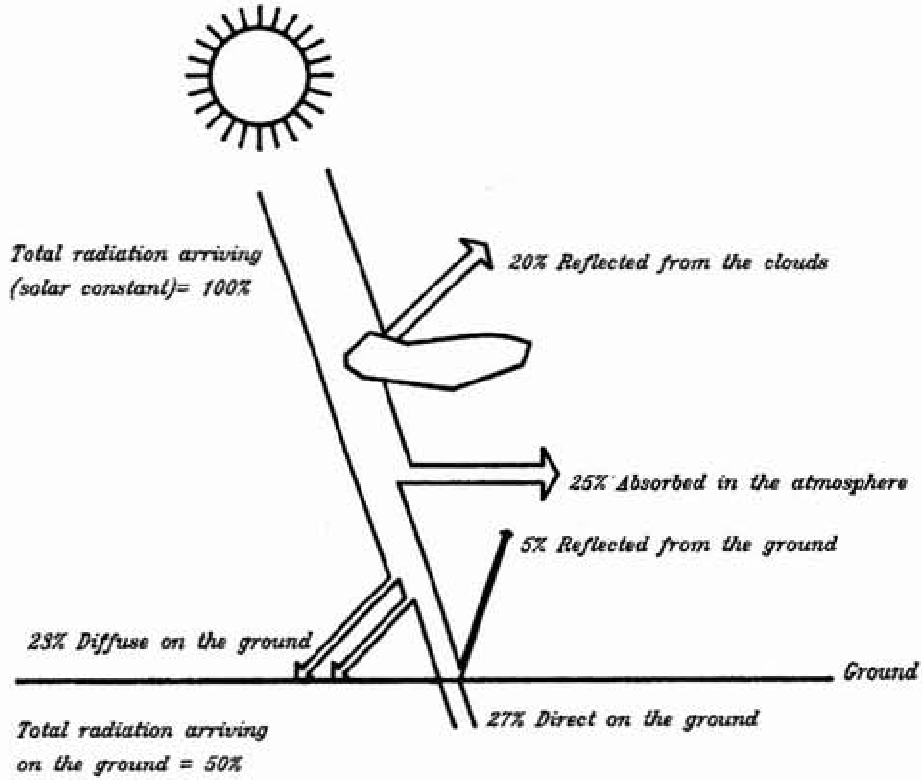


FIG. 1-4 (*)
The passage of solar radiations through the atmosphere

The earth-sun relationship affects the amount of radiation received at a particular point on the earth's surface by three ways:-

First, The cosine low, which states that the intensity on a tilted surface equals the normal intensity times the cosine of the angle of incidence (figure 1-5).

Second, Atmospheric depletion, which is affected by the length of the radiation path through the atmosphere,

(*) DESIGN WITH CLIMATE Vector Olgyay P. 33

the absorption of radiation by ozone, vapor and dust particles in the atmosphere.(figure 1-6).

Third, Duration of sunshine, the length of the daylight period.

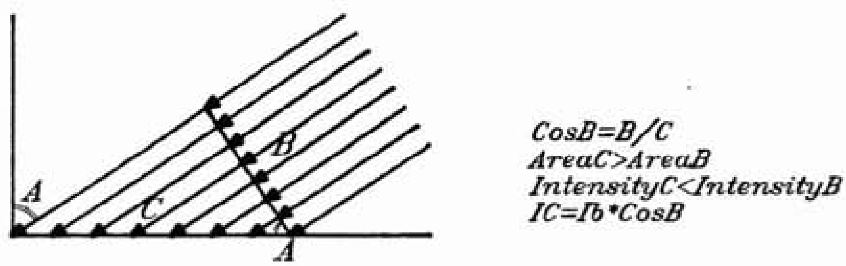


FIG. 1-5(*)

The angle of incidence

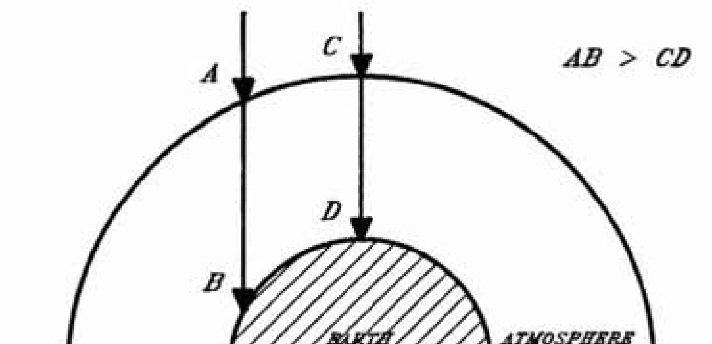


FIG. 1-6(**)

Radiation path length through atmosphere

(*) MANUAL OF TROPICAL HOUSING AND BUILDING Part 1, Climatic design P. 5

(**) MANUAL OF TROPICAL HOUSING AND BUILDING Part 1, Climatic design P. 5

1.3.2- AIR TEMPERATURE

The rate of heating and cooling of the surface of the earth is the main factor determining the temperature of the air above it. The variation of the diurnal temperature depends upon the state of the sky. On clear days a large amount of incoming radiation and a free path for outgoing radiation produce a wide daily temperature range, on overcast days the variation is less.

The air temperature is the lowest just before sunrise, as diffused radiation from the sky causes temperatures to rise even before down. The air temperature is the highest over land about two hours after noon, when the effects of the direct solar radiation and high air temperature already prevailing are combined.

The maximum average and the minimum average temperatures, together with the other averages and extremes, do not give a clear indication of the temperature distribution during the month. Monthly mean temperature can be given for each of the 12 months. The average is taken between each day's maximum and minimum and then the average of the 30 day's average is found. To give an indication of diurnal variation, this can be supplemented by maximum and minimum monthly mean.

It is important for the designer not only to obtain the maximum monthly mean temperature, but also the minimum monthly mean, which will give an indication of the diurnal variations.

In order to give a reasonable accurate conception of air temperature conditions, it is suffusions to establish monthly mean maximum and minimum of air temperature for each of the 12 months. Maximum and minimum monthly mean air temperature is the average of 30 days. These will establish the monthly mean range of air temperature. These values for each of the 12 months are necessary to give an indication of diurnal climatic variations.

1.3.3- RELATIVE HUMIDITY

The expression of "the atmospheric humidity" refers to the water vapor content of the atmosphere. These water vapor gained as a result of the evaporation of the water surfaces and moist ground, and also plant transpiration.

Relative humidity is the ratio of the actual humidity in a given volume of air to the maximum moisture capacity at that particular temperature. On other wards, The relative humidity (RH) is the ratio of the actual amount of moisture present, to the amount of moisture which the air could hold at a given air temperature.

*(*) RH = (AH/SH)*100 [%]*
where AH is the absolute humidity
SH is the saturation-point humidity.

If the air actually contains all the water vapor it can hold, then it is said to be saturated and its relative humidity is 100%. But if the actual vapor content is lesser than the potential content at the same temperature, then the relative humidity is lesser than 100%.

To give an indication of prevailing humidity conditions, it is sufficient to establish the maximum and minimum monthly mean relative humidity values for each of 12 months. The average of 30 days maximum and minimum will establish the maximum and minimum monthly mean and then the monthly mean range of relative humidity is found.

1.3.4- WIND

The distribution and characteristics of the winds over any region, are determined by several global and local factors. The principal determinants are the seasonal differences in atmospheric pressure between

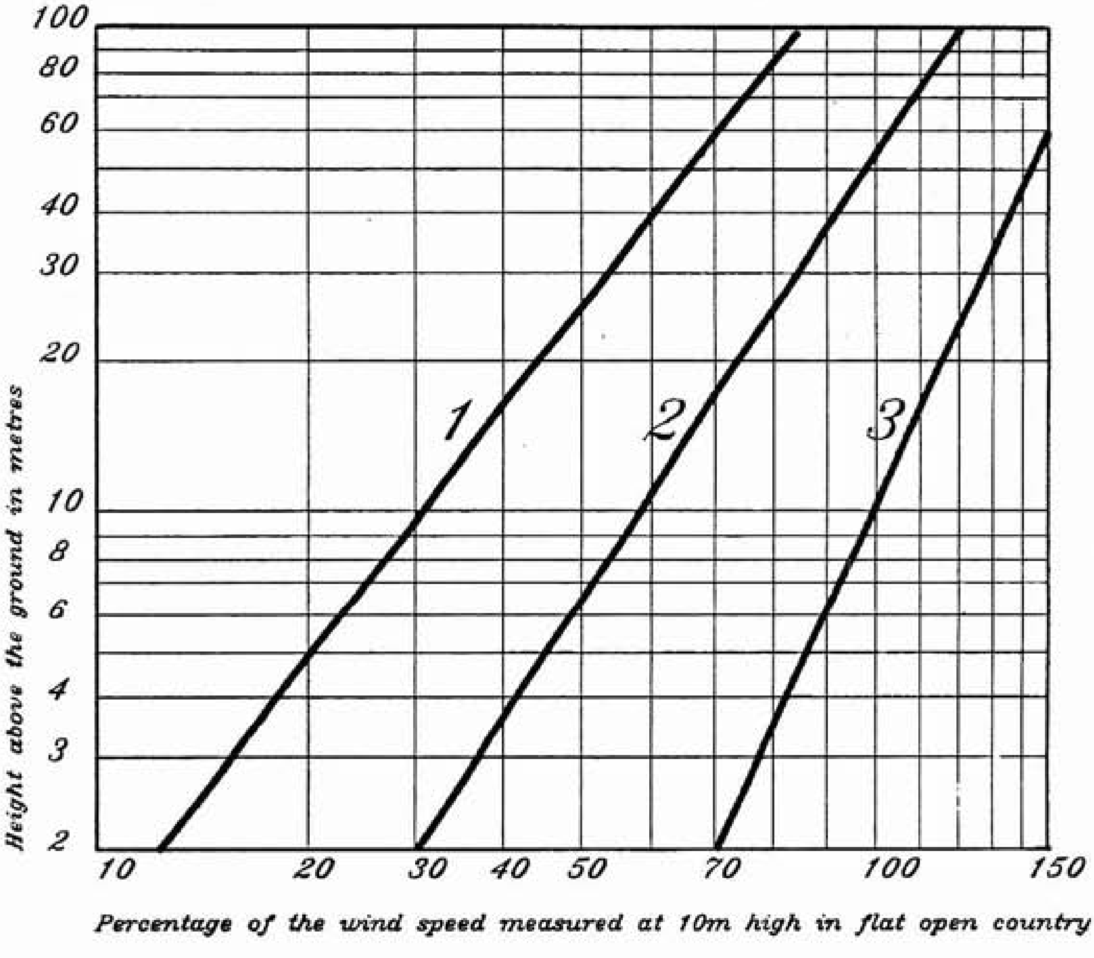
(*) MANUAL OF TROPICAL HOUSING AND BUILDING Part 1, Climatic design P. 14

places, the rotation of the earth, the daily variations in heating and cooling of land and sea, and the topography of of the given region and its surroundings. Also, the mass of air moved by wind system brings with it characteristics has been acquired at its original place and on its way.

Because wind affects ventilation, it can be used for cooling. It can cause driving rain, carry dust and require structures to be strengthened. The designer must try to determine whether there is a prevailing direction of winds, whether predictable daily and seasonal shifts occur. He also must find out the recognizable pattern of daily and seasonal velocities. It is also important for the designer to note the calm periods in each month.

Free wind velocities are normally recorded in open flat areas at a height of 10 m. Velocities near the ground are a good deal lower than the free wind speed. The variation in wind speeds depend largely upon ground cover and topography. Variations of wind speed with height and terrain are shown in figure (1-7).

Wind directions can be grouped into eight categories: the four cardinal (N., E., S., W.) and four semi-cardinal compass points (NE., SE., SW., NW.). Wind velocity is measured in meters per second (m/s).



1 – Wind speed variation with height in urban centers
2 – Wind speed variation with height in suburban areas
3 – Wind speed variation with height in flat open country

FIG. 1-7 (*)
Variation of wind speed related to height

(*) HOUSING, CLIMATE AND COMFORT. Martin Evans P.15

The wind data for a given location is normally provided to give an indication of prevailing and secondary directions and wind speeds for each of the 12 months. For design purposes when considering air movement in relation to human comfort, it is most convenient to express wind speed in meters per second. Several methods of diagrammatic representation have been evolved. Figure(1-8) shows one of these methods.

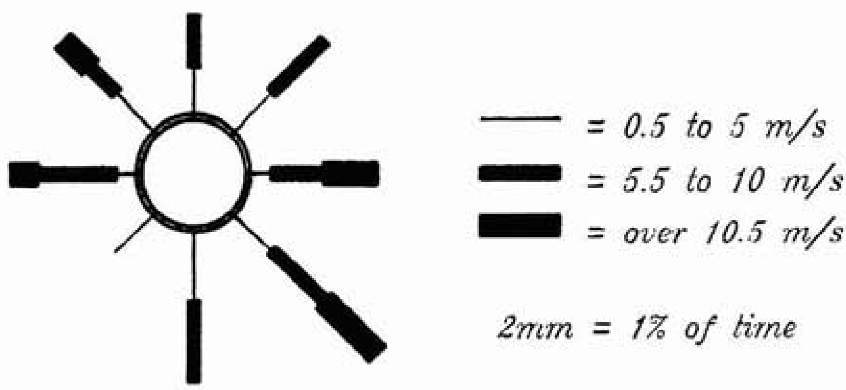


FIG. 1-8 (*)
Wind frequency graph

(*) MANUAL OF TROPICAL HOUSING AND BUILDING. Part 1, Climatic design P. 18

1.3.5- PRECIPITATION

The precipitation is the collective term used for all forms of water deposited from the atmosphere. As air rises, its pressure is reduced and it expands and cools. The required energy for the expansion process is drawn from the energy within the air mass. As mass of rising air cools by expansion, it eventually reach its dew point. Then large scale of condensation occurs, forming clouds composed of tiny water droplets, then finally the precipitation occurs.

Precipitation in the form of rain is expressed in millimeter per a time unit (mm/month or mm/day). Values indicating the total precipitation for each of the 12 months of the year would show the pattern of dry and wet seasons of the year.

It is important to ascertain not only the total rainfall for each month of the year, but also the maximum rainfall for any 24-hour period to be able to ensure appropriate drainage from roofs.

1.4- CLIMATIC DATA REPRESENTATION

IT is not easy to understand the nature of a particular climate conditions by merely looking at the vast amount of data published in the records of the nearest meteorological station. It is necessary to sort, summarize and simplify available data with reference to the objectives and requirements of climatic design.

A certain amounts of the climatic data for a given location must be collected and analyzed. In order to use the climatic data with the computer-aided architectural techniques, these data should be simplified either in graphical or numerical forms. These climatic data are summarized in table (1-3) and may be represented in graphic format or in numeric form.

TABLE 1-3[*]

The basic climatic data.

Climatic variable		Unit
Temperature	Mean	°C. (°F.)
	Mean daily maximum	°C. (°F.)
	Mean daily minimum	°C. (°F.)
	Mean daily range	°C. (°F.)
	Mean monthly maximum	°C. (°F.)
	Mean monthly minimum	°C. (°F.)
Humidity	Mean vapour pressure	mb (Nm²) (mm Hg)
	Mean relative humidity	%
	Mean daily maximum	%
	Mean daily minimum	%
Preciptation	Mean	mm (ins)
	Extreme maximum	mm (ins)
	Extreme minimum	mm (ins)
	Number of days with rain	days
	Maximum in 24 hours	mm (ins)
Wind	Mean speed	km/hr, m/sec, mph
	Frequency of calms	%
	Frequency of wind direction	%
	Mean speed for each direction	km/hr, m/sec, mph
	Frequency speed and direction	%
Solar radiation	Hours of sunshine	hours
	Mean daily radiation	BTU/ft² day, kcal/m² day
Cloud cover	Mean cloud cover	oktars
	Number of days with clear skies	days
	Number of days with overcast skies	days

[*] HOUSING, CLIMATE AND COMFORT Martin Evans P. 5

1.4.1- Graphic representation

To understand a new unfamiliar climate one must relate it to a familiar one then measure and note essential differences. This is best done by using the standard graphic presentation. When the two graphic presentation are placed side by side similarities and differences become apparent and characteristic features can be identified.

For the purpose of showing the diurnal variations throughout the year of climate conditions, an climatic chart can be used such as that shown in figure (1-9).

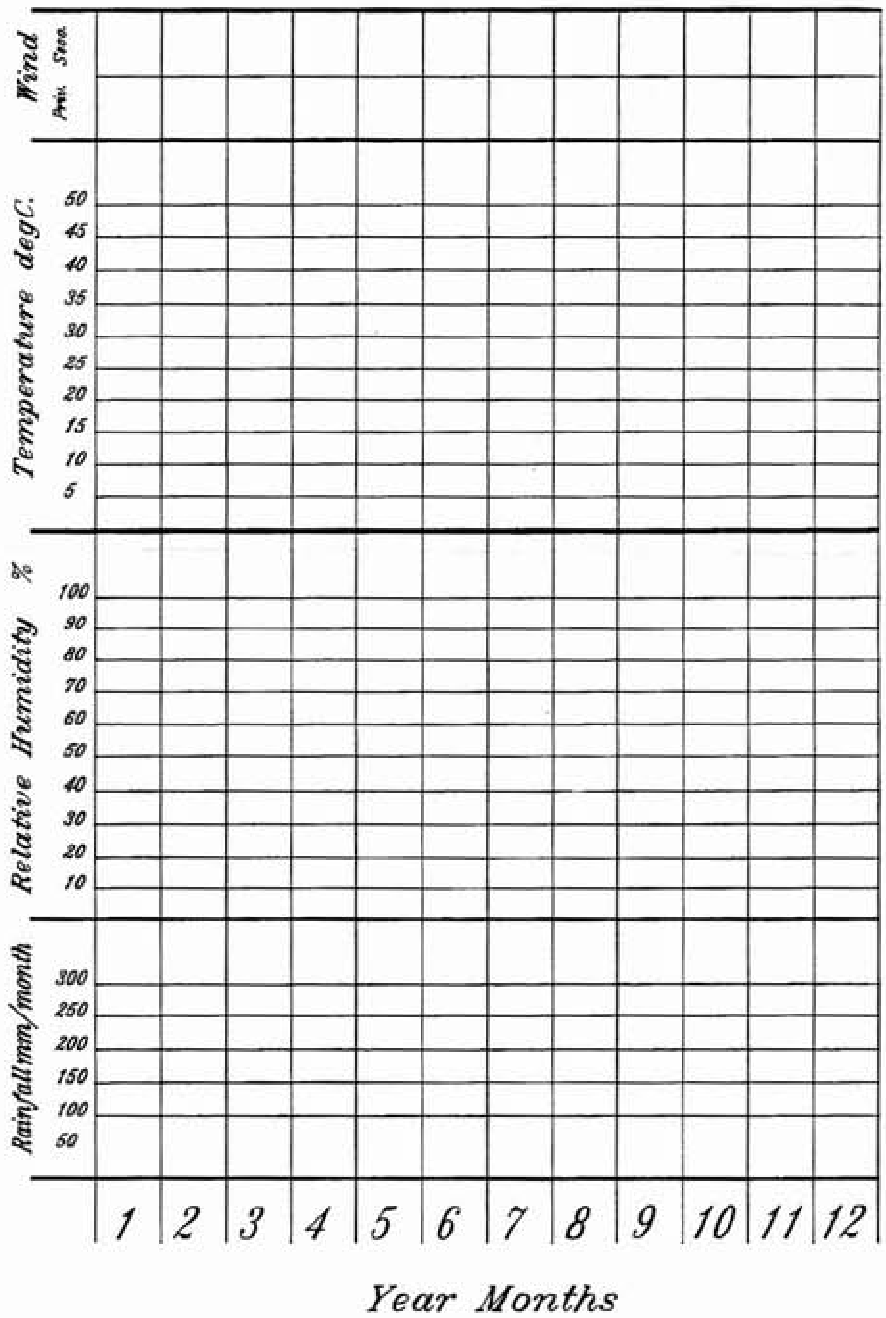


FIG. 1-9
Climatic data chart

1.4.2- Numeric representation

The numerical form of climatic data may be more easier than graphical format to use in feasibility analysis technique, that used in programming pattern for climatic design of house. The basic data of climate can be represented numerically on a data form such as that shown in table (1-4).

In our purpose of programming the climatic design of house, The first function of the computer program is input the existing climatic data. The input data function will be illustrated in details later in chapter five.

TABLE 1-4
Climatic data table

	Location Latitude Longitude Altitude

AIR TEMPERATURE C°	1	2	3	4	5	6	7	8	9	10	11	12
Extreme maximum												
Mean monthly maximum												
Mean daily maximum												
Mean												
Mean daily minimum												
Mean monthly minimum												
Extreme minimum												
Mean diurnal range												

HUMIDITY %

Mean daily maximum												
Mean daily minimum												
Mean humidity												
Mean vapour pressure												

RAIN mm/d

Mean monthly												
Maximum in 24 hours												

SKY

Hours of sunshine												
Cloud cover %												

WIND m/s

Maximum velocity												
Mean velocity												
Prevaling direction												
Secondary direction												

1-5- SUMMARY

THE climatic conditions of a specific location are dominated by incoming solar radiations and the effects of latitude, altitude, wind, atmospheric impurities and manmade forms.

The general principles of climatic variations and climatic elements are the considerations of the present chapter. This is because the first stage in the climatic design of house process is to obtain the basic climatic data of the building sit. The climatic data should recorded related to a period of time by its specific values of air temperature, relative humidity, precipitation, and wind speed and direction.

The numeric representation of the climatic data is the form of the required data which will be used in the climatic design of house process. The climatic data are used in the biological evaluation process which discussed in the next chapter.

Chapter 2
BIOLOGICAL EVALUATION

2.1- INTRODUCTION

THE objective of climatic design process of house is to protect the man against the physical stresses of the natural environment and provide comfortable human living conditions. This process leads to achieve a house design which create comfort at lower cost through reduction of mechanical conditioning. Hence, the impact of climate on human comfort should be considered in biological evaluation of climatic design of house.

The thermal balance between human body and the surrounding environment, should be assembled according to biophysical effect of climate on human body and human physiological and sensory responses to thermal stresses. Also, the relationship of various climatic elements to each other should be considered as a natural correctives which may play a useful role to restore the feeling of comfort.

The effects of climatic elements on human thermal comfort should be assembled from separated studies into a single scale which combines all these effects. This scale can be transferred into a mathematical formula which can be used as the evaluation process.

2.2- HUMAN BODY THERMAL BALANCE

THE thermal balance between the human body and the surrounding environment is one of the primary requirement for comfort. In order to feel comfortable, man must maintain the temperature inside his body within narrow limits. Hence, the thermal balance involves keeping the body temperature within a narrow range, regardless of the relatively wide variations in the surrounding air temperature.

The human comfort can be achieved when the body reaches equilibrium with the environment which depends on the combined effect of many factors such as activity, acclimatization, clothing, air temperature, thermal radiation, humidity and air movement.

The human body heat production should balance heat losses and gains to and from the surrounding environment. When this balance is not achieved, the inner-body temperature rises or falls, as the heat loss is smaller or greater than the heat production, until stabilization is achieved at a new level or until the body collapses. The thermal balance of the human body is shown in figure (2-1)

NG Part 1, Climatic design P. 43

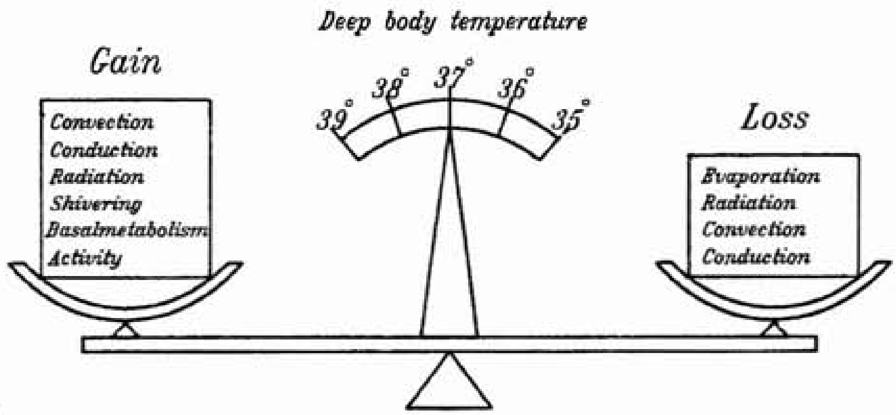


FIG. 2-1 (*)
The thermal balance of human body

2.2.1- METABOLIC HEAT PRODUCTION

The heat production of human body is produced from the process of metabolism. This process is the combines of food in the body with oxygen and generates the energy required for the functions of various organs in the body.

The metabolic rate increases when work is performed in order to provide the needed energy for the work. The level maintained at complete rest in a laying position is referred to as the basal metabolism, although the metabolic level is the lowest during sleep. It is possible to compute the metabolic rate from measurement of the oxygen consumption of the body. Every liter of oxygen which is used in the metabolic process produces on average about 5 kilo-calories.

(*) MANUAL OF TROPICAL HOUSING AND BUILDING Part 1, Climatic design P. 43

For a given level of activity the metabolic rate depends upon age, sex, size and weight of the body. Table (2-1) gives some typical metabolic rate for adult men performing different activities, in Kcal/h/man and Btu/h/man.

TABLE 2-1[*]

Metabolic levels of various activities

ACTIVITY	*METABOLIC PRODUCTION* Kcal/h	Btu/h
Basal Metabolism	*60 - 70*	*240 - 280*
Sitting at rest	*90 - 100*	*360 - 400*
Sedentary activity	*100 - 120*	*400 - 480*
Walking on a level at 4 Km/h	*210 - 270*	*480 - 1080*
Walking on a level at 7 Km/h	*300 - 400*	*1200 - 1600*
Walking up 10% slope at 4 Km/h	*340 - 480*	*1360 - 1920*
Light industrial work	*150 - 300*	--- ---
Moderate industrial work	*300 - 480*	*1200 - 1600*
Heavy industrial work	*450 - 600*	*1800 - 2400*
Very heavy work	*600 - 750*	*2400 - 3000*

2.2.2- HUMAN BODY HEAT EXCHANGE

The heat exchanges between the human body and the surrounding environment processed through four principles of the physical heat flow. These principles are: Conduction, convection, radiation and evaporation. (figure 2-2).

[*] MAN, CLIMATE AND ARCHITECTURE B. Givoni P. 22

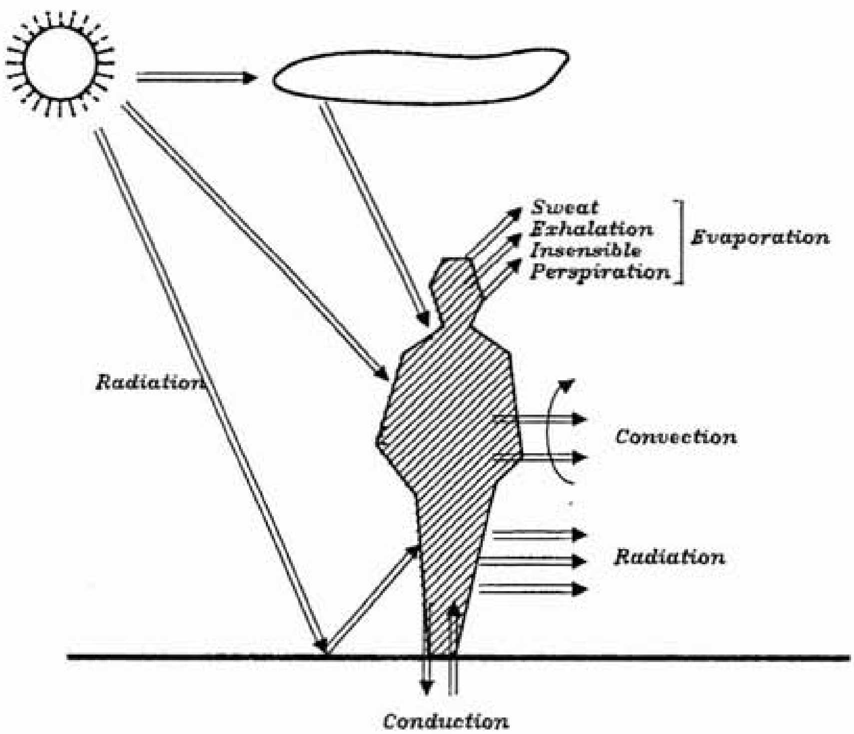


FIG. 2-2 [*]
Human body heat exchange

A- Conduction

When two objects at different temperatures are contacted, heat passes from the warmer to the cooler. This form of heat flow Known as conduction which depends on the temperature difference between the body surface and the object which the body is in contact with. In the case of heat transfer between the skin and air, the rate of transfer is further influenced to an important extent by air movement and clothing.

[*] MANUAL OF TROPICAL HOUSING AND BUILDING Part 1, Climatic design P. 34

B- Convection

Convection is the form of heat flow between the body skin and the surrounding air. The rate of heat exchange between human body and the ambient air by convection, either lose or gain heat, depends mainly on air temperature. Convection is assumed to be linear function of the difference between the temperature of air and the temperature of skin. The rate of heat exchange by convection increased with increasing of the temperature difference between the air and the skin.

C- Evaporation

Heat loss by evaporation can be examined in very much the same way as heat loss by conduction. As water evaporates it absorbs heat from its immediate neighbor; but this evaporation and the consequent cooling can continue only if the evaporated water vapor is free to move away from the site of evaporation. The heat loss by evaporation depends upon the difference between the vapor pressure at the body skin and the vapor pressure of the surrounding air.

D- Radiation

The physics of heat exchange by radiation is rightly regarded as a complex one, because the body is involved in two different types of radiation. The first type is visible and short infrared radiation, which called solar radiation. The second type is long infrared, which called thermal, due to the differences in temperature between the body skin and the surroundings. The heat exchange by radiation operates through five channels listed in table (2-2).

TABLE 2-2(*)

Channels of radiation exchange

CHANNEL	*SPECTRAL TYPE*
1-Solar radiation direct	*Visible and short infrared*
2-Solar radiation reflected on cloud.	*Visible and short infrared*
3-Solar radiation reflected on ground.	*Visible and short infrared*
4-Thermal exchange with ground, etc.	*Long infrared*
5-Thermal loss to sky	*Long infrared*

2.2.3- HUMAN RESPONSES TO THERMAL STRESSES .

Some processes within the body are continuous in order to maintain the temperature inside the body within the required limits. There are varieties of physiological and sensory responses which reflect the strain imposed on the body to maintain thermal balance under stress conditions. These responses also caused by the discrepancy between the rate of heat production and heat loss. Physiological and sensory responses are

(*) PHYSIOLOGICAL OBJECTIVES IN HOT WEATHER HOUSING Douglas H.K. Lee P. 3

effected by changes in the environmental conditions and the rate of physical activity. The main physiological responses are the circulatory regulation, change in skin and inner_body temperatures and weight loss. The main sensory responses are the thermal sensation and the feeling of skin wetness.

A- Circulatory regulation.

Regulation of the blood flow in the peripheral layer of the body is the first physiological mechanism activated to adjust the rate of heat loss to variations in the external environment. The thermal resistance of the subcutaneous layer depends on its blood content. When the blood content of this layer more heat can flow through it by conduction.

When the body is exposed to hot environment, Vase_Dilatation increases the heat transfer from the body core to the skin. This transfer increases the heat loss to the surrounding environment by convection and radiation.

B- Sweating

The evaporation cooling by sweating effect is the principal mechanism of thermal adjustment in the hot conditions, and when working in comfortable conditions. Evaporation from the body takes place in tow forms:

First, Passive water loss from the lungs and the skin, which described as a diffusion process and is caused by vapor pressure difference between the body and the ambient air. This process depends mainly on the metabolic rate, oxygen requirement and on the rate of breathing.

Second, Active sweating, which starts when the dry heat loss by convection, radiation, and insensible perspiration, falls below the rate of heat production.

C- Inner_body temperature.

Normal body temperature at rest and in comfortable environments are relatively constant, when the rectal temperature is about 37 °C and oral temperature about 36,7 °C.

The body temperature varies during the day, according to changes in climatic conditions, having the minimum early in the morning and the maximum late in the evening. The diurnal range is about 0.6 °C, individual variation of +0.3 or -0.3 °C.

D- The skin temperature.

The skin temperature over the body is not constant and consequently temperature gradients between the body core and the skin are different. The heat exchange between the human body and the surrounding air is influenced by the skin temperature by two ways :-

First, Modifying the dry heat exchange through convection and radiation.

Second, Determining the evaporation capacity of the body under the ambient vapor pressure and wind conditions.

E- Thermal sensation.

The perception of hot and cold conditions is a result of natural activity which act as thermo-receptors. There are specific thermo-receptors for warmth and for cold. Under cold exposure the cold receptors are more active in giving the sensation of cold and similarly under exposure to heat, the warmth receptors stimulate a feeling of warmth.

F- Skin wetness

The sensible perspiration response is applicable in warm conditions and in specific combinations of air temperature, humidity, air movement, and metabolic rate. When the rate of sweating increases, or the evaporation capacity of the air decreases, the drops of sweat spread on the skin forming a larger area for contact with the ambient air.

2.3- BIOPHYSICAL EFFECTS OF CLIMATE

THE measurement of climatic effects on human comfort has been investigated in many methods of evaluation. One of these methods describes the negative effects, expressed as stress, pain, disease, and death. Another method defines the conditions in which man's productivity, health, and physical energy are at their highest efficiency.

The quantitative effect of climate on man can be defined as a compound effects of various climatic elements. The major elements of climate which affect human comfort can be categorized as : air temperature effects, humidity effects, air movement effects and solar radiation effects. Also, the interrelationship between climatic elements must be considered to evaluate the biological effects of climate on human comfort.

2.3.1- AIR TEMPERATURE EFFECTS

Under constant conditions of vapor pressure and air movement the human body responds to a rise in the air temperature mainly with an increase of the skin temperature and sweat rate. The rate of this increase depends on the relative humidity level and air movement.

The quantitative effect of changes in the air temperature on the sweat rate at rest, under conditions of low humidity, can be estimated from the formula:

(*) *^S=aV 0.3 (ta-350)*

Where *^S* is the change in sweat rate (g/h), *V* is the air velocity (m/sec), *ta* is the air temperature, and *a* is a coefficient corresponding to the clothing as shown in table(2-3).

TABLE 2-3(**)

Clothing coefficient

CLOTHING	COEFFICIENT
Semi-nude (short or bathing suit only)	26.9
Short trousers + short-sleeved shirt	22.0
Long trousers + long sleeved shirt	19.7

The primary physiological response to a drop in the air temperature below the comfort zone is the contraction of the peripheral blood capillaries, which reduces the flow of blood to the skin. The range of dry bulb temperature

(*) MAN, CLIMATE AND ARCHITECTURE B. Givoni P. 61
(**) MAN, CLIMATE AND ARCHITECTURE B. Givoni P. 61

within which comfortable conditions may be *established is approximately between 16 to 28 °C Below 16 °C excessive clothing or high activity rates are required. Above 30 °C excessive air movement and sweating is required to maintain comfort.*[*]

2.3.2- HUMIDITY EFFECTS

The humidity of the air does not directly affect the human comfort, but it determine the evaporation capacity of the air and hence the cooling efficiency of sweating. The evaporation capacity of the air is determined by the difference between the vapor pressures of the skin and the ambient air. The effect of the air vapor pressure is closely related to the wetness of the skin.

As long as the skin is dry, the rate of sweat secretion and evaporation depends only on the metabolic heat production and the dry heat exchange. When the air is very dry horny layer will form with cracks and fissures in the skin, causing irritation and various skin disturbances. Evaporation decreases dry-bulb temperature by the effect of adding moisture. This moisture will restore comfortable temperature at the outer limit of the comfort zone. (figure 2-3).

[*] HOUSING, CLIMATE AND COMFORT Martin Evans P. 19

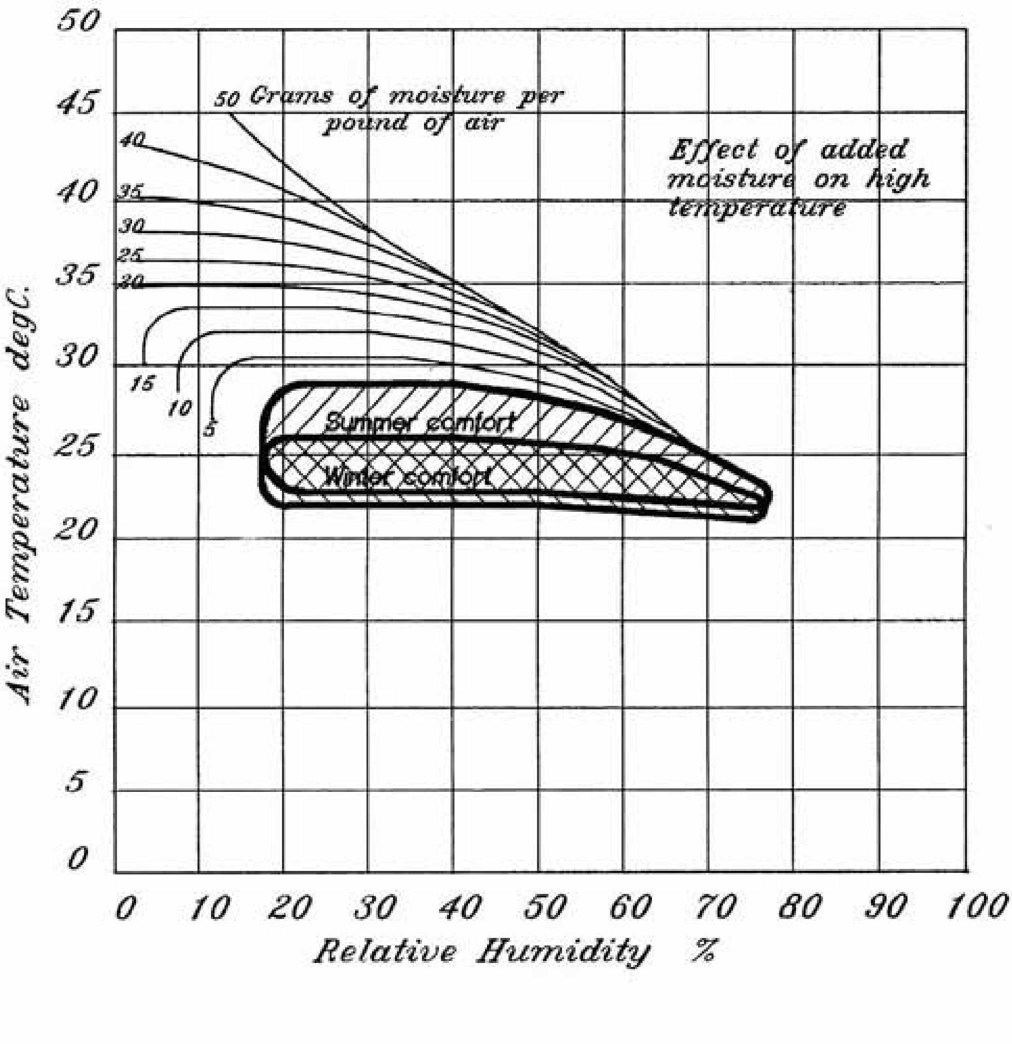


FIG. 2-3[*]
Effect of added moisture on high temperature

[*] DESIGN WITH CLIMATE Vector Olgyay P. 21

2.3.3- AIR MOVEMENT EFFECTS

Air movement affects the human body through its effects on the convection heat exchange of the body, the evaporation capacity of the air, and consequently the cooling efficiency of sweating. For bravely, air movement causes a cooling sensation due to heat loss by convection and due to increased evaporation from human body. The optimum air velocity, which help to restore human comfort, is not constant but depends on the air temperature, relative humidity, metabolic heat production and clothing.

The probable impact of air velocities on human body can be assembled as shown in table(2-4). The wind velocities theoretically needed to restore comfort when air temperature is higher than the comfort zone. (figure 2-4). Also the air motion theoretically needed to restore comfort when relative humidity is higher than the comfort zone. (figure 2-5).

TABLE 2-4(*)

The impact of wind velocities on man

WIND VELOCITY	*PROBABLE IMPACT*
Up to 0.25 m/sec	*Unnoticed*
0.25 to 0.5 m/sec	*Pleasant*
0.5 to 1.0 m/sec	*Generally pleasant but causing a constant awareness of air movement*
1.0 to 1.5 m/sec	*From slightly drafty to annoyingly drafty*
Above 1.5 m/sec	*Requires corrective measures if work and health are to be kept in high efficiency.*

(*) DESIGN WITH CLIMATE Vector Olgyay P. 20

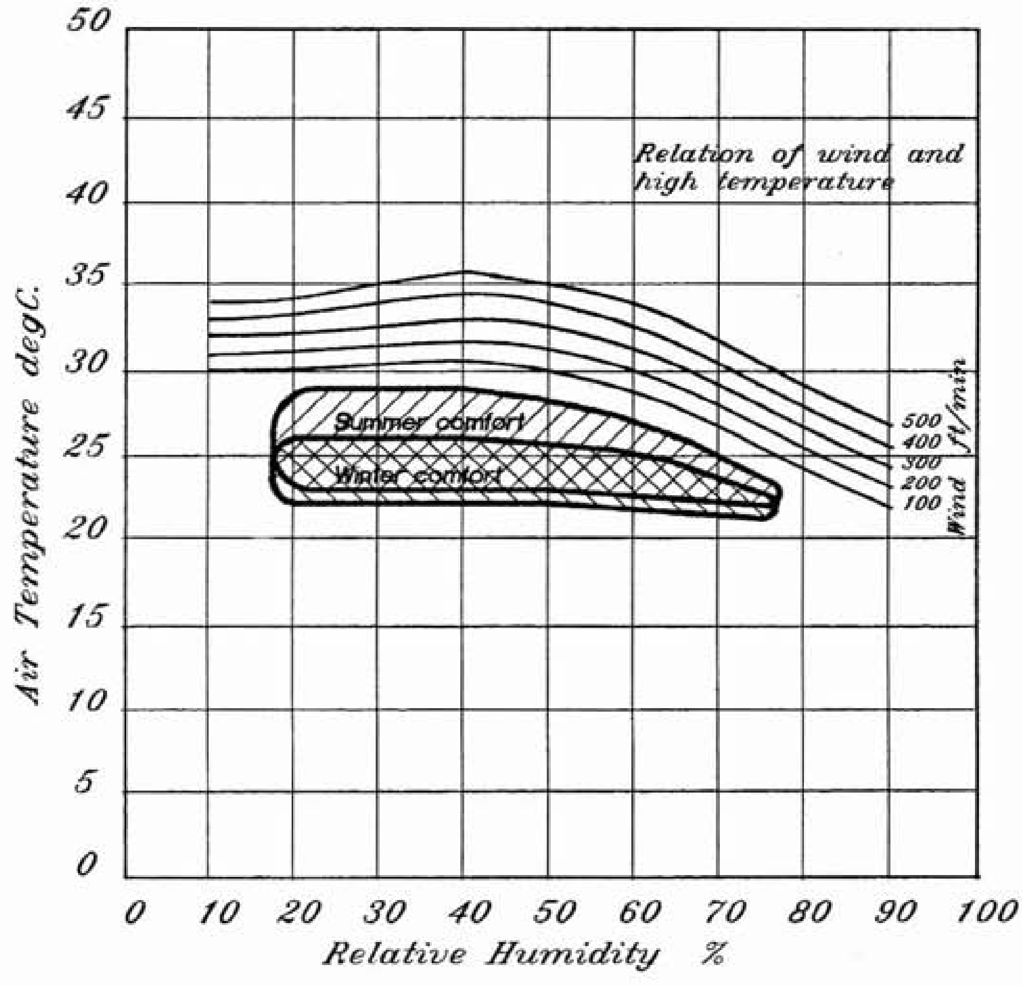


FIG. 2-4 (*)
Relation of wind and high temperature

(*) DESIGN WITH CLIMATE Vector Olgyay P. 20

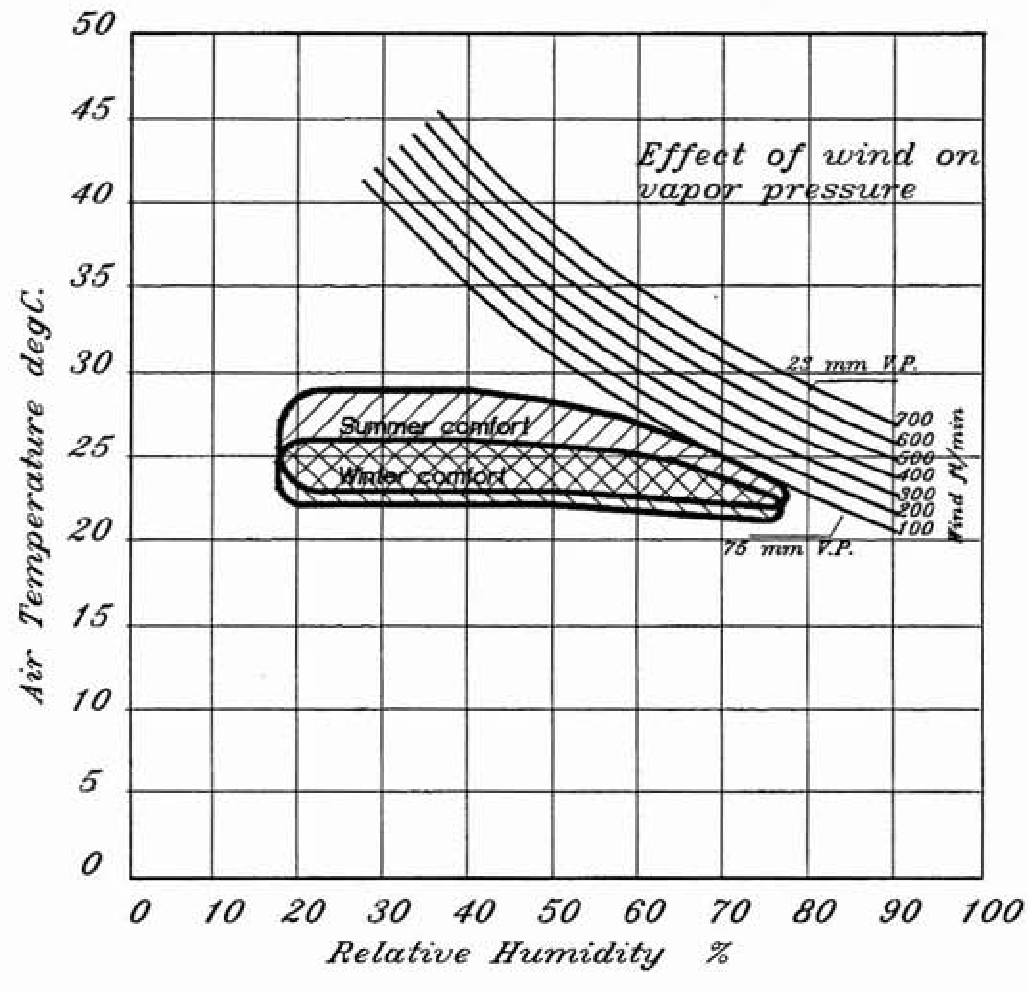


FIG. 2-5 (*)
Effect of air movement on vapor pressure

(*) DESIGN WITH CLIMATE Vector Olgyay P. 20

2.3.4- SOLAR RADIATION EFFECTS

The human body is exposed to solar radiation in three ways ; directly, after reflection from clouds and particles in the atmosphere and after reflection from the ground. Varying proportions of this incident radiation are reflected from the skin or clothing.

Solar radiation has thermal and biological effects on human body. These effects of solar radiation depends on the body's posture with respect to the sun, clothing, reflectivity of the surroundings and air velocity. Also, sweating rate of human body is effected by solar radiation according to clothing and activity of the man. The effects of solar radiation on the increase of sweat rate in relation to clothing and work are demonstrated by the experimental results shown in table (2-5).

Human comfort can be achieved at low air temperature if the heat loss of the body can be counteracted with the sun's radiation. Radiation curves which shown in figure(2-6) indicate that 50 Btu of sun radiation can counteract a 2.14 °C drop in dry-bulb temperature.

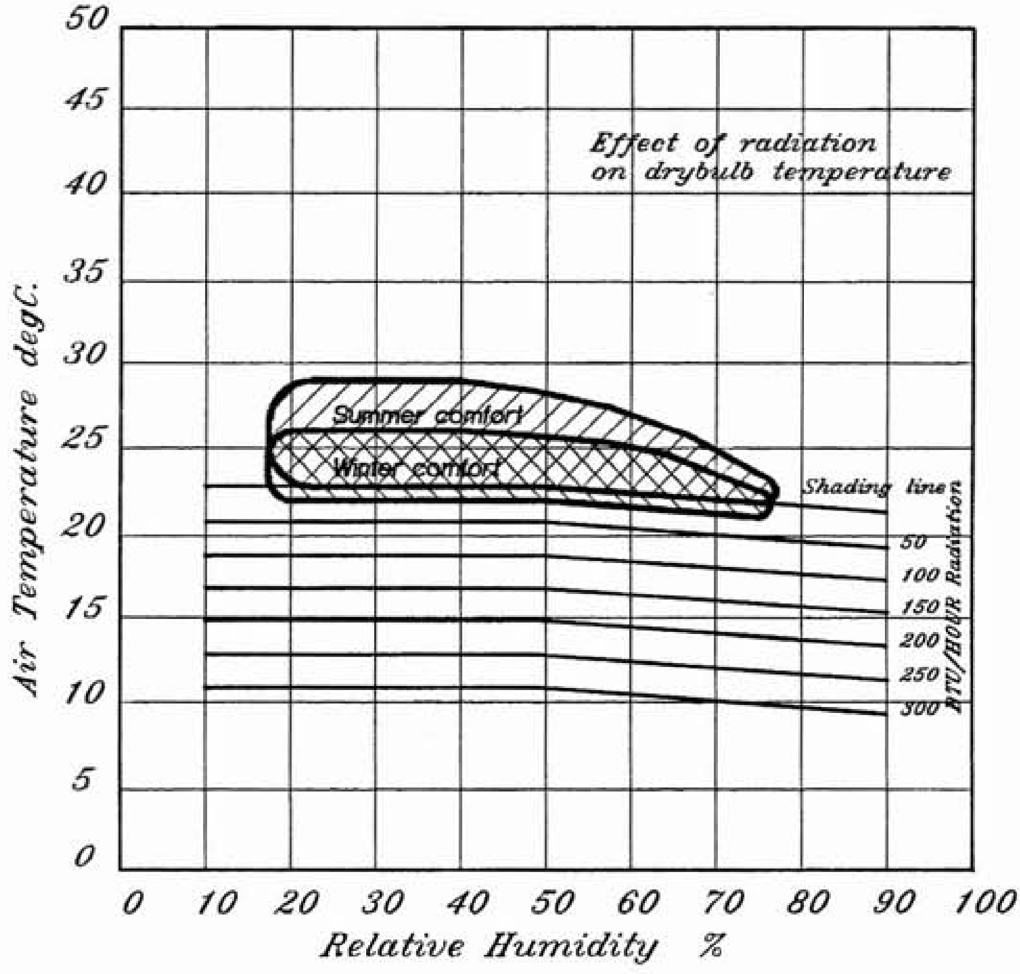


FIG. 2-6 (*)
Relation of radiation and drybulb temperature

(*) DESIGN WITH CLIMATE Vector Olgyay P. 21

TABLE 2-5[*]

Effect of solar radiation on increasing of sweat rate (g/h) in relation to clothing and work

ACTIVITY	SEMI-NUDE	CLOTHING	DIFFERENCE
Setting	324	132	192
Working	240	176	64
Average	282	154	128

[*] MAN, CLIMATE AND ARCHITECTURE B. Givoni P. 71

2.4- THERMAL COMFORT SCALES

THE thermal comfort scale is the second stage of programming pattern for climatic design of house process. It can be used to formulate the biological evaluation method. The range of climatic conditions which is necessary to restore human comfort can be defined as the "Comfort Zone".

The comfort zone does not have real boundaries, since the comfortable conditions are differs with individuals, types of clothing, and the nature of activity. Furthermore, it depends also upon sex, age, and the geographical location. Women in general prefer a little higher temperature than men and persons over 40 years of age generally prefer a little higher temperature than men and women below this age.

Human comfort does not depend only on the air temperature, but also on the relative humidity of the air and air movement. Table(2-6) shows the ranges of comfortable temperatures and humidity for some different conditions.

TABLE 2-6(*)

Comfort temperature ranges

Conditions	*Humidity%*	*Day temp.C°*	*Night temp.C°*
Upper range of comfort with 1m/sec. air movement	*0 - 30*	*32.5 - 29.5*	*29.5 - 27.5*
	30 - 50	*30.5 - 28.5*	*29 - 26.5*
	50 - 70	*29.5 - 27.5*	*28.5 - 26*
	70 - 100	*29 - 26*	*28 - 25.5*
Range of comfort with light summer clothes.	*0 - 30*	*30 - 22.5*	*27.5 - 20*
	30 - 50	*28.5 - 22.5*	*26.5 - 20*
	50 - 70	*27.5 - 22.5*	*26 - 20*
	70 - 100	*27 - 22.5*	*25.5 - 20*
Lower range of comfort with normal or warm clothes and thick bedding at night.	*0 - 30*	*22.5 - 18*	*20 - 16*
	30 - 50	*22.5 - 18*	*20 - 16*
	50 - 70	*22.5 - 18*	*20 - 16*
	70 - 100	*22.5 - 18*	*20 - 16*

After reviewing all the effects of climatic conditions on human body, it is necessary to evaluate the combined effects of climatic elements on the human comfort and to express any combination of these climatic elements in terms of a single formula, known as thermal comfort scale.

There are many attempts have been done in order to devise a single scale which combines the effects of climatic conditions on human thermal comfort. Some scales are based on subjective thermal sensation, while some of them are related to physiological responses.

(*) HOUSING, CLIMATE AND COMFORT Martin Evans P. 23

Most existing indices have some limitations in their practical application and usefulness under different conditions. Some of these difficulties arise from the fact that the experiments were carried out under widely varying indoor climatic conditions. Also the experimental methods were different. As a consequence of this, each of the indices is valid and useful for a limited range of conditions - not universally.(*)

2.4.1- EFFECTIVE TEMPERATURE

Effective temperature scale is frequently used scales of thermal sensation but it overestimates the effect of humidity both at cool and comfortable temperature, and at very high temperature.

The Effective Temperature scale can be defined as the temperature of the air at 100% relative humidity which give the same thermal sensation as a given combination of air temperature, humidity, air movement and mean radiant temperature. Figure(2-7) shows the effective temperature nomogram as the normal scale, valid for persons wearing normal, light, indoor clothes.

(*) MANUAL OF TROPICAL HOUSING AND BUILDING Part 1, Climatic design P. 50

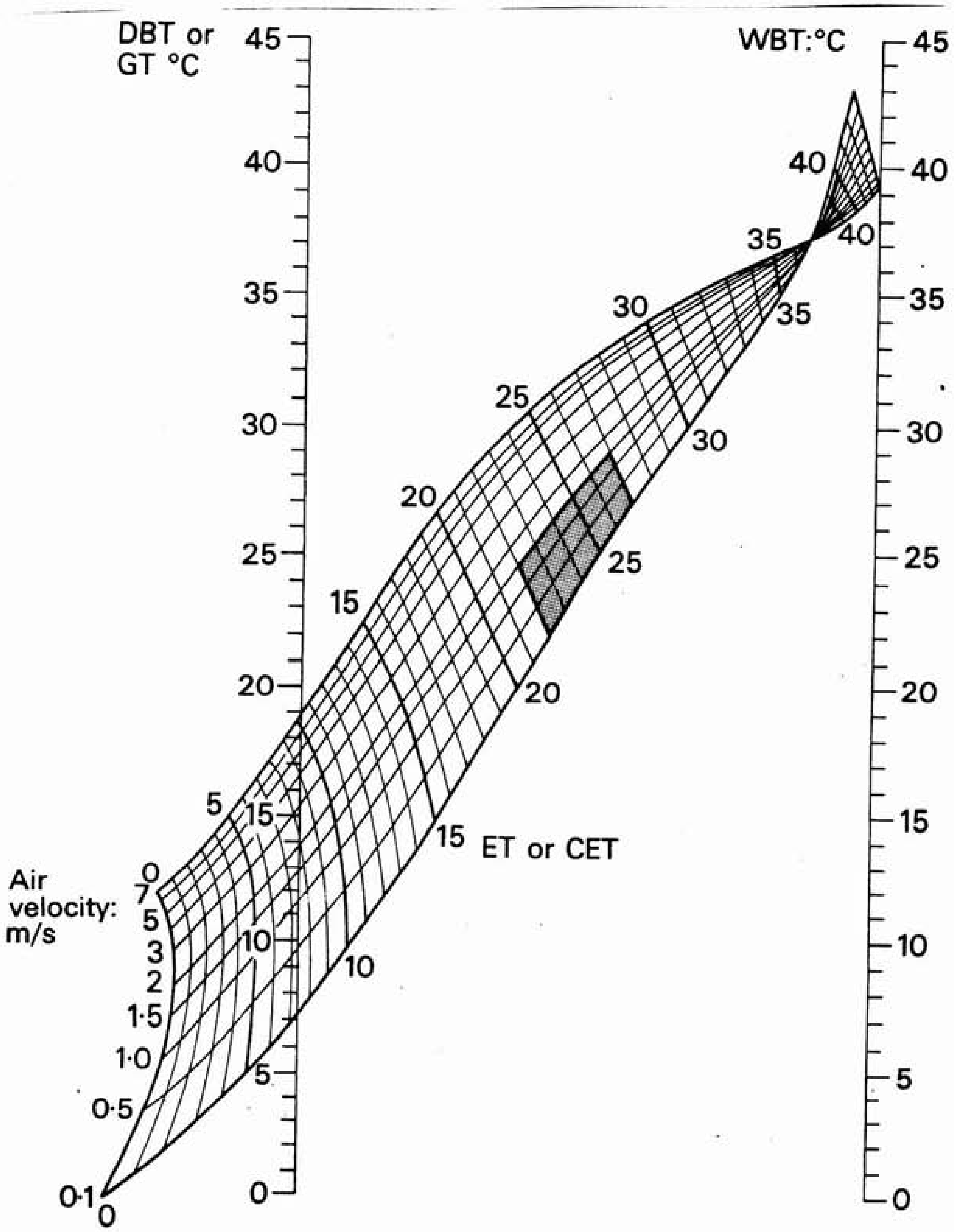


FIG. 2-7[*]
Effective Temperature Nomogram

(*) MANUAL OF TROPICAL HOUSING AND BUILDING Part 1, Climatic design P. 54

2.4.2- INDEX OF THERMAL STRESS(INS)

The Index of Thermal Stress is based on the quantity of sweat required to maintain a skin temperature of 35 °C. When the sweat rate is between 0 and 100 gm/hr the thermal comfort is achieved. The variables included in the formula to establish the Index of Thermal Stress are air temperature, humidity, air movement, solar radiation, metabolic rate and clothing. When the air temperature is below 20 °C sweat no longer affects in the control of body temperature. So, the Index of Thermal Stress can cover the range of climatic conditions in most climates except that below 20 °C of air temperature.

2.4.3- BIOCLIMATIC CHART

One of the most important comfort scales is the Bioclimatic Chart. The present study will be based on the bioclimatic chart which is developed by V.Olgyay. Vector Olgyay proposed a systematic procedure for adapting the design of a building according to local climatic conditions and human requirements to feel comfortable. The Olgyay's procedure built up by using Bioclimatic Chart, which can be defined as a temperature-humidity diagram used to display the comfort needs of a sedentary person.(figure 2-8).

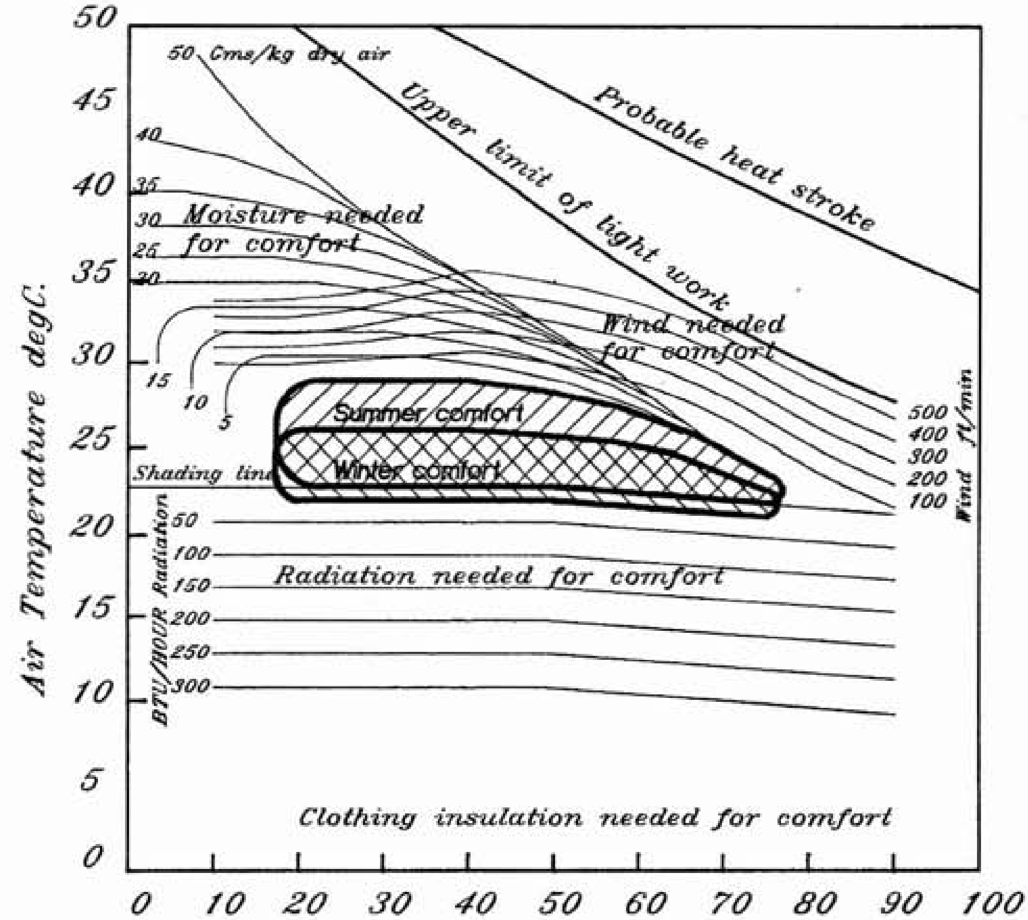


FIG. 2-8(*)
Bioclimatic Chart

(*) DESIGN WITH CLIMATE Vector Olgyay P. 22

The Bioclimatic Chart shows the combination of air temperature (on a vertical scale) and relative humidity (on a horizontal scale). Also the chart shows the corrective measures which are required when the combination of temperature and humidity are falls outside of the comfort zone. These corrective measures include air movement, radiant heating, radiant cooling and evaporation cooling.

Any climatic condition determined by its dry-bulb temperature and relative humidity can be plotted on the chart. If the plotted point falls into the comfort zone, man feel comfortable in shade. If the point falls outside the comfort zone, the corrective measures be needed. Then, the climatic control strategies are needed according to the point location and choice the required climatic design recommendations which elicits to restore comfortable human living condition.

In order to use the bioclimatic chart to execute the biological evaluation process by using the computer aid, the chart should be simplified in the form which can be transfered into a mathematical method. For this reason we can divide the bioclimatic chart according to its curves into fifteen zones as shown in figure (2-9). Each of these fifteen zones refers to define the corrective measures which required when the combination of temperature and humidity falls inside that zone.

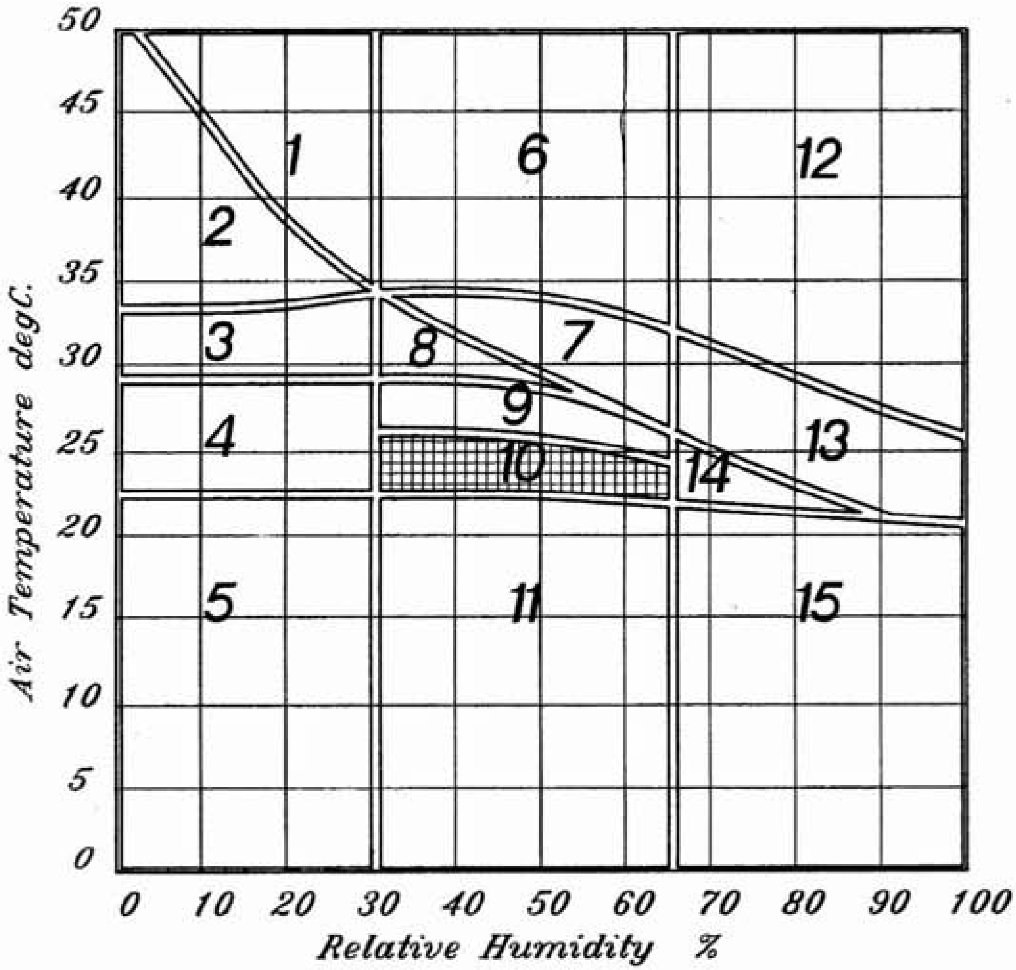


FIG. 2-9
Bioclimatic Chart Zones

2.5- SUMMARY

THE impact of climatic conditions on human body is the compound effects of the various climatic elements. The correlation between climatic elements should be considered to evaluate the biological effects of climate on human thermal comfort.

The comfort limits does not depend only on the air temperature, but also on the relative humidity and air movement. So the impact of climatic conditions on human comfort should be considered in the climatic design of house process. It is necessary to evaluate the effect of climatic elements on human comfort by using a thermal comfort scale.

The proposed program will use the bioclimatic chart as a comfort scale. This chart can be developed as shown in figure (2-9) which can be used as the biological evaluation scale in order to specify the needed climatic design recommendations.

Chapter 3
THERMAL DESIGN PRINCIPLES

3.1- INTRODUCTION

AFTER surveying the given climatic condition and showing the dependence of human comfort with thermal conditions, it is necessary to clarify the basic thermal design principles. Designing houses to take advantage of natural effects, in order to confirm human comfort, should utilize natural possibilities to improve indoor conditions without the aid of mechanical apparatus.

The process of heat flow through building envelope from the external surface to the internal surface may be visualized by considering the thermal properties of building material which used to construct the building envelope. The structure of building envelope may be contain several layers. The heat flow through each layer causes changes of its temperature.

The nature of heat exchange through the building elements is affected by the thermal properties of building materials which used to construct the building elements. Then, it is necessary to clarify some basic physical facts regarding the nature of heat exchange and ways of its propagation.

3.2- THERMAL PROPERTIES OF BUILDING MATERIALS

THE building envelop modify the interior climatic conditions according to the nature of heat exchange through the outer building elements. When appropriate thermal properties for building materials and elements are chosen, it will be possible to achieve and maintain the comfortable living conditions.

An outline of the thermal quantities and of the thermal properties of building materials and elements is given under the next subtitles.

The thermal resistance and heat capacity of a given multi-layers building element (Walls and Roofs) depends on the thermal properties of the used building materials. In order to provide sufficient information to evaluate the thermal performance of the building elements, the thermal properties of building materials should be considered.

The primary thermal properties which determine the way in which building materials absorb and transmit heat are conductivity, thermal capacity, and surface characteristics.

3.2.1- CONDUCTIVITY

Conductivity is the rate of heat flow in a time unit by conduction from one surface to the other surface of material through an area unit of a thickness unit when there is a unit difference in temperature between the tow surfaces. It is assumed that the temperature on either side of the material, and the distribution of temperature through the material, are uniform and constant with time. Conductivity is expressed in K.cal/h m^2 °C/m(*)

3.2.2- THERMAL CAPACITY

The term thermal capacity of a material refers to the amount of heat required to raise the temperature of a volume unit of the material by a unit difference in temperature. Materials are heated differently by the same quantity of heat, according to the product of their specific heat and density. The thermal capacities of materials are only significant when thermal conditions are fluctuating. Under steady state conditions, the thermal capacity has a little effect.

(*) MAN, CLIMATE AND ARCHITECTURE B. Givoni P. 105

3.2.3- SURFACE CHARACTERISTICS

The external surface of any building material has three properties namely its absorbtivity, reflectivity and emissivity. Absorbtivity is the property of the material surface which determine the proportion of thermal radiation falling on the surface which be absorbed. Most of the material surfaces absorb only part of the incident thermal radiation and reflect a part of this radiation (figure 3-1).

The emissivity is the relative power of a material to emit radiant energy. The color of a material surface gives an indication of its absorbtivity for solar radiation. The absorbtivity decreases and the reflectivity increases with lightness of color. Table(3-1) gives typical values of absorbtivity and emissivity for various surfaces types and colors.

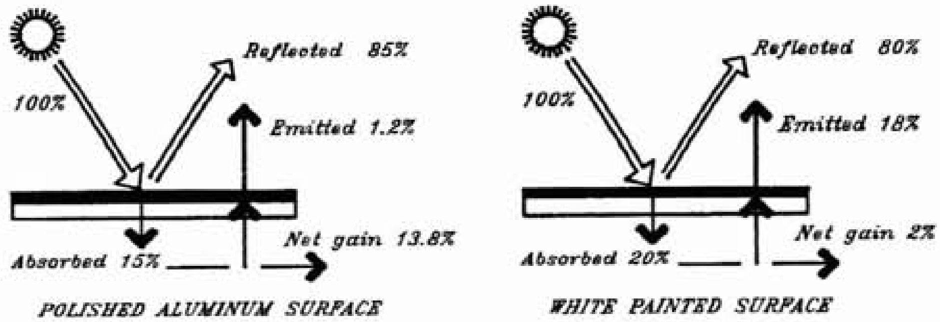


FIG. 3-1 (*)
Surface properties of some materials

(*) CLIMATIC DESIGN Donald Watson, FAIA, and Kenneth labs P. 163

TABLE 3-1(*)

Absorptivities and emissivities of various surfaces

MATERIAL OR COLOR	SHORTWAVE ABSORPTIVITY	LONGWAVE EMISSIVITY
Aluminum foil, bright	0.05	0.05
Aluminum foil, oxidized	0.15	0.12
Aluminum paint	0.50	0.50
Galvanized steel, bright	0.25	0.25
Whitewash, new	0.12	0.90
White oil paint	0.20	0.90
Grey color, light	0.40	0.90
Grey color, dark	0.70	0.90
Green color, light	0.40	0.90
Green color, dark	0.70	0.90
Ordinary black color	0.85	0.90

(*) MAN, CLIMATE AND ARCHITECTURE B. Givoni P. 108

3.3- THERMAL PROPERTIES OF BUILDING ELEMENTS

THE building envelope separates the indoor space from the external environment and modifies or prevents the direct effect of climatic variable such as outdoor air temperature, humidity, wind, solar radiation and rain. The ratio of the internal to the external temperature depends on the thermo-physical properties and thickness of the structure materials which affect the thermal properties of the building elements.

The primary thermal properties which determine the way in which building elements absorb and transmit heat are thermal transmittance, thermal admittance, thermal resistance, solar heat flow, and time lag.

3.3.1- THERMAL ADMITTANCE

The admittance is the ability of the surface of the building element to absorb or transmit heat to or from the air which adjacent to the surface when the air temperature is different from the temperature of the surface. The thermal admittance is expressed in w/m2°C

The approximate increase in internal temperature of a space is given by the formula :-

[*] $dt = Q / (\text{sum } A*a + x)$

Where
dt = Temperature increase.
*sum A*a = Sum of the admittance of each surface * area of each surface A1*a1 + A2*a2 + ...*
Q = Total rate of heat gain within the space.
x = Allowance for the heat capacity of the air and the heat transfer through windows.

The heavy materials such as brick and concrete achieve high admittance, while low admittance is achieved to the thin layers of materials with air cavities. Values for admittance of some building elements are given in table(3-2).

[*] HOUSING, CLIMATE AND COMFORT Martin Evans P. 83

TABLE 3-2[*]

Thermal admittance of building elements

ELEMENT CONSTRUCTION	ADMITTANCE W/m2 degC.
WALLS:	
Lightweight or hollow block, more than 75 mm thick (650 Kg/m3)..................	3.0
Hollow concrete or clay block, more than 75 mm thick (1100 Kg/m3).................	4.0
Brick, more than 75 mm thick (1700 Kg/m3)........	5.0
Concrete, more than 75 mm thick (2200 Kg/m3).....	6.0
Two fiber board sheets, 13 mm thick with an air space between them.....................	2.0
Partitions of material, over 1100 Kg/m3 with a lining of resistance 0.18m2 degC/w......	3.0
FLOORS:	
Dense concrete..................................	6.0
Concrete covered with carpet or wood block.......	3.0
Suspended timber floor..........................	2.0
Suspended timber floor covered with carpet.......	1.5
CEILINGS:	
Plastered concrete..............................	6.0
Plasterboard, cavity and dense slab.............	3.0
Lath and plaster or plasterboard ceiling with roof cavity and pitched roof...............	2.0
WINDOWS: Calculate the heat flow according to the "U" value, radiation heat gain, and ventilation heat loss or gain.	

[*] HOUSING, CLIMATE AND COMFORT Martin Evans P. 161

3.3.2- THERMAL RESISTANCE

The actual heat flow across a given building element (Wall or Roof) depends not only on the thermal conductivity (y) of the material, but also on the thickness (d) of the element.

Therefor the thermal resistance (r) of the building element is defined by :- $r = d/y$

When computing the rate of heat flow between indoor and outdoor air, the thermal resistance of both surfaces must be added to the thermal resistance of the element itself. The overall thermal resistance (R) of a single layer building element is given by :-

(*) $R = 1/hi + d/y + 1/ho$

(hi & ho are the thermal conductivity of both inside and outside surfaces of the element).

When the element is composed of several layers, the overall thermal resistance is the sum of the separate resistances of the layers. Thus overall resistance is :-

(**) $R = 1/hi + d1/y1 + d2/y2 + \ldots + 1/ho$

(*) MAN, CLIMATE AND ARCHITECTURE B. Givoni P. 105
(**) MAN, CLIMATE AND ARCHITECTURE B. Givoni P. 105

3.3.3- SOLAR HEAT FLOW

At night, both the outdoor air and the external surfaces of the outer building elements are at their minimum temperature. After sunrise the outdoor air temperature increases which causes heat flow to the external surfaces of building element and raising its temperature.

The heat flow through a building element is derived from solar radiation. The sol-air temperature is the theoretical temperature of the air which will result from solar radiation. The formula for sol-air temperature in a simplified form is :-

(*) *tsa = to + &Iro - x*

Where
tsa = Sol-air temperature
to = External air temperature
& = Absorbtivity of the surface to solar radiation
I = Incident solar radiation
ro = External surface resistance
x = Drop in temperature due to radiation emitted from the surface.

The amount of solar heat flow (q) through a building element, when solar radiation falls on the external surface, depend on the absorbtivity (&) of the surface and total heat flow (U) of the element construction. The heat flow through the building

(*) HOUSING, CLIMATE AND COMFORT Martin Evans P. 78

element subject to solar radiation per unit area can be calculated as follow :-

[*] $q = U\ (to - \& * I * ro - ti)$

Where ti is the inside air temperature

3.3.4- TIME LAG

The variation of climatic conditions produce a non-steady state conditions. The effect of this variations on building is that in hot period heat flows from the external environment into the building and at night during the cool period the heat flow is reversed. The time lag is the delay between the impact of the diurnal variation of temperature and radiation on the external surface, and the resultant temperature variation on the internal surfaces.

Figure(3-2) shows the diurnal variation of external and internal temperature as a function of time.

In practical work the time lag (O) and the decrement factor (U) values are used. This can be calculated for a particular construction, but the method is rather involved and not well tested. Values of (O) and (U) can also be determined experimentally.[**]

[*] HOUSING, CLIMATE AND COMFORT Martin Evans P. 79

[**] MANUAL OF TROPICAL HOUSING AND BUILDING Part 1, Climatic design P. 86

Figure(3-3) gives a graphic indication of these values and table(3-3) lists the (O) and (U) values of several frequently used constructions.

TABLE 3-3 (*)

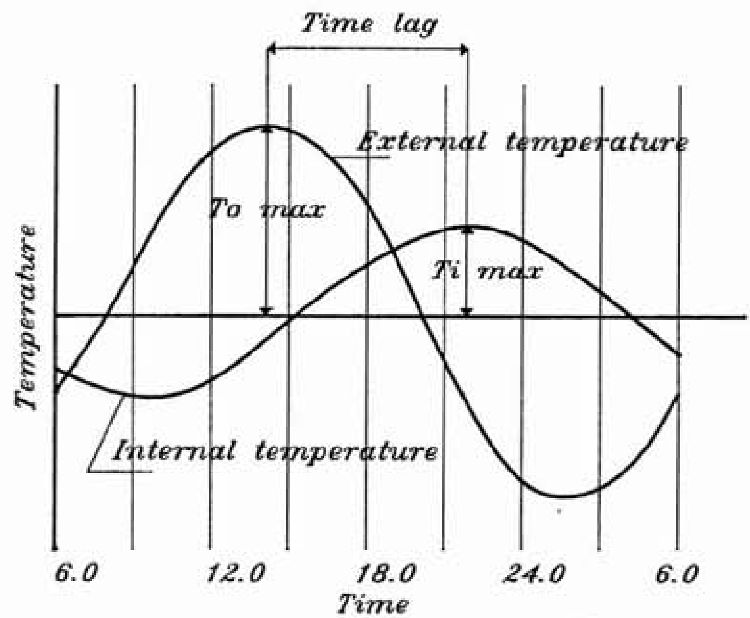
The decrement factors (U) and the time lag values(O) of some constructions

Constructions	*Thickness, mm*									
	50		*100*		*150*		*200*		*300*	
	O:h	*U*	*O:h*	*U*	*O:h*	*U*	*O:h*	*U*	*O:h*	*U*
Concrete	*1.3*	*0.67*	*3.0*	*0.45*	*4.4*	*0.30*	*6.1*	*0.20*	*9.2*	*0.09*
Stabilised earth	*---*	*---*	*2.4*	*0.48*	*4.0*	*0.34*	*5.2*	*0.24*	*8.1*	*0.12*
Timber	*2.5*	*0.48*	*5.4*	*0.23*	*8.3*	*0.11*	*---*	*---*	*---*	*---*
Mineral wall	*2.5*	*0.48*	*5.3*	*0.22*	*---*	*---*	*---*	*---*	*---*	*---*

Walls:	*O:h*	*U*
Cavity wall, two skins of 100mm dense concrete blocks, both faces with 15mm cement render..........	*10.0*	*0.073*
Same, but with hollow concrete blocks.................	*10.8*	*0.056*
Cavity wall, two skins of 100mm hollow terra-cotta blocks, both faces with 15mm cement render..........	*8.7*	*0.100*

Roofs:	*O:h*	*U*
100mm reinforced concrete slab, bituminous asbestos felt finish, with 40mm glass wool insulation under the slab..	*3.0*	*0.450*
Same, but insulation on top of the concrete slab......	*11.8*	*0.046*
240 mm hollow pot slab, underside rendered, 60mm screed, bitominous asbestos felt membrane, 30mm concrete paving slabs on 20mm bedding..............	*12.0*	*0.045*

(*) MANUAL OF TROPICAL HOUSING AND BUILDING Part 1, Climatic design P. 290



Decrement factor $= \frac{To\ max}{Ti\ max}$

FIG. 3-2 (*)

Time lag and decrement factor

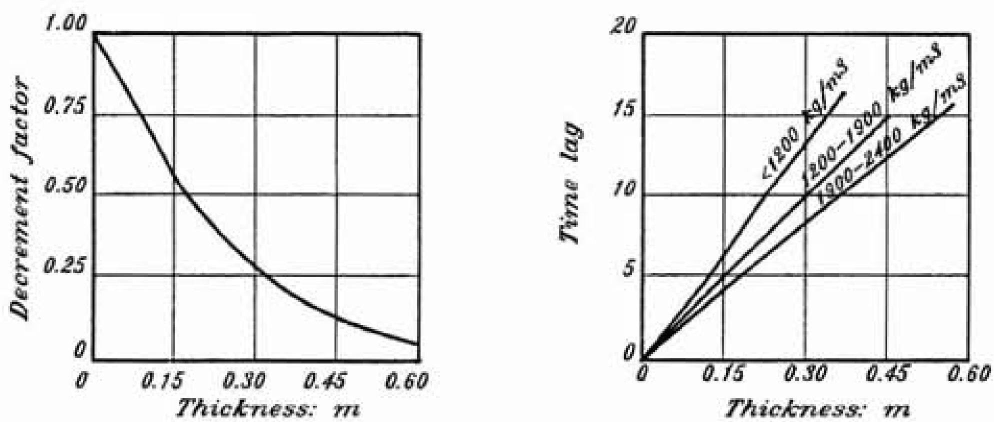


FIG. 3-3 (**)

Decrement factor and time lag values for massive walls

(*) MANUAL OF TROPICAL HOUSING AND BUILDING Part 1, Climatic design P. 84
(**) MANUAL OF TROPICAL HOUSING AND BUILDING Part 1, Climatic design P. 86

3.3.5- THERMAL TRANSMITTANCE

Thermal transmittance or 'U' value indicates the total amount of heat transmitted from the air on one side of a building element to the air at the other side, per an area unit of the surface, per a unit difference in air temperature. The 'U' value is influenced by the thermal resistance of the component parts of the element and their ability to absorb and emit heat through the external and internal surfaces. This 'U' value is expressed in w/m2 deg C. and can be calculated from the following equation :-

(*) $$U = \frac{1}{1/hi + (1/C1 + 1/C2 + ..1/Cn) + (d1/K1 + d2/K2 + ..dn/Kn) + 1/ho} \quad W/m^2\ °C$$

Where

hi = Coefficient of heat transfer for the inner surface of the element in w/m2 deg C.

ho = Coefficient of heat transfer for the outer surface of the element in w/m2 deg C.

C1,C2,Cn = Thermal conductance of n separate air spaces in the element structure in w/m2 deg C.

k1,k2,kn = Thermal conductivities of n successive layers of different materials in w/m2 deg C.

d1,d2,dn = Thickness of n successive layers of different materials in meters.

The values of all thermal properties of a multi layer building element can be calculated by using the chart which is shown in figure(3-4)

(*) DESIGN PRIMER FOR HOT CLIMATES Allan konya P. 110

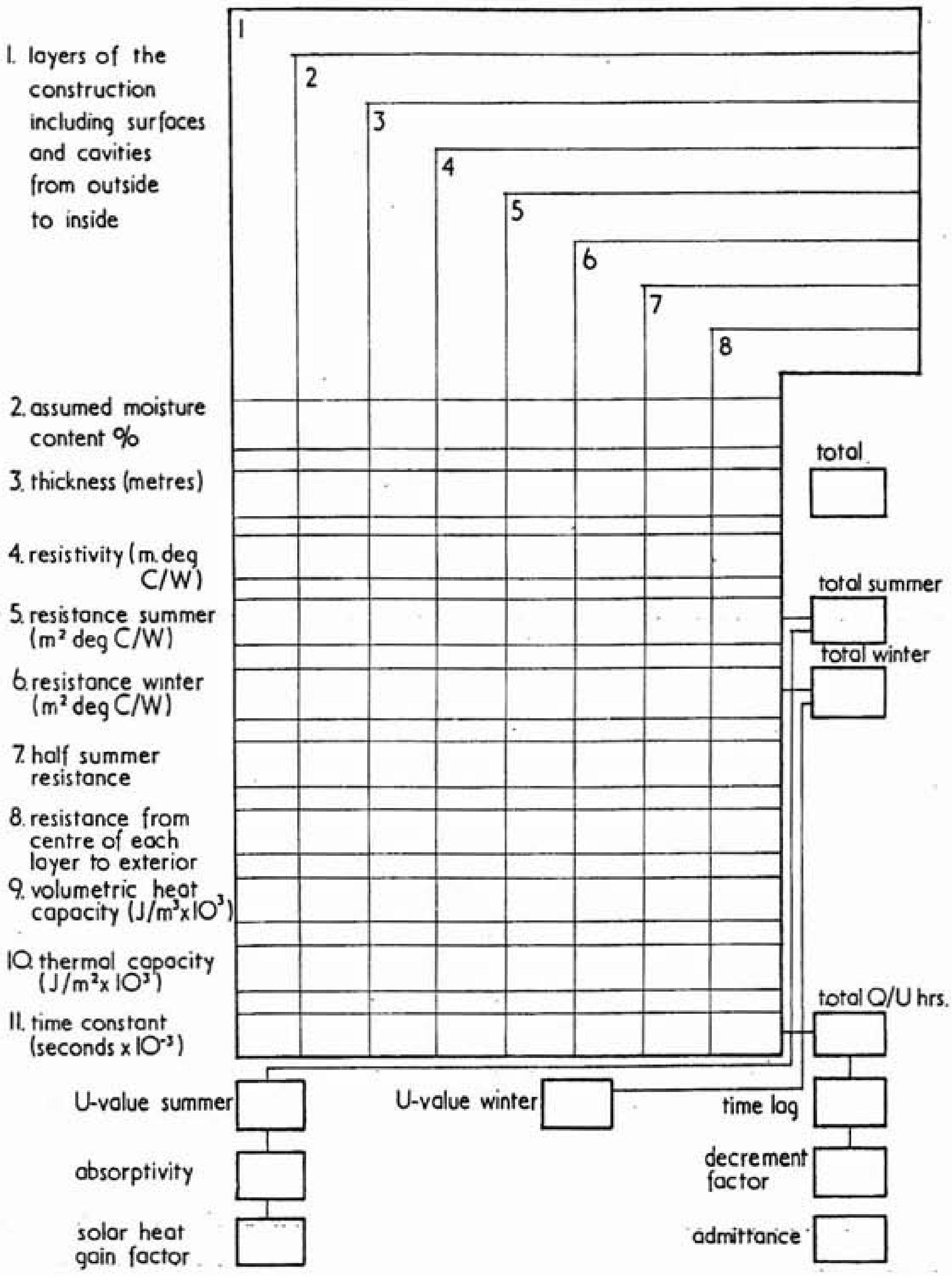


FIG. 3-4(*)

Thermal properties chart of multi-layers building elements

(*) HOUSING, CLIMATE AND COMFORT Martin Evans P. 85

3.4- HEAT TRANSFER IN BUILDINGS

AFTER reviewing the thermal properties of building material and elements, the process of heat transfer between indoor space and external environment can be visualized by considering the heat gain sources and heat losses process.

During heat transfer process the heat change its transfer mode. Thus solar energy reaches the building envelope in the form of radiation, absorbed at the external surfaces and flows across the material of building elements by conduction. If the building element contains an air space, the heat flows across it by convection and radiation.

The rate of heat transfer in and out a building is effected by the thermal properties of the building material which is used in building elements.

When selecting building material according to human thermal requirements, the principle factors to consider in the heat transfer process are:-

First, The difference between the maximum external and internal air temperature.

Second, The difference between the minimum external and

internal air temperature.
Third, The ratio between the temperature of the internal and external surfaces and the time lag.
Fourth, The ratio between the integrals of temperature per time functions of the internal and external surfaces.

The building envelope intercedes with external climate, to create a new interior microclimate zone. The heat transfer in buildings processed, according to available heat gain sources, by conduction, convection and evaporation (figure 3-5). The total heat gain or loss can be calculated by the following equation :-

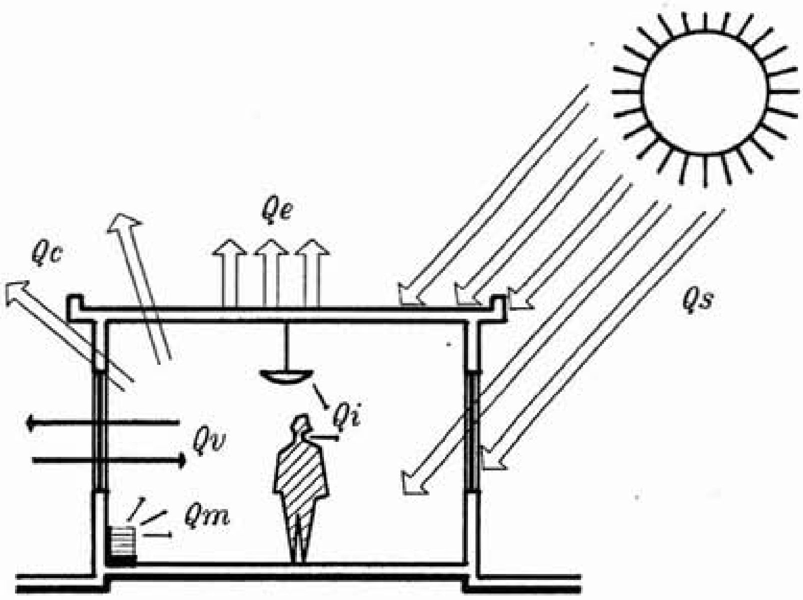
(*) *Qi + Qs +- Qc +- Qv +- Qm - Qe = 0 = Thermal balance*

Where

Qi = Internal heat gain
Qs = Solar heat gain
Qc = The heat flow by conduction
Qv = The heat flow by conviction
Qm = Mechanical heating or cooling
Qe = The rate of cooling by evaporation

If the sum of the above equation is negative, the building will be cooling and if it is positive, the temperature in the building will increase.

(*) DESIGN PRIMER FOR HOT CLIMATES Allan konya P. 111



$$Qi+Qs\pm Qc\pm Qv\pm Qm-Qe=0$$

FIG. 3-5(*)
Heat transfer in buildings

3.4.1- SOLAR HEAT GAIN

Solar radiation may reach a building envelope directly from the sun or scattered by the atmosphere and reflected by clouds. A part of the incoming solar radiation to a building after reflecting from the surfaces of the surrounding ground and buildings. The effects of the solar heat gain processed in two ways:-
First, By entering through windows and absorbed by internal surfaces and causing a heating effect.
Second, Through absorbed by the external surfaces and transferred to the indoor space.

(*) DESIGN PRIMER FOR HOT CLIMATES Allan konya P. 111

The rate of solar heat gain influenced by the thermal properties of building materials and elements which are exposed to the effect of solar radiation. The windows account for the greatest amount of solar heat entering the building while roofs account for a relatively less of solar heat gain. Walls account for amount of solar heat gain lesser than windows and roofs. Figure(3-6) shows the diurnal variation of heat flow through the area unit of differently building elements.

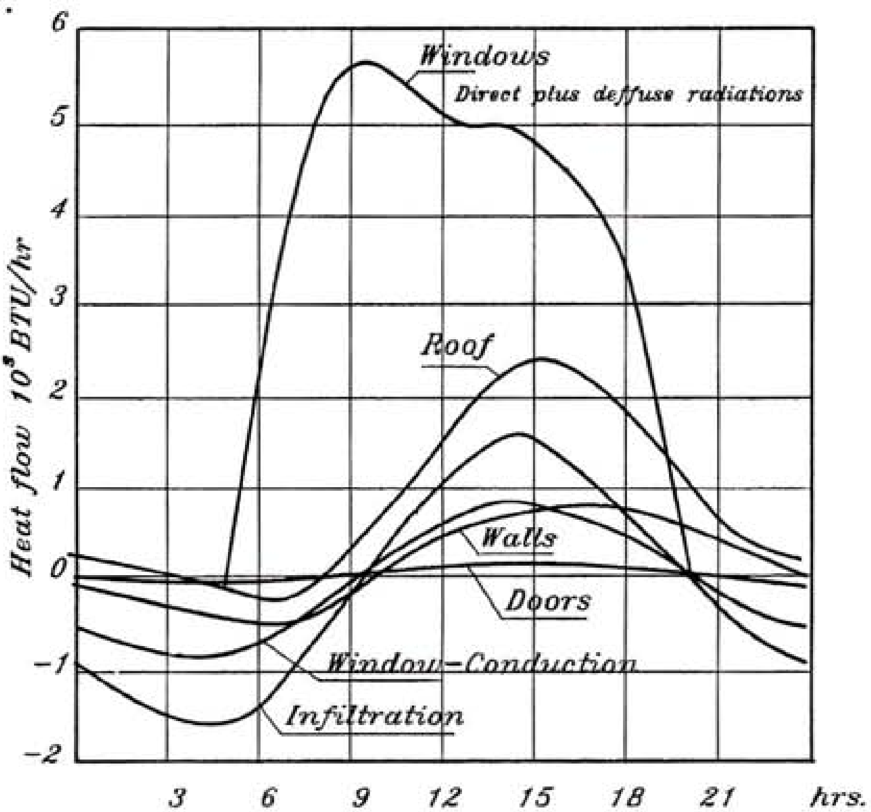


FIG. 3-6 (*)
The variations of heat flow through area unit of some building elements

(*) DESIGN WITH CLIMATE Vector Olgyay P. 72

3.4.2- INTERNAL HEAT GAIN

There are several potential sources of heat gains within the building such as power sources, electric lighting, cooking and occupants. For many of these heat sources, the heat gain form can be divided into two forms. The first form is the sensible heat, which causes an increasing rate of the air temperature.

All internal heat sources release sensible heat but some of them release latent heat energy which is the second form of the heat gain forms. Table(3-4) shows the rate of heat production for a number of typical heat sources.

TABLE 3-4[*]
Internal typical heat sources

TYPE OF HEAT GAIN	SENSIBLE HEAT(W)	LATENT HEAT(W)
HEAT SOURCES		
Electric light	....	As wattage
Electric power	....	+1000
Water	-2400	+2400
Evaporation	-666	+666
PEOPLE		
Ambient air temperature : 20 °C.		
Seated at rest	+76	+26
Sedentary activity	+83	+49
Standing or walking	+85	+61
Ambient air temperature : 25 °C.		
Seated at rest	+61	+41
Sedentary activity	+63	+69
Standing or walking	+64	+82
Ambient air temperature : 30 °C.		
Seated at rest	+51	+51
Sedentary activity	+52	+79
Standing or walking	+52	+94

[*] HOUSING, CLIMATE AND COMFORT Martin Evans P. 150

3.4.3- CONDUCTION HEAT FLOW

Conduction heat flow may occur through building elements either inwards or outwards. The direction of this heat flow defined according to the temperature difference between both sides of the building element. The rate of heat flow by conduction through a building element can be described by the following equation :-

(*) $Qc = A * U * \hat{}T$

Where

Qc = Conduction heat flow rate, in W
A = Surface area, in m2
U = Transmittance value, in W/m2 deg C.
^T = Temperature difference

The above equation is solved for each building element and the results are added to define the total amount of heat flow by conduction

3.4.4- CONVECTION HEAT FLOW

The exchange of indoor air with fresh outdoor air can provide either cooling or heating effect. If the outdoor air has a lower temperature than the indoor air, convection heat flow provide cooling effect. If the indoor air has a lower temperature than the outdoor

(*) MANUAL OF TROPICAL HOUSING AND BUILDING Part 1, Climatic design P. 76

air, convection heat flow provide heating effect.

Convection heat flow rate between indoor and outdoor air depends on the rate of air exchange through outer openings. The rate of ventilation heat flow is described by the following equation :-

(*) $Qv = 1300 * V * \hat{}T$

Where
Qv = Ventilation heat flow rate, in W
1300= Volumetric specific heat of air, in J/m3 deg.C.
V = Ventilation rate, in m3/s
^T = Temperature difference, in deg C.

3.4.5- EVAPORATION HEAT LOSS

Evaporation of water absorbs a significant amount of heat. This phenomenon can be utilized for the cooling of air when the air is dry. If the rate of evaporation is known, the rate of cooling by this evaporation rate can be calculated. The estimation of evaporation rate depends on many variables, such as : available moisture, humidity of air, temperature of the moisture and of the air and velocity of the air movement.

Evaporation cooling effect will be utilized to reduce air temperature as far as possible. Then, evaporation heat loss is ignored for the purposes of calculation.

(*) MANUAL OF TROPICAL HOUSING AND BUILDING Part 1, Climatic design P. 76

3.5- CLIMATE CONTROL STRATEGIES

THE heat exchange through building envelope between indoor space and external environment should be controlled to create a specified set of indoor conditions. Figure (3-7) shows that the extremities of climatic variations can be attenuated by such means.

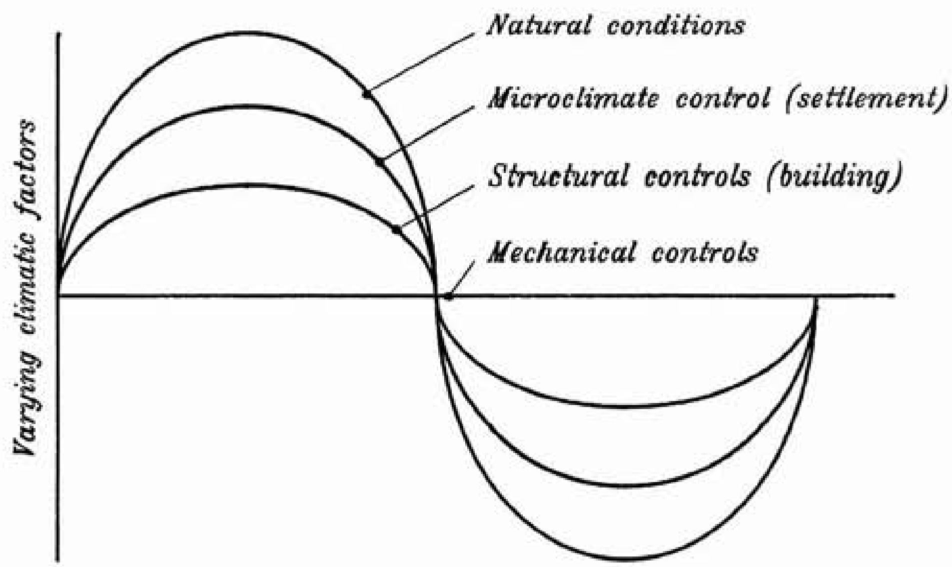


FIG. 3-7(*)
Potential of climatic controls

(*) MANUAL OF TROPICAL HOUSING AND BUILDING Part 1, Climatic design P. 92

Application of the heat flow control options to the mechanisms of heat transfer in buildings produce a set of nine practicable climate control strategies (figure 3-8). These nine practicable climate control strategies can be separated into those appropriate to the climatic conditions under comfort zone and those appropriate to the climatic conditions over comfort zone.

By plotting of combined air temperature and relative humidity data on the bioclimatic chart and define the zone where these climatic data falls , as described previously in chapter (2) , the climate control options can be selected . This process leads to define the climate control strategies which are appropriate to the given climatic data .

The following subtitles describes the needed climate control strategies which can confirm human comfort when the given climatic conditions are outside of the comfort limits.

	GAIN	LOSS
SOLAR HEAT	Promot solar gain	Resist solar gain Promot radiant cooling
CONDUCTION HEAT FLOW	Resist conduction heat flow	Resist conduction heat flow Promot conduction cooling
CONVECTION HEAT FLOW	Resist convection heat flow Resist infiltration	Promot ventilation Resist infiltration
EVAPORATION HEAT FLOW		Promot evaporative cooling

FIG. 3-8
Climate control strategies

3.5.1- PROMOTE SOLAR GAIN

At lower temperature (under comfort zone) man can be comfortable if the heat loss of the body can be contracted with the incoming solar radiation.

Hence, for any plotted point of a given air temperature and relative humidity which falls within shaded zones of the bioclimatic chart in figure (3-9), promote solar gain is necessary to restore human comfort.

3.5.2- RESIST SOLAR GAIN

At high temperature (over comfort zone) man can be relatively comfortable if the solar heat gain is minimized by many architectural applications.

Hence, for any plotted point of a given air temperature and relative humidity which falls within shaded zones of the bioclimatic chart in figure (3-10), it is necessary to resist solar gain to restore human comfort.

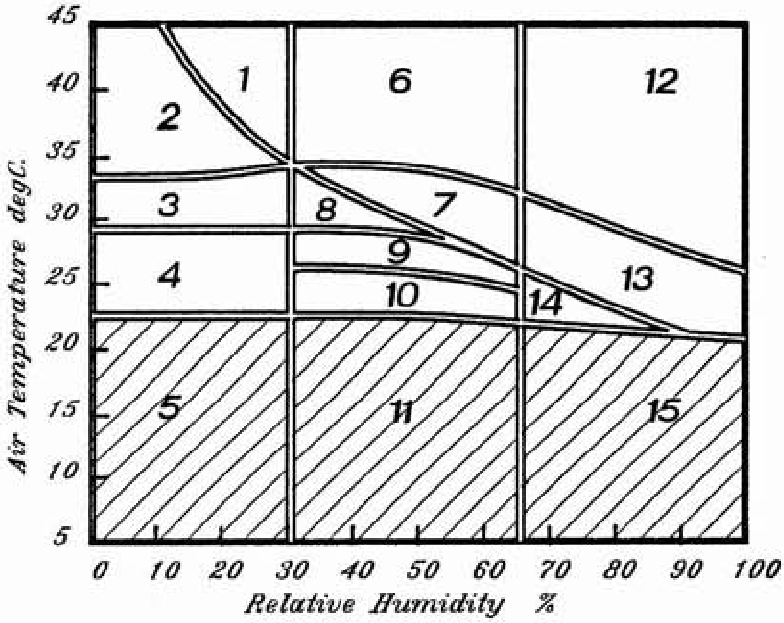


FIG. 3-9
Bioclimatic Zones where promote solar gain is nedded

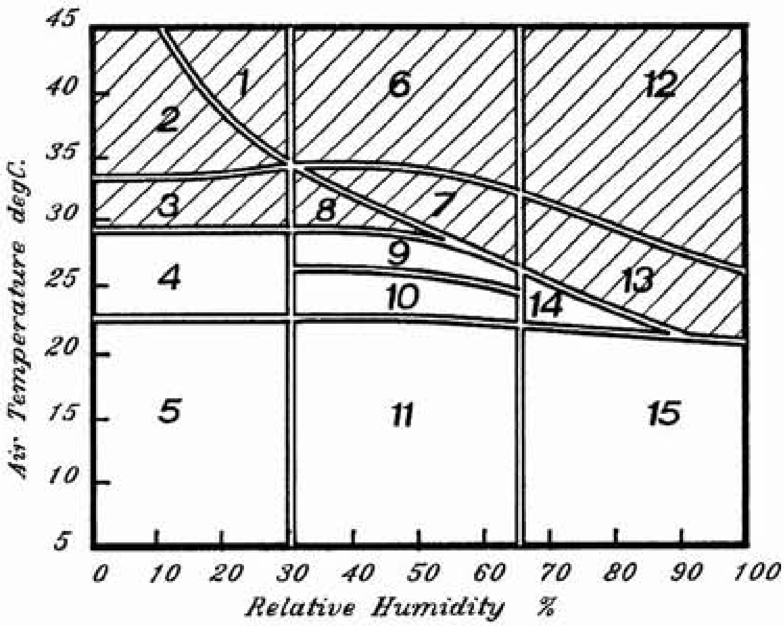


FIG. 3-10
Bioclimatic Zones where resist solar gain is nedded

3.5.3- PROMOTE RADIANT COOLING

The radiant cooling generally is not well suited to warm and humid climates, but the greatest radiant cooling potential is found in dry climate.

Hence, for any plotted point of a given air temperature and relative humidity which falls within shaded zones of the bioclimatic chart in figure (3-11), it is necessary to promote radiant cooling to restore human comfort.

3.5.4- RESIST CONDUCTIVE HEAT FLOW

Conductive heat flow either inwards or outwards is suited if the difference between indoor and outdoor temperature is large. For this reason if the difference between a given climatic conditions and human comfort limits is narrow, the conductive heat flow is not well suited. Hence, for any plotted point of a given air temperature and relative humidity which falls within shaded zones of the bioclimatic chart in figure (3-12), it is necessary to resist conductive heat flow to restore human comfort.

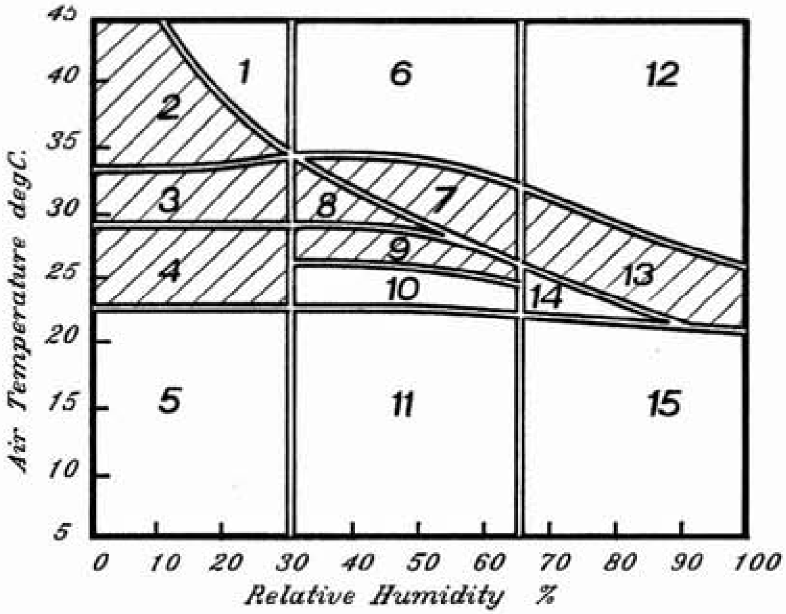


FIG. 3-11

Bioclimatic Zones where promote radiant cooling is nedded

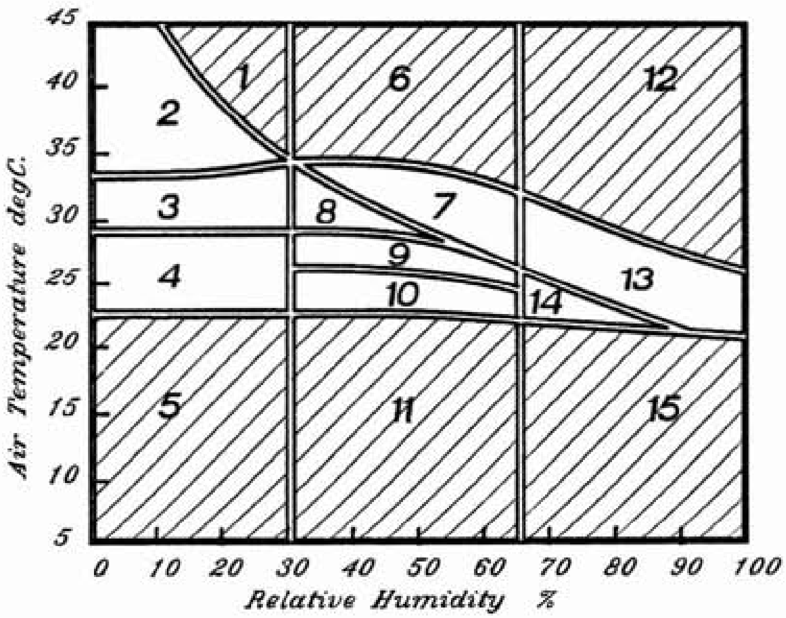


FIG. 3-12

Bioclimatic Zones where resist conduction heat flow is nedded

3.5.5- PROMOTE EARTH COOLING

The use of underground shelter or promote earth cooling can be suitable if the climate is very warm and dry or if the climate is very cold and dry.

Hence, for any plotted point of a given air temperature and relative humidity which falls within shaded zones of the bioclimatic chart in figure (3-13), it is necessary to promote earth cooling to restore human comfort.

3.5.6- RESIST EXTERNAL AIR FLOW

External air flow affects the rate of heat loss by increasing the convection heat flow through the building envelope. When the climate is very cold and dry the heat loss is not suitable and the water vapor contained in the air should not be lost.

Hence, for any plotted point of a given air temperature and relative humidity which falls within shaded zones of the bioclimatic chart in figure (3-14), it is necessary to resist external air flow to restore human comfort.

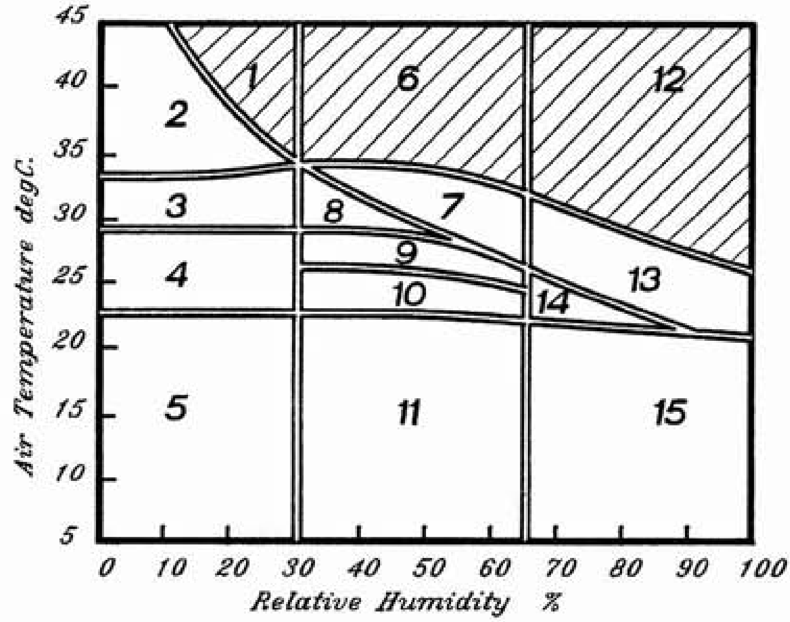


FIG. 3-13

Bioclimatic Zones where promote earth cooling is nedded

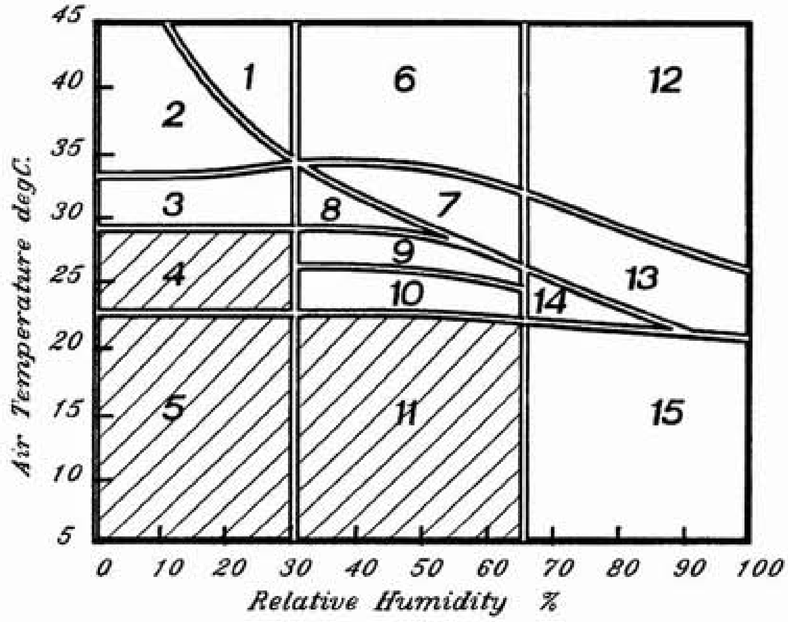


FIG. 3-14

Bioclimatic Zones where resist external air flow is nedded

3.5.7- PROMOTE VENTILATION

The upper comfort limit is raised when ventilation increases since air movement causes a cooling sensation due to heat loss by convection and evaporation.

Hence, for any plotted point of a given air temperature and relative humidity which falls within shaded zones of the bioclimatic chart in figure (3-15), it is necessary to promote ventilation to restore human comfort.

3.5.8- RESIST INFILTRATION

Infiltration and exfiltration refers to exchange of cold and warm air through joints and cracks between indoor space and outdoor environment. The amount of heat exchange by Infiltration and exfiltration increases with increasing wind speed and temperature difference between indoor and outdoor air. Hence, for any plotted point of a given air temperature and relative humidity which falls within shaded zones of the bioclimatic chart in figure (3-16), it is necessary to resist Infiltration to restore human comfort.

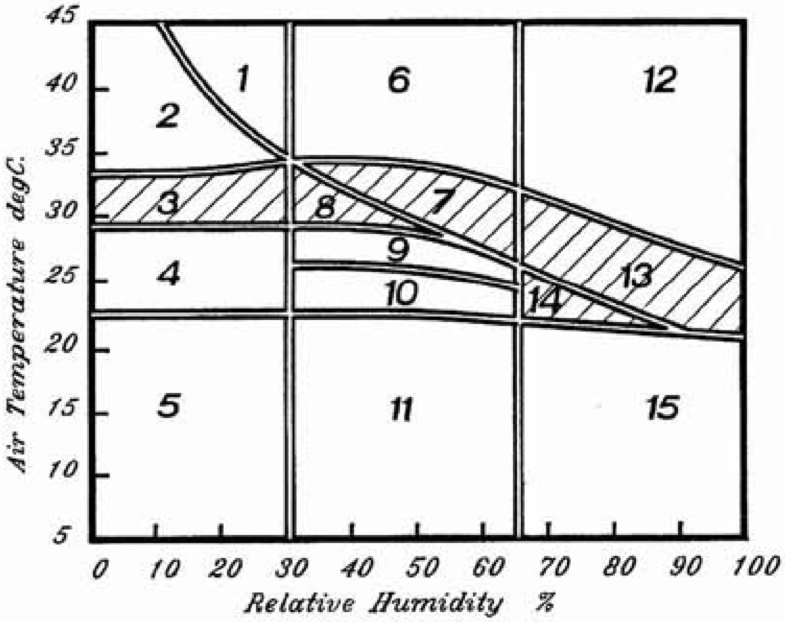


FIG. 3-15
Bioclimatic Zones where promote ventilation is nedded

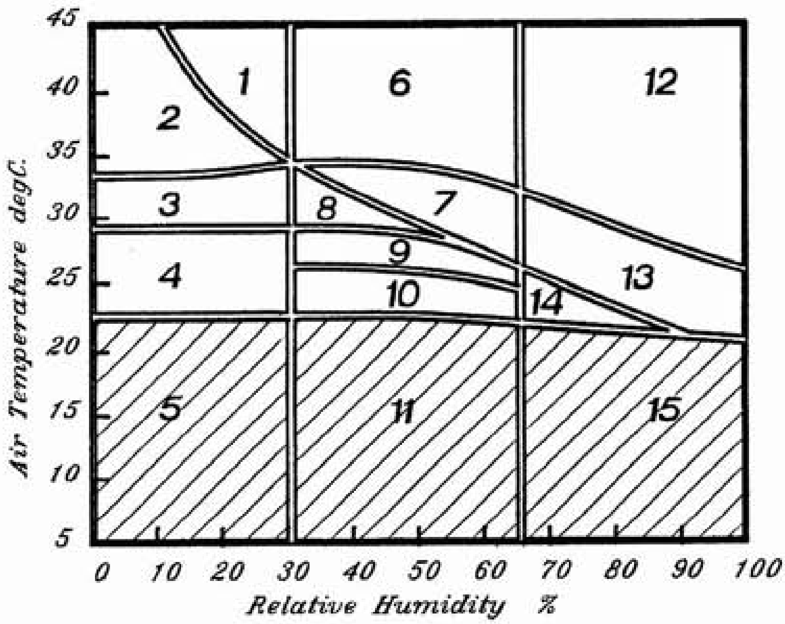


FIG. 3-16
Bioclimatic Zonse where resist infiltration is nedded

3.5.9- PROMOTE EVAPORATIVE COOLING

The temperature decrease caused by evaporation of added moisture will restore comfortable temperature when air temperature is over than comfort limit and humidity is lesser than comfort limit.

Hence, for any plotted point of a given air temperature and relative humidity which falls within shaded zones of the bioclimatic chart in figure (3-17), it is necessary to promote evaporative cooling to restore human comfort.

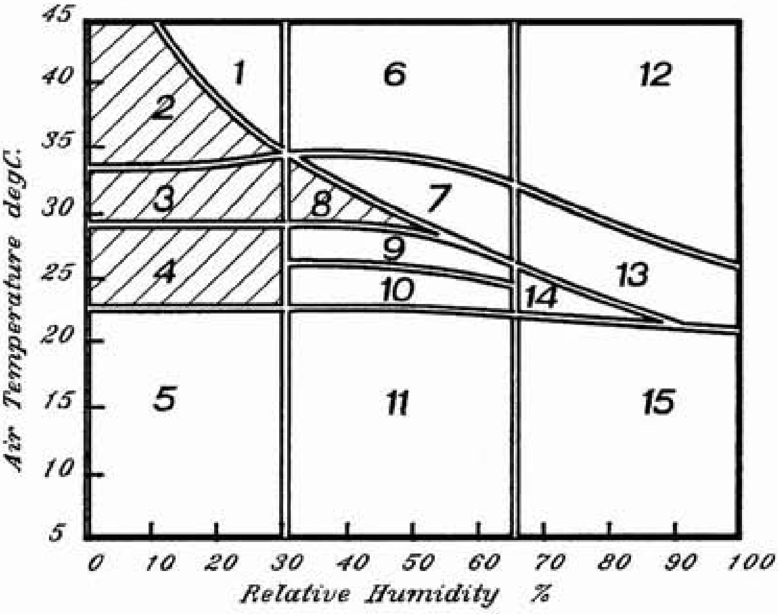


FIG. 3-17

Bioclimatic Zones where promote evaporation cooling is nedded

3.6- SUMMARY

Heat exchange process through the building envelope depends on the thermal properties of the used building materials. The basic thermal properties which determine the heat exchange through a building element are thermal admittance, thermal resistance, solar heat flow, time lag and the thermal transmittance.

The heat flow between indoor spaces and external environment should be controlled by climatic design applications in order to create a comfortable indoor conditions.

The previous developed bioclimatic chart can used in order to define the appropriate climate control strategies for a given climatic conditions, determined by its air temperature and relative humidity. The produced correlations between the climate control strategies and the climatic conditions will be used in the next chapter to specify the needed climatic design recommendations.

Chapter 4
CLIMATIC DESIGN APPLICATIONS

4.1- INTRODUCTION

4.2- BUILDING FORM

4.3- BUILDING ORIENTATION

4.4- BUILDING ENVELOP

4.5- HOUSE PLAN

4.6- OPENINGS DESIGN

4.7- HOUSING LAYOUT

4.8- LANDSCAPING

4.1- INTRODUCTION

IN the previous chapters, the climatic data, which is needed to climatic design process, was discussed in chapter 1. Also a given climatic data was evaluated, in chapter 2, according to human comfort conditions by using Olgyay's bioclimatic chart. In chapter 3, the principles of climatic design and climatic control strategies are outlined in order to specify the appropriate climatic design recommendations for any given climatic conditions.

To overcome the effects of climatic variation on human comfort, the house building should be designed according to the local climatic criteria. The comparison of climatic data and the requirements for thermal comfort provides the basis for the selections of design decisions appropriate for the given climatic data. The basic design decisions can be simplified in building form, building orientation, building envelop elements, house plan, opening design, housing layout, and landscaping. No rigid recommendations are made, since there are many ways in architecture to approach the goal of human comfort. Then, once the designer understands the local climatic conditions, the set of climatic design recommendations can be elaborated and climatic design choices compared in order to choose the appropriate design recommendations.

The third phase of the programming pattern for climatic design of house is to generate solutions which are described in this chapter as the basis of climatic design performance according to its scientific principles and its practical applications.

The climatic design performance can be grouped under seven headings: building form, building orientation, building envelop, openings design, house plan, housing layout, and landscaping.

4.2- BUILDING FORM

THE form of house building should be designed to take advantage of the favorable aspects of the local climatic conditions, and to reduce the impact of unfavorable aspects. Also the building form should be designed related to improvement of the comfortable internal climatic conditions, and to the creation of comfortable conditions in the external spaces between and around buildings. Therefor, the shape of building is a significant design consideration.

The optimum form of house building is that which loses the minimum amount of outgoing heat in cold season and accepts the least amount of incoming heat in hot season. The ratio of enclosed volume to external surface area determine the climatic stresses occur by exposure to fluctuating air temperature and winter wind. This ratio also is an important indicator of the speed of building heat up by day and cool down at night. The minimum amount of conductive heat flow can occurre by reducing the ratio of external surface area to enclosed volume. Figure (4-1) shows a comparison between some typical forms, with the same floor area.

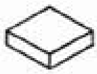
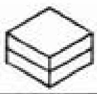
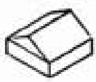
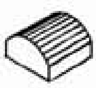
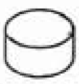
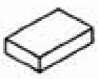
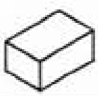
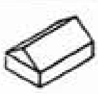
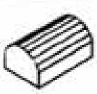
FORM	Floor area m^2	Surface area m^2	Volum m^3	Surface area to Volum ratio S:V
	100	220	300	73 %
	100	340	600	56 %
	100	266.60	450	59 %
	100	295.99	551.42	53 %
	100	206.36	300	68 %
	100	312.72	600	52 %
	100	199.94	375.88	53 %
	100	221.99	300	74 %
	100	343.99	600	57 %
	100	270.22	450	60 %
	100	297.48	542.13	55 %

FIG. 4-1
Surface to volume ratio of different forms

The previous comparison leads to clear that the surface to volume ratio changes related to the building form. The external surface area to enclosed volume ratio can be reduced by using the compact forms.

In hot dry regions, the objective of building design is reducing the heat gain. The compact courtyard form is required to reduce exposure to the direct sun radiation through the hot season (figure 4-2). Also the compact form can be used to reduce exposure to winter wind turbulence. The small courtyard could provide cooling effect in the hot dry climates because the courtyard floor and walls are shaded during most of the day time. Figure (4-3) explain the thermal system of a courtyard house.

On the equator, the east and west walls and roofs will receive the highest amount and intensity of solar radiation. The sun path in the winter is shorter and lower than the sun path in the summer. Then, the appropriate strategy for winter solar heating is to face the major wall and window areas to the south or north facing at latitudes further north or south from the equator.

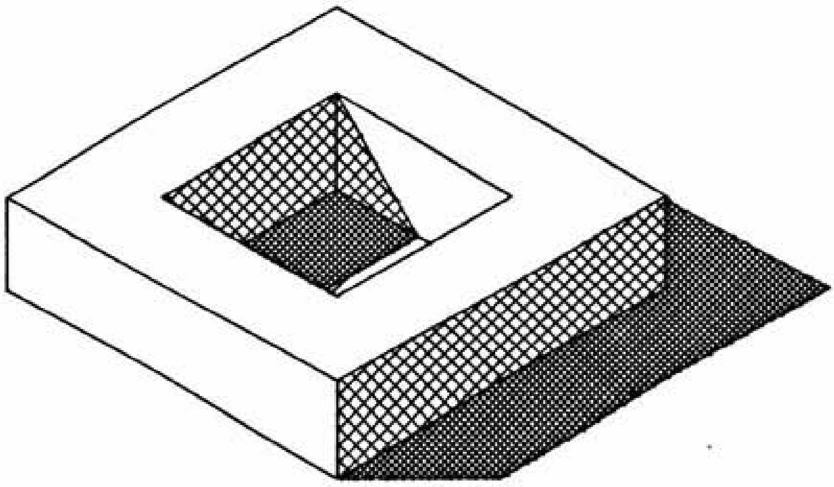


FIG. 4-2
Shading of a compact courtyard form

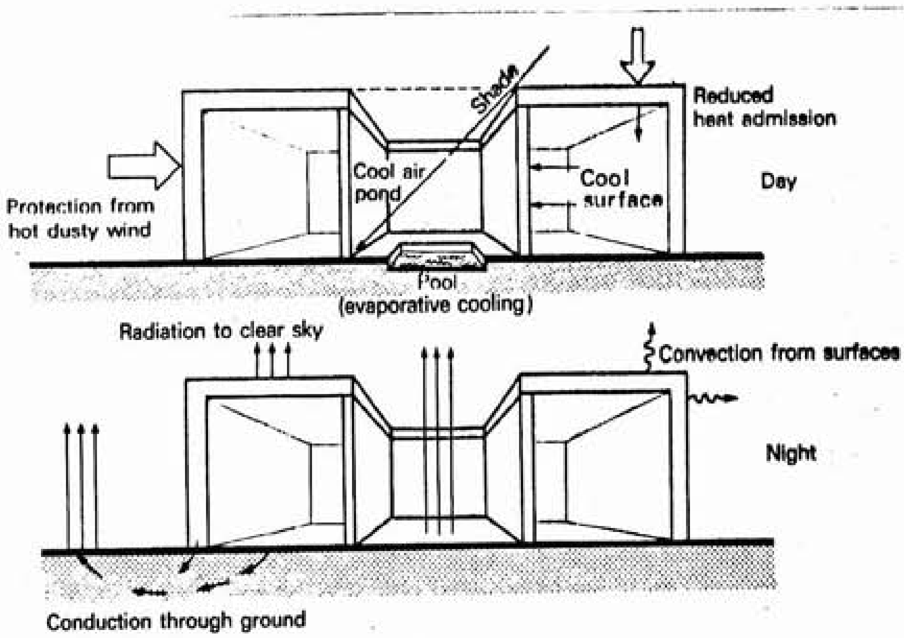


FIG. 4-3
The thermal system of a courtyard house

The east and west elevations do not receive any significant amount of irradiation in winter, Therefor, the elongated form with east-west long axis is required in cold regions. In hot regions, the compact building forms are desired to reduce solar heat gain during the hot period of the day time and reduce heat losses during the coled period.

The optimum shape of houses for some climatic regions was defined by Vector Olgyay in his book "*DESIGN WITH CLIMATE*". Figure (4-4) shows a graphical presentation of Olgyay's conclusions for basic forms of houses in different regions.

The air movement around building mass has a very large variation according to the shape of this mass and its orientation against the direction of external air movement. Figure (4-5) shows the relationship between the building form and length of the wind shadow. The wind shadow increases in proportion to the building height and affected by the roof pitch. The building width has little effect on the wind shadow.

The climatic design recommendations of building form are simplified in figure(4-6) with its purposes of climate control strategies. Also the bioclimatic chart is shown for every climatic design recommendation in order to specify the climatic conditions where those recommendations are needed to confirm human comfort.

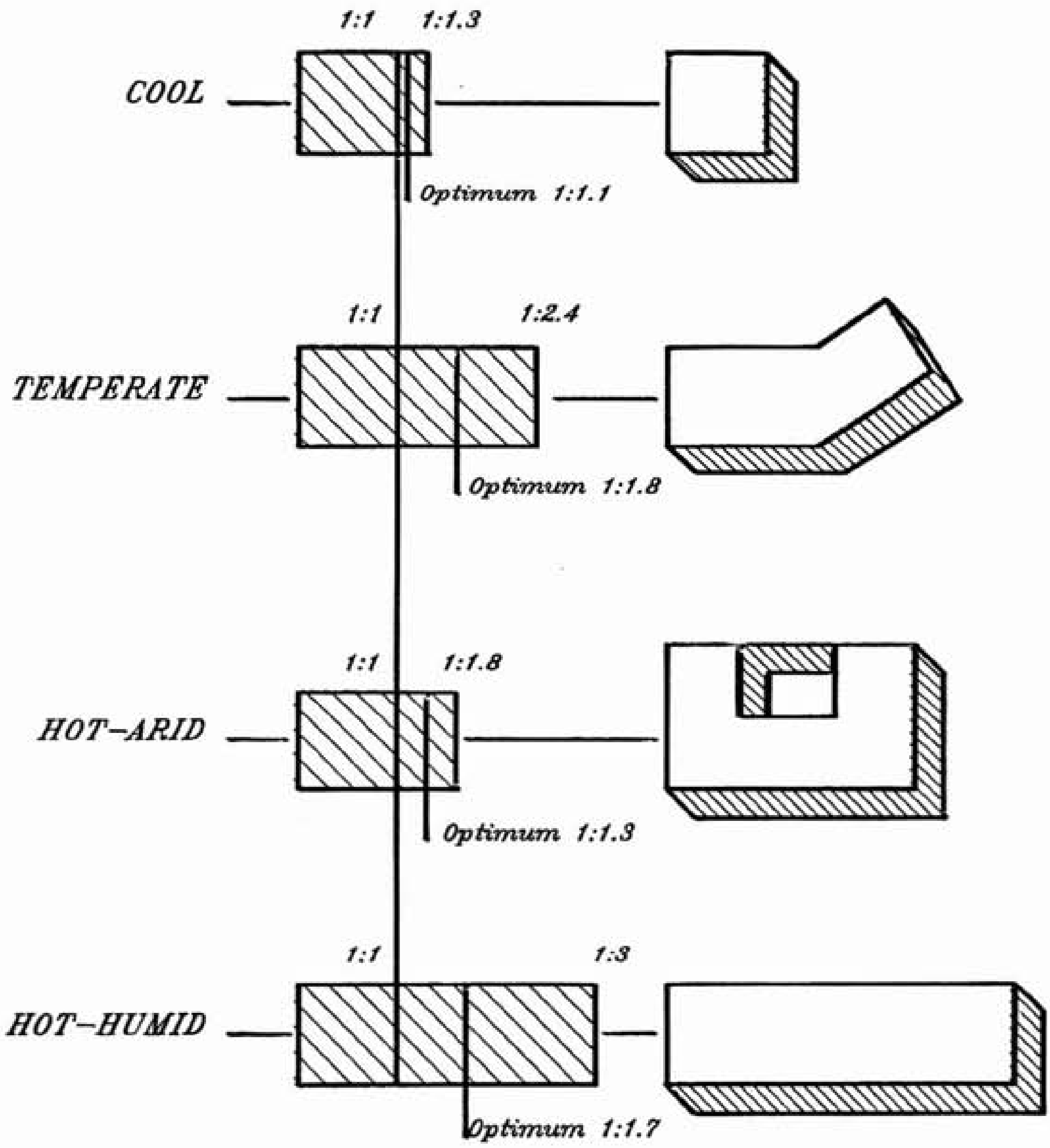


FIG. 4-4 (*)
Basic forms of houses in different regions

(*) DESIGN WITH CLIMATE Vector Olgyay P. 89

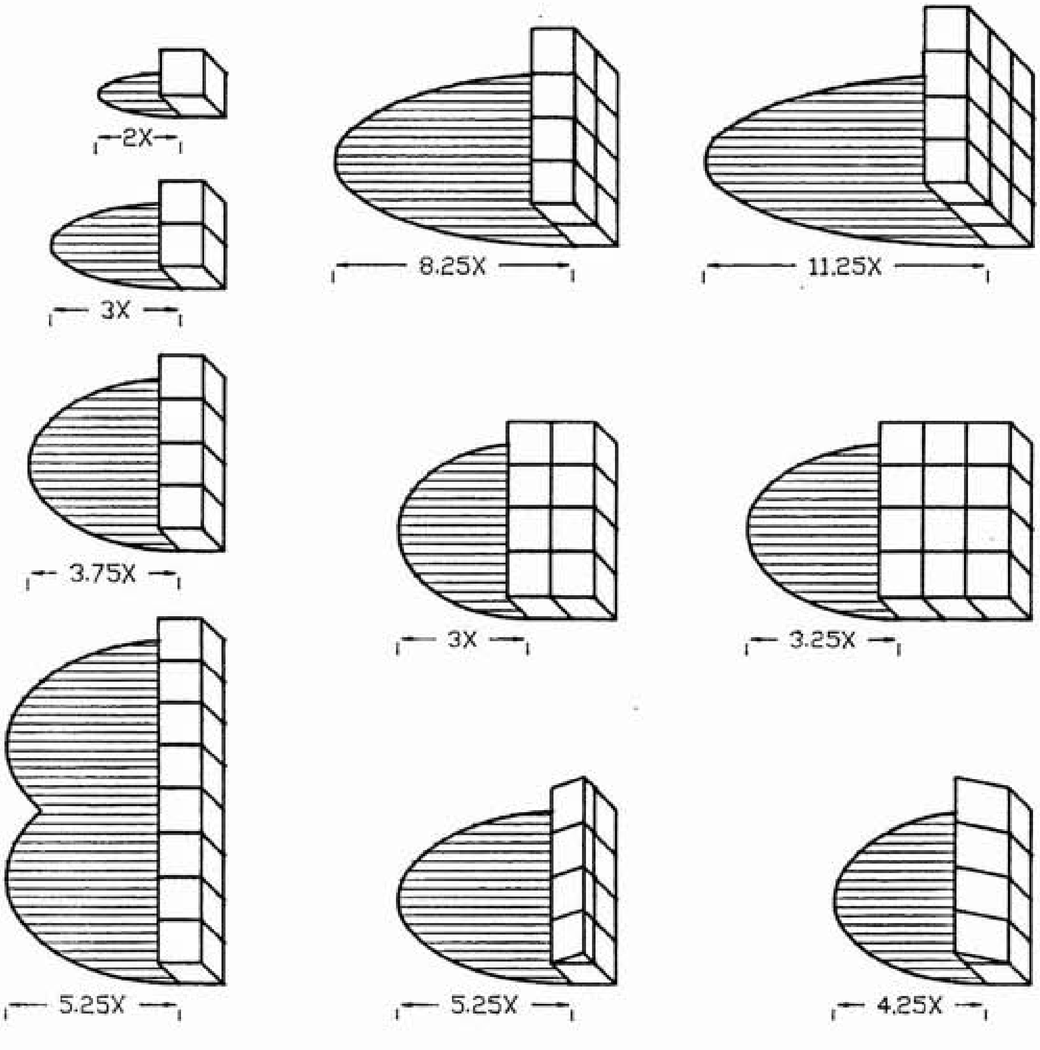


FIG. 4-5[*]
Effect of form on wind shadow length

[*] DESIGN PRIMER FOR HOT CLIMATES Allan konya P. 55

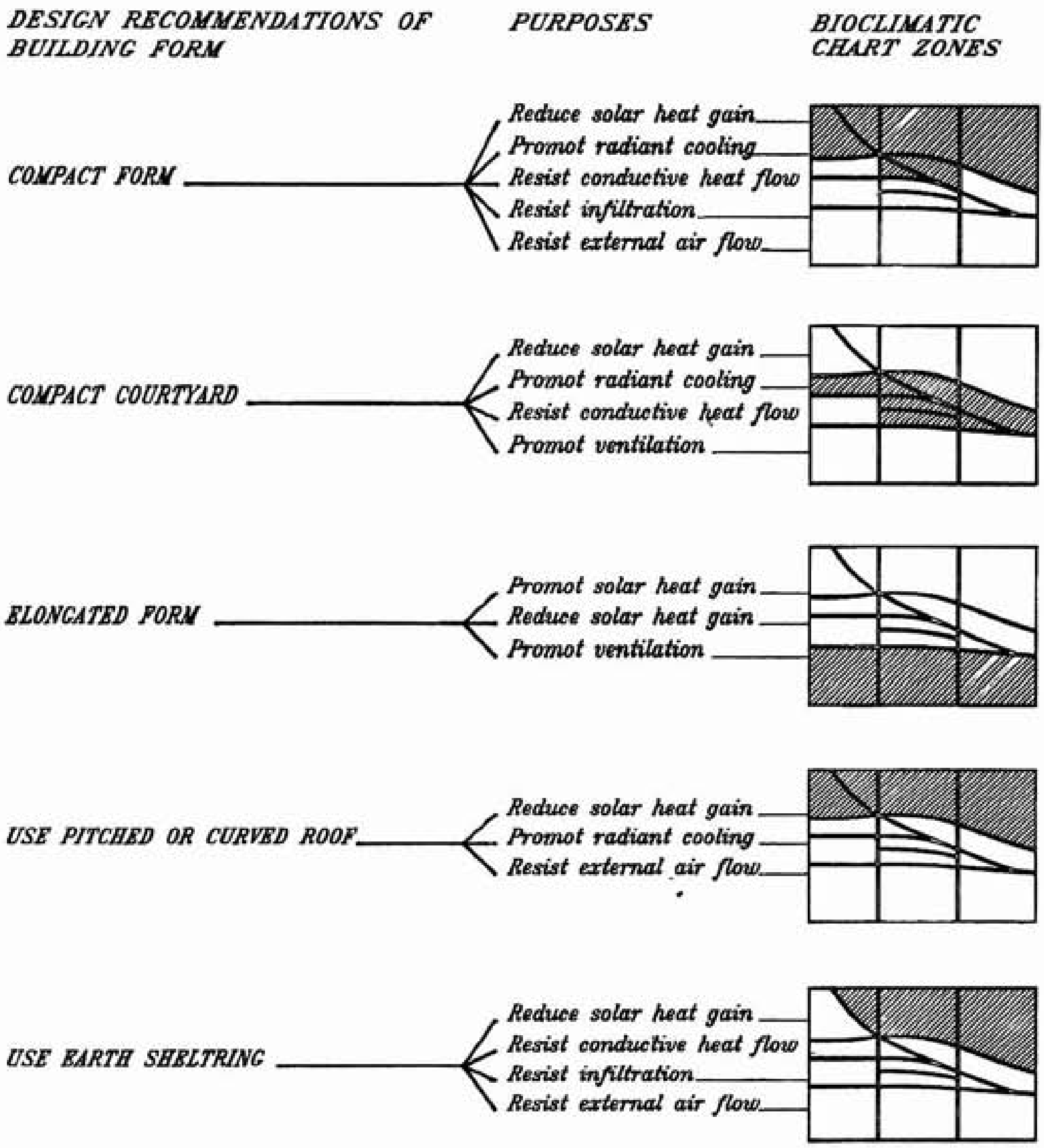


FIG. 4-6
Climatic design recommendations of building form

4.3- BUILDING ORIENTATION

BUILDING orientation in architecture may be defined as science of combining the demands related to many natural factors such as :- local variation of climatic conditions, local topography, and the surrounding views. The directions and speeds of prevailing wind and the surrounding views should be considered in house design process. The house building orientation is affected also by the quantities of solar radiation which falls on different building sides at different day times.

The heat effect of direct solar radiation that falls on the south side of the building is lower than that falls on the west side, while it is more than which falls on east side, because the air temperature at mid day is hotter than at the morning and colder than at the afternoon. Also the incident angle of solar radiation on south facing is smaller than on the west facing. (figure 4-7). The correct building orientation can be determined by considering the sun movement and the incident angle of the sun radiation at various day times and year seasons (figure 4-8).

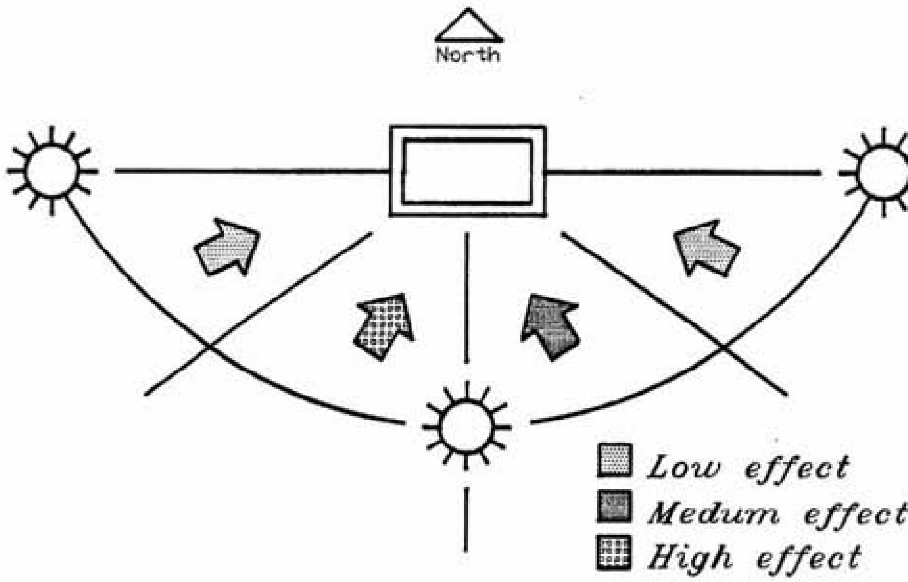


FIG. 4-7
The heat effect of solar radiations during day times

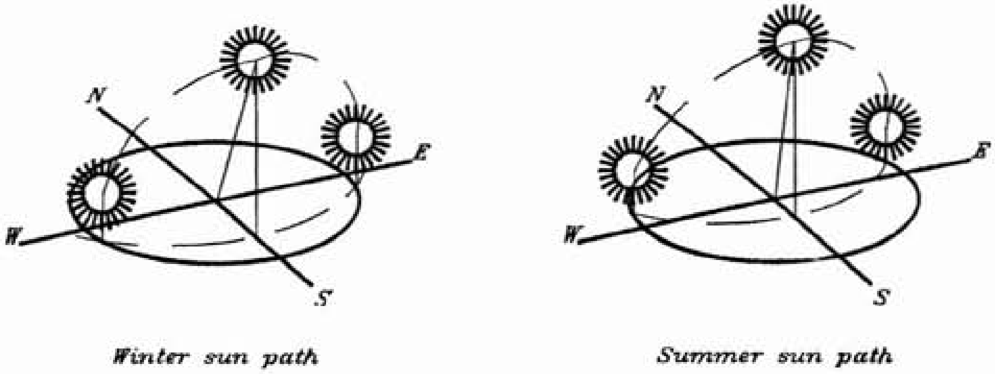


FIG. 4-8
Summer and winter sun path

The variation in orientation produced by regional requirements is diagramatically presented in the accompanying illustration. In northern latitudes, the air is generally cool and there is a great need for the sun's heat. Consequently, buildings should be oriented so as to receive the maximum amount of radiation throughout the year. However, the same building in the south, where the air is heavy with heat, should turn its axis to avoid the sun's unwanted radiation and pick up cooling breezes instead. (*)

The optimum orientation of house building should be positioned to receive solar radiation as much as possible during underheated period (winter), while during overheated period (summer), the building should be positioned to decrease solar radiation impacts as much as possible.

In order to reduce solar heat gain during summer season the long axis of the building mass should positioned east-west. Then, to promote solar heat gain during cool season and reduce it during the hot season the long axis of the building mass should be oriented east-west. The optimum orientation applied to four typical climate regions are shown on regional orientation chart in figure (4-9).

(*) DESIGN WITH CLIMATE Vector Olgyay P. 55

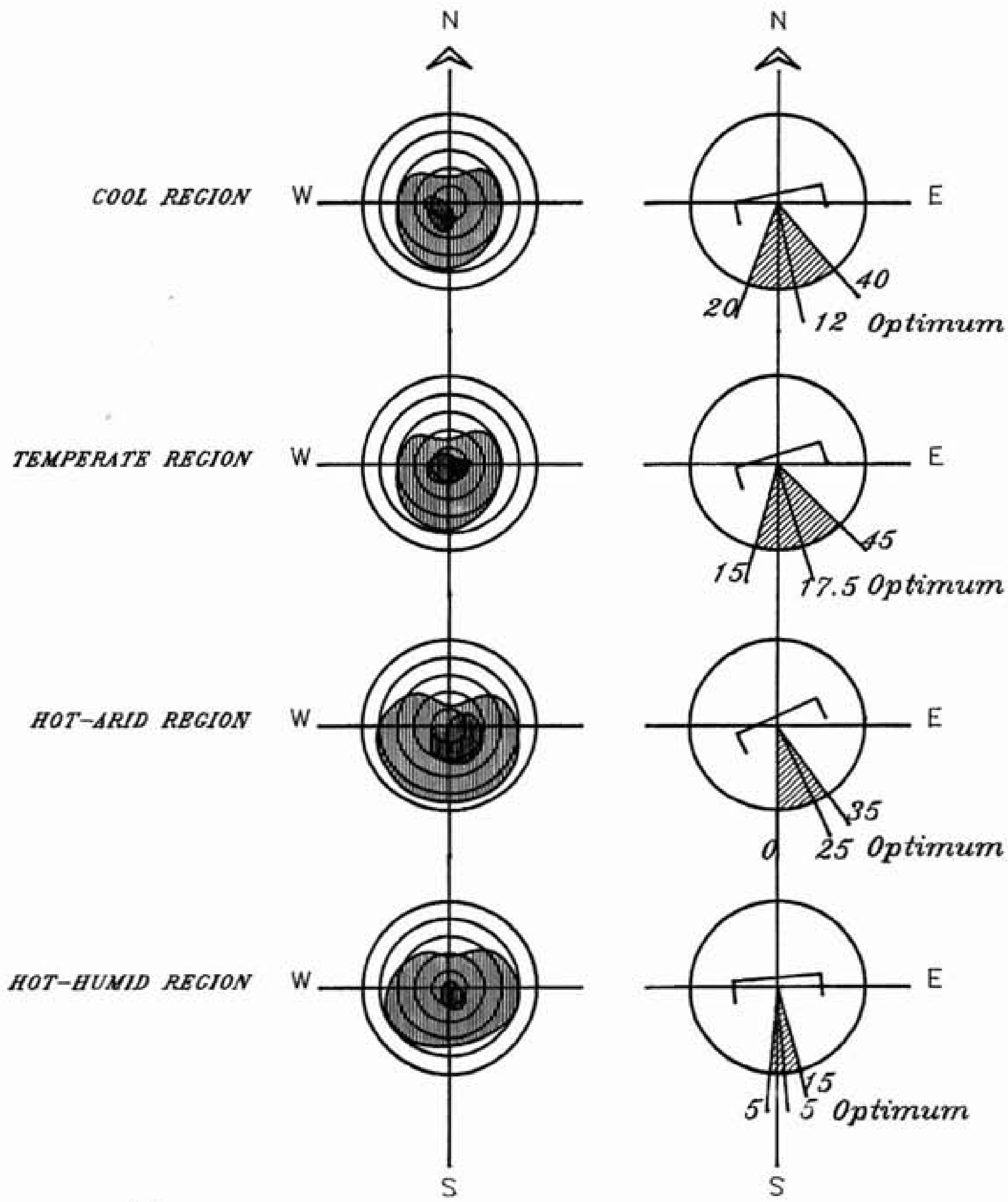


FIG. 4-9(*)
Regional orientation chart

(*) DESIGN WITH CLIMATE Vector Olgyay P. 61

In the northern of the equator the north side of building receive very little amount of direct solar radiation , therefore , heat gain is not so critical on the north walls as on those which are facing other directions. In the southern of the equator the above relationships are reversed. During winter season the south walls will receive a greater solar radiation intensity than those during summer season. Therefore , maximizing the south facing, by making the long axis east-west position, may allow the increasing of the solar heat gain in cold conditions.

The air flow around building mass is determined according to many factors. One of these factors is the orientation of the building mass against the prevailing wind direction. The windward side of building mass is exposed to the air flow effect, thereby, the indoor conditions rae influenced by the area of the windward side. Also exposed angle causes a variation in wind effects. Figure (4-10) shows the variations in air flow around some typical forms related to its orientation against prevailing wind direction.

The design recommendations of building orientation and its effect in the field of climatic control strategies related to the climatic conditions defined on bioclimatic chart can be summarized as shown in figure (4-11).

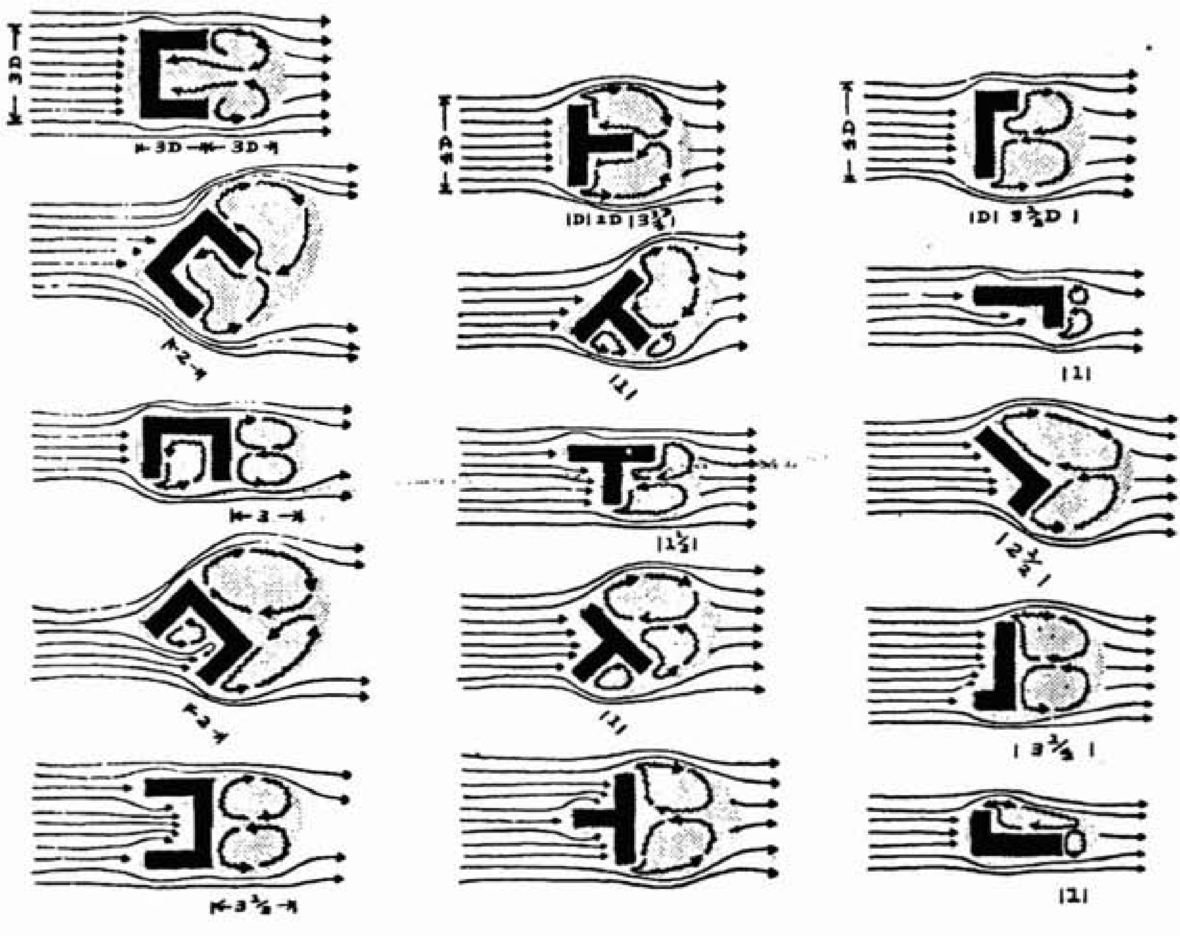


FIG. 4-10(*)
Variation in air flow around some typical forms

(*) KLIMAGERECHTES BAUEN Sedky Karam P. 43

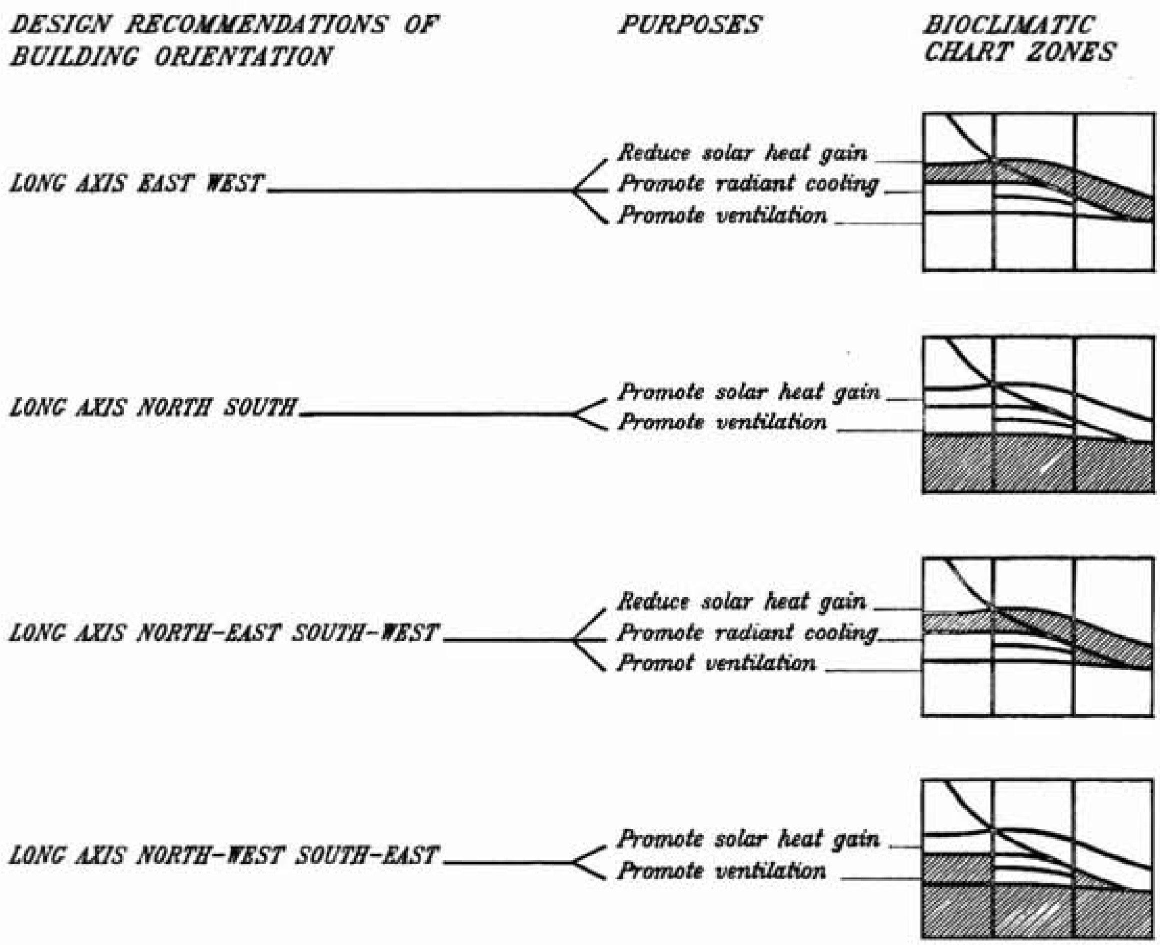


FIG. 4-11

Climatic design recommendations of building orientation

4.4- BUILDING ENVELOP

The total amount of heat exchange between internal and external spaces of the building depends, not only, on the local climatic conditions, but also, on the thermal properties of the house envelope elements (external walls and roofs).

> *One experimental solar structure built by the Massachusetts Institute of Technology utilizes a phase-change heat storage material sandwiched within a one-inch thick concrete tile. In a sense, the material is "preprogrammed" to evolve heat by its own internal chemical thermostat : The tile panels store excess day heat above 74 °F and release it at night when room temperature fall below 74 °F. These lightweight storage cells can be used conventional floor, wall, and ceiling construction, without the increased structural requirements for heavy masonry massing.*(*)

The roof of any building is exposed to greater impact of direct solar radiation than the outer walls. Walls receive about two-thirds of the maximum solar

(*) CLIMATIC DESIGN Donald Watson, FAIA, and Kenneth labs P. 123

radiation that falls on the roofs and the reception period of the direct solar radiation on walls is also shorter than on roofs .

The basic method of utilizing the large diurnal air temperature variations consists of the use of high thermal capacity structure . Using heavy material with high thermal capacity will absorb much of the heat entering through the outer surface , before the inner surface temperature increase . The building envelop elements should have the time lag required to give protection against daily temperature fluctuations.

During hot period of the day heat flows through external elements into the building while some of this heat is reflected on the external surface and some of it is stored in the envelop structure. At night, during the cold period, the building envelop will re-emits the stored heat (figure 4-12).

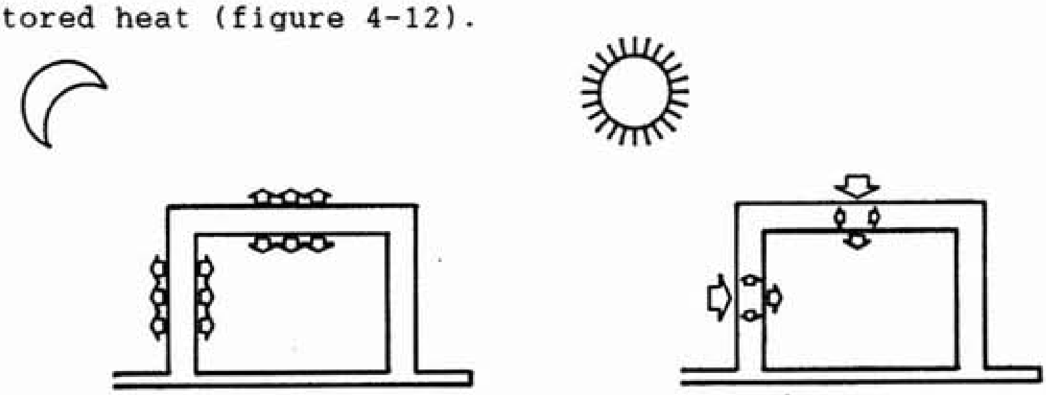


FIG. 4-12

Heat flow through building envelop

For tropical climates with higher annual and diurnal ranges in air temperature the high thermal capacity of building material should be used to construct the elements of building envelop. By using high thermal capacity materials the solar heat flow through envelop elements can be controlled.

The time rate of acceptance and diffusion of heat throughout the building material will determine its overall thermal performance. The material's conductivity as well as its heat capacity has major impact on its overall thermal performance. An index of this property is "Thermal admittance".

Table (4-1) shows the thermal properties of some building materials. The building material with high thermal admittance quickly store and release heat while materials with low thermal admittance respond slowly and hold a little heat.

The most effective method to resist heat flow through the building elements is to construct it as a double layer with an air layer in between. However , a simple ceiling with a ventilated space would be more effective to resist heat flow as well as the double walls. The building elements which are made up of two or more layers separated by air spaces will provide a resistance to heat flow.

TABLE 4-1[*]

Thermal properties of some building materials

MATERIAL DESCRIPTION	HEAT CAPACITY BTU/cu.ft(°F)	CONDUCTIVITY TU/hr.(ft)°F	T. ADMITTANCE BTU/ft²(°F)
Acoustic tile	5.8	0.033	0.44
Adobe	19.6	0.37	2.7
Aluminum	35.9	128.0	67.8
Brick, common (120 pcf)	24.0	0.42	3.2
Brick, face (130 pcf)	26.0	0.75	4.4
Concrete	29.4	1.0	5.4
Copper	51.0	227.0	108.0
Corkboard	24.6	0.023	0.27
Glass (Pyrex)	26.8	0.59	4.1
Gypsum	51.3	0.25	2.2
Iron, cast	54.0	27.6	38.6
Limestone	34.7	0.54	3.5
Marble	18.0	1.5	7.1
Paraffin	18.6	0.14	2.3
Particleboard (160 pcf)	27.7	0.1	1.36
Plasterboard	22.4	0.43	3.1
Playwood	9.9	0.067	0.81
Sand	18.0	0.19	1.85
Soil,light&dry(80 pcf)	18.0	0.2	1.9
Soil,average(damp 131 pcf)	30.1	0.75	4.75
Soil,wet(117 pcf)	35.1	1.4	7.0
Wood,hardwood	18.7	0.09	1.3
Wood,white oak	26.8	0.1	1.6
Wood,softwood	10.6	0.067	0.84
Wood,white pine	18.1	0.063	1.07
Water	62.4	0.35	4.67
Glass,cellular insulation	2.2	0.033	0.27
lead	21.8	20.1	20.9
Ice	27.0	1.35	6.04
Bakelite	20.4	9.7	16.6
Steel (mild)	58.7	26.2	39.2
Granite	31.7	1.4	6.6

[*] CLIMATIC DESIGN Donald Watson, FAIA, and Kenneth labs P. 122

The amount of heat resistance depends not only on the width of the air space but also on the characteristics of the enclosing surfaces. As heat transfer across the air spaces takes place mainly by radiation from one surface to another (figure 4-13). The surface of building materials influence the overall thermal performance of the building elements and it can help to reduce the heat loss or gain.

By using a dense cover of planting next to building envelop it will intercept the solar radiation before it reaches the building envelop, thereby reducing solar heat gain (figure 4-14).

The color of the surface gives an indication of its absorptivity for solar radiation which decrease, and the reflectivity increases, with lightness. The materials which reflect rather than absorb radiation and which more readily release the absorbed quantity as thermal radiation will cause lower temperature with the building element .

The external surface with light color or shiny surfaces will reflect a large part of the incident solar radiation. Light colors or shiny surfaces will reflect a large part of the incident solar radiation more than the dark colors. Table (4-2) shows the reflectivity amount of the surface of some typical materials.

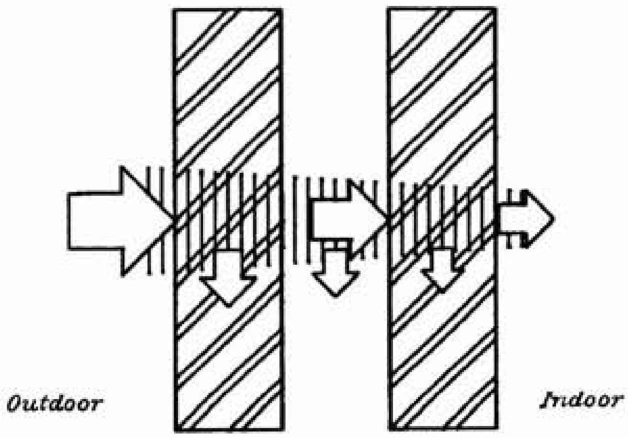


FIG. 4-13
Heat flow through double building elements

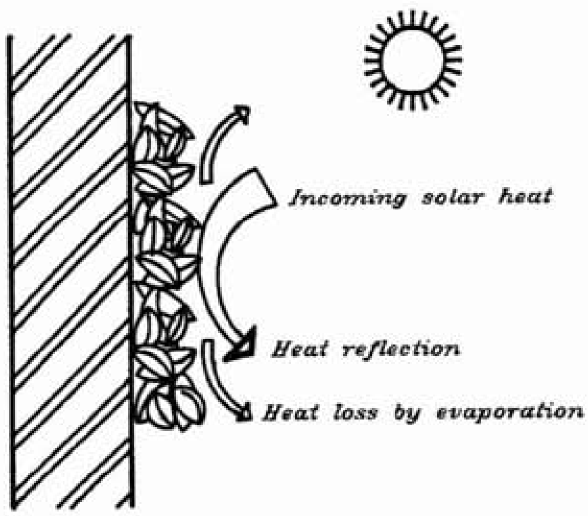


FIG. 4-14
Planting next to building envelop

TABLE 4-2(*)

Reflectivity amount of some typical surface materials

SURFACE	*REFLECTIVITY PERCENT OF SOLAR RADIATION*
Polished aluminum	*85*
White-lead paint	*71*
Light green paint	*50*
Grey paint	*25*
Black matte	*3*

The climatic design recommendations of building envelop elements are simplified in figure(4-15) with its purposes of climate control strategies. Also the bioclimatic chart is shown for every climatic design recommendation in order to specify the climatic conditions where those recommendations are needed to confirm human comfort.

(*) DESIGN WITH CLIMATE Vector Olgyay P. 68

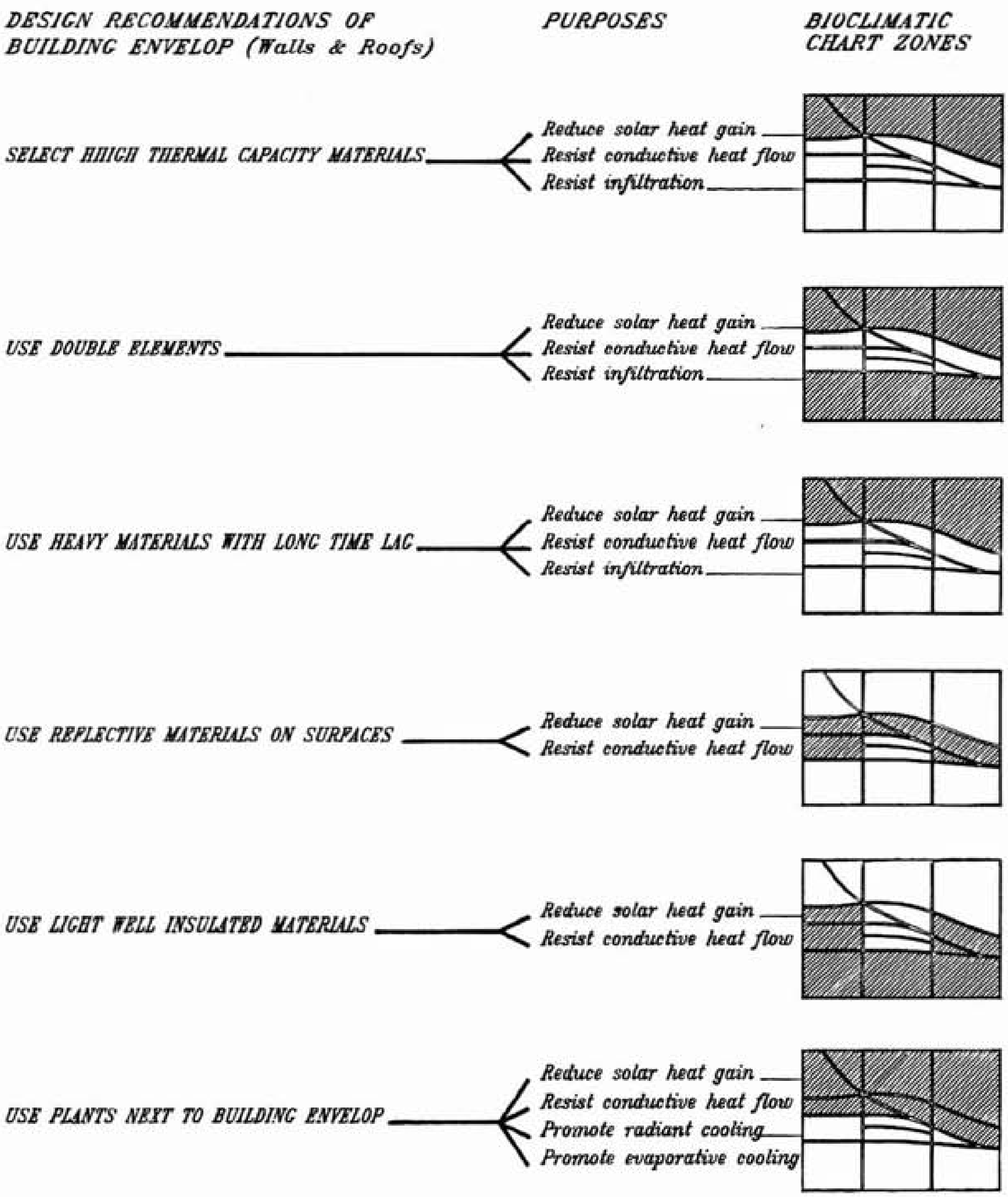


FIG. 4-15

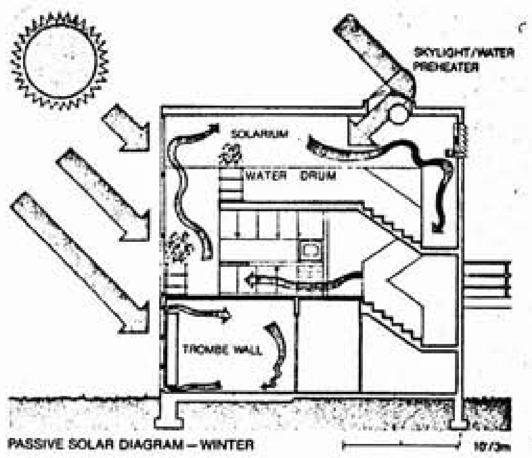
Climatic design recommendations of building envelope

4.5- HOUSE PLAN

BY relating to sun path and air movement the house plan has important impact on heat flow between indoor spaces and external environment. The solar energy can be put to use when it is most available by orient specific rooms to get direct solar radiation in cold regions. One of the most methods to maximize solar heat gain is maximizing the exposure to direct solar radiation. In the north of the equator south-facing has the major influencing by direct solar radiation during the hot period of the day time.

The general concept of using south-facing room planing for passive heating can be carried one step further in design by creating solar oriented rooms such as sun-rooms or atrium.(figure 4-16).

The favorable orientation include: an east or southeast facing window for bedrooms , kitchen and breakfast area to benefit from the earliest winter morning sunshine; a south orientation for day time living areas; a southwest orientation for sunspaces.



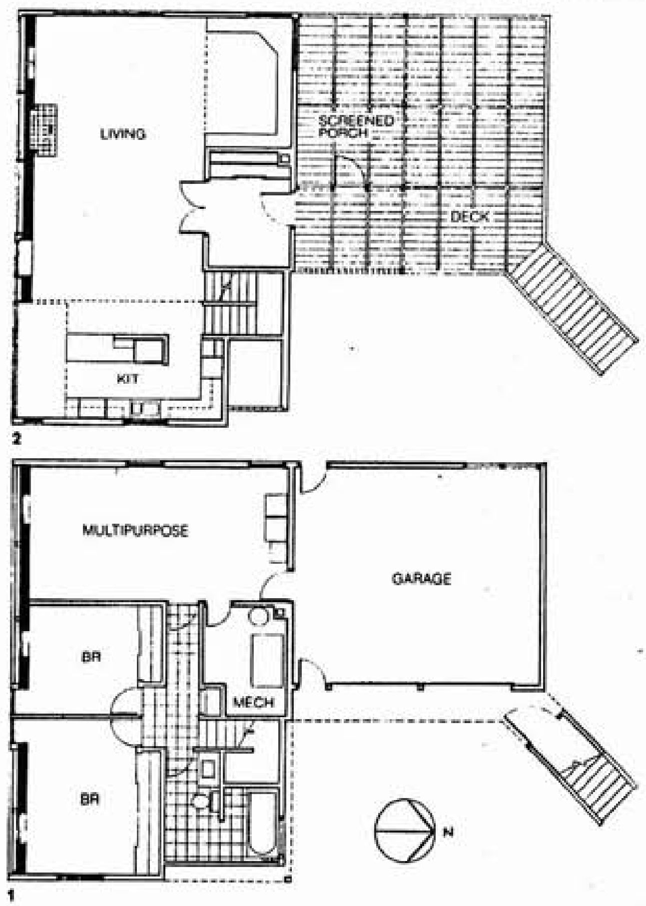


FIG. 4-16(*)
Plan design to maximize exposure to solar radiations

In hot regions the protection of direct solar radiation will be more important. This protection can be achieved by the use of north-facing living-rooms , and by locate circulation spaces and other secondary spaces on the south-facing in the northern of the equator . This relation shape are reversed in the thouthern of the equator (figure 4-17).

When the air temperature is higher than comfort limits, heat gain from the external air must be reduced. Also there are several sources of heat gains within the house , these heat gain must be reduced as far as possible. Internal heat gain can be removed from the house interior if the outside air temperature is lower than the inside air temperature , and if the vapor pressure outside is lower than the inside.

When internal air temperature and humidity are equal to or more than the external air temperature and relative humidity, the inside air movement becomes very necessary. Air shafts is one of the most design aids which promote internal air movement. The incoming air is cooled by conduction when it comes into contact with the cold inner surface of the wind catcher duct.

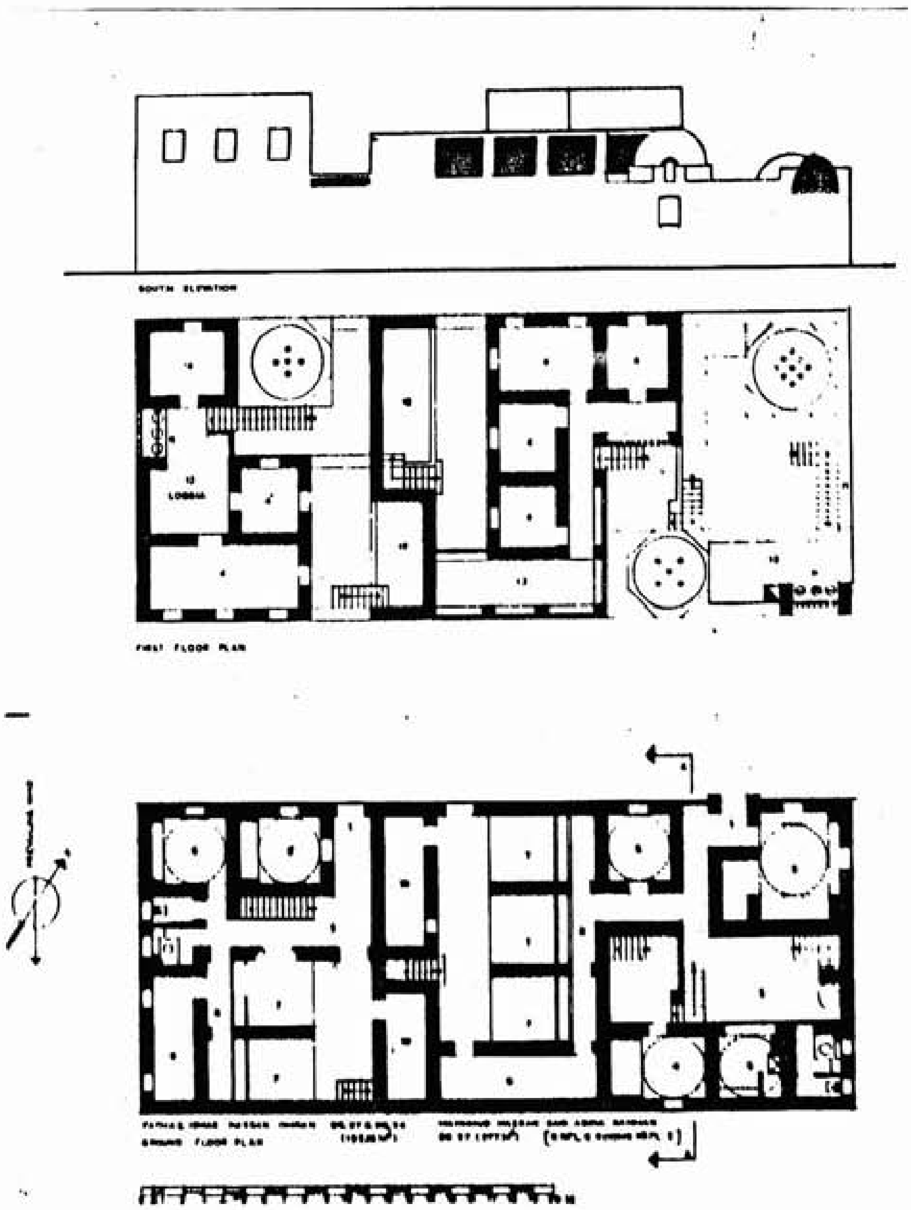


FIG. 4-17(*)
Plan design to minimize exposure to solar radiations

(*) ARCHITECTURE FOR THE POOR Hassan Fathy Fig. 107

In hot seasons , when the internal air temperature are too hot for night comfort , one of the traditional solutions is to provide outdoor sleeping areas. In this case the human body will be warmed by the floor surface which absorb heat during the day and re-emits the heat at night.

The courtyard in the house which built as a compact courtyard form can be used as an outdoor sleeping area. In some hot climates , roof spaces may be the most comfortable spaces in the evening after sunset, and before internal air temperature have dropped sufficiently for comfort.

In tropical climates, the appropriate house plan is to locate living rooms on north facing, while circulation and other secondary spaces located on south facing in the northern hemisphere. The above relationship are reversed in the thouthern hemisphere.

The climatic design recommendations of house plan are simplified in figure(4-18) with its purposes of climate control strategies. Also the bioclimatic chart is shown for every climatic design recommendation in order to specify the climatic conditions where those recommendations are needed to confirm human comfort.

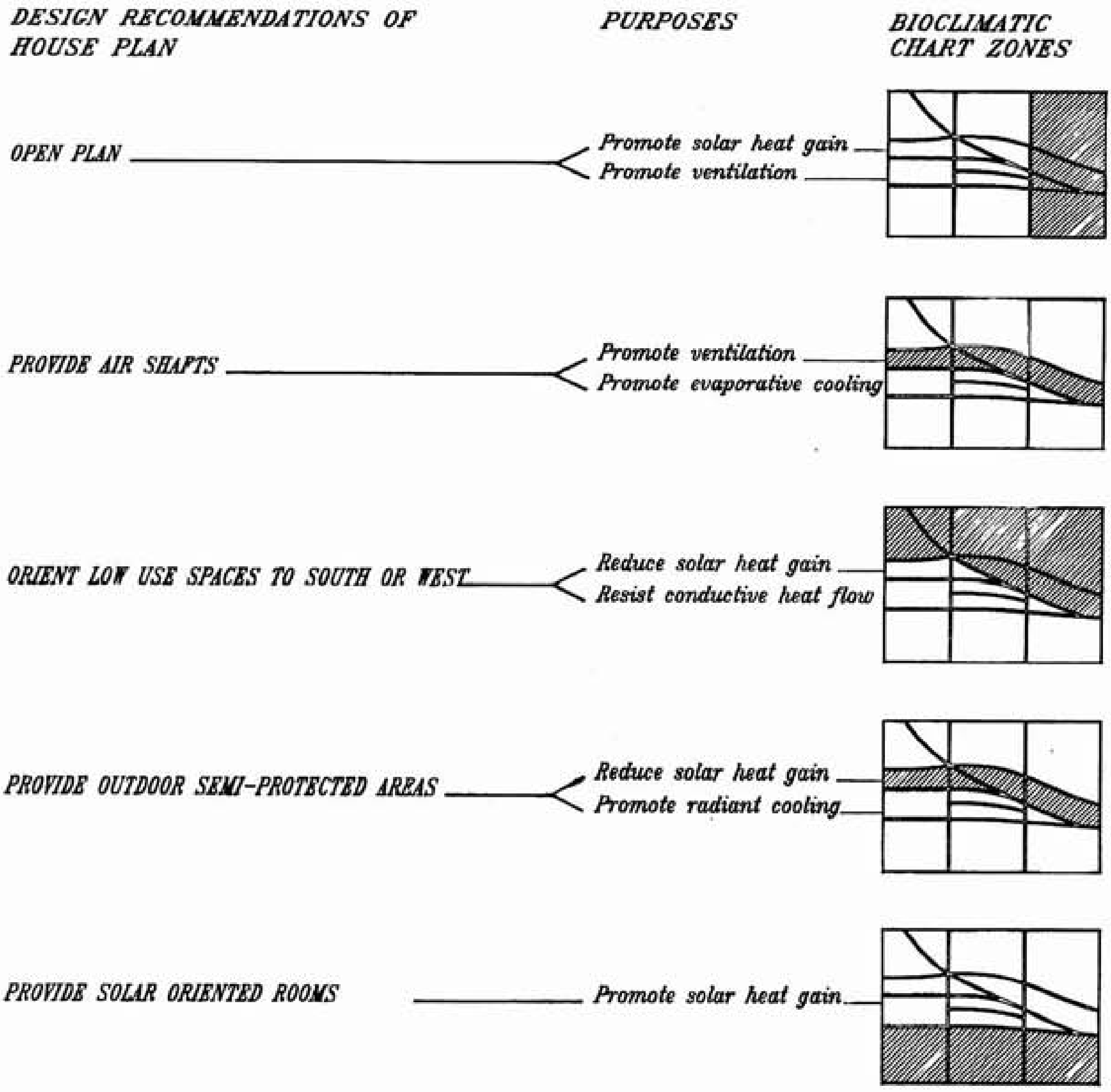


FIG. 4-18

Climatic design recommendations of house plan

4.6- OPENINGS DESIGN

SOLAR radiation affects buildings not only through the external walls and roofs but also enters through outer glazed openings which transmit solar heat with very little loss in heat energy. The solar heat which enters through glazed openings can increase the indoor air temperature more than that of the air outdoor.

So, the outer opening of the house building has major effect on the internal thermal environment. Openings , unlike other building elements , usually contain adjustable elements and are composed of a number of different layers such as glass, wood, metals and other materials.

When climatic conditions are within or above comfort range, solar radiation can cause or increase discomfort. Therefore outer opening , especially glazed openings, should be protected from direct solar radiation when temperatures are within or above the comfort range (figure 4-19).

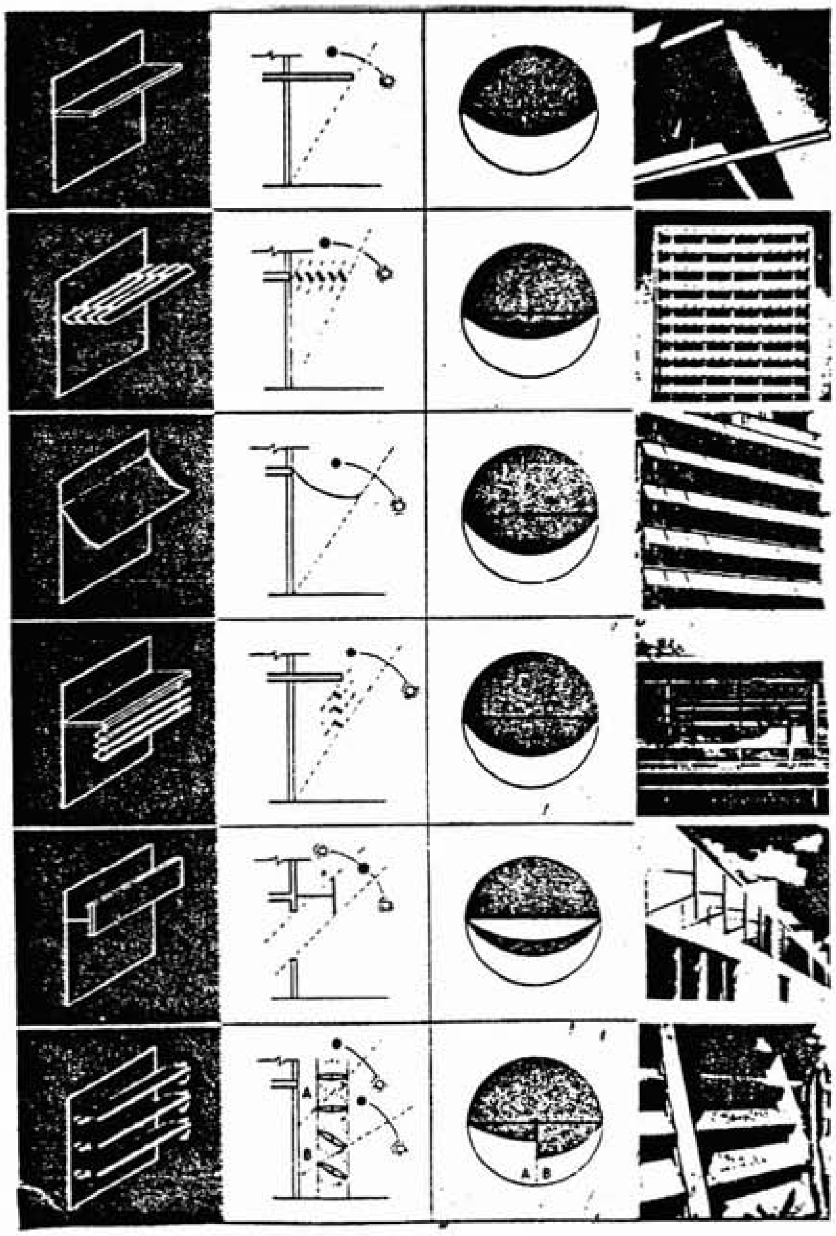


FIG. 4-19(*)
Shading on outer openings

(*) DESIGN WITH CLIMATE Vector Olgyay P. 82

The reflected radiation from nearby surfaces could increase the impact of solar radiation. For cold conditions maximizing the nearby reflective surfaces can help to promote solar heat gain through outer openings (figure 4-20).

One of the principal functions of outer openings is to provide natural light and ventilation. In hot seasons direct sun light should be minimized. Figure (4-21) appears some types of window designs can be used to resist natural light in hot dry regions. In cold seasons the main criterion for natural lighting is to ensure that there is sufficient light when the sky brightness is low.

When the temperatures are below the comfort zone solar radiation can be helpful as it can raise internal temperatures to create comfortable conditions. Then, the large glazed openings can be used to raise internal air temperature while small glazed openings could be considered as a protection from direct solar radiation.

When the diurnal range is high with cold temperatures in the morning and high temperatures at mid-day, solar radiation entering through the windows will be useful in the morning, and may help to achieve comfortable conditions. Increasing the area of east openings provide more solar heat gain in the morning while reducing it later in the day.

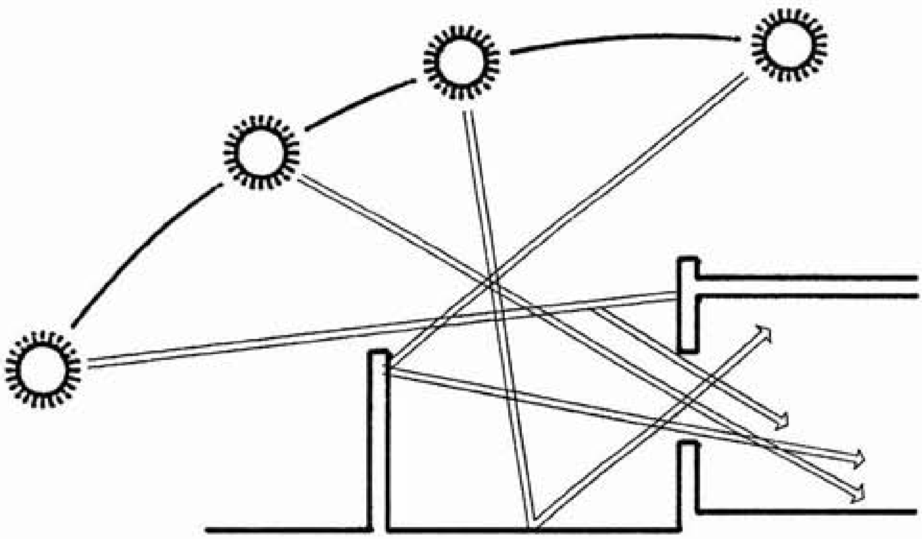


FIG. f4-20

Solar heat flow through outer openings

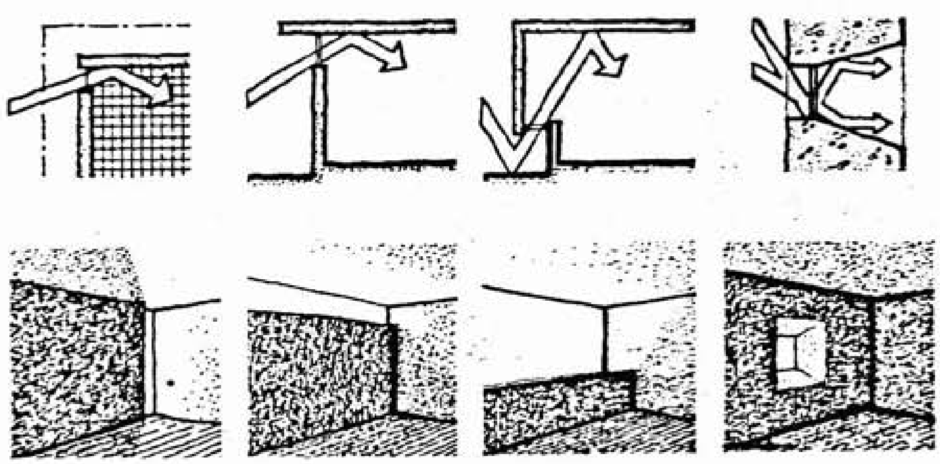


FIG. 4-21(*)

Minimize natural light

(*) DESIGN PRIMER FOR HOT CLIMATES Allan konya P. 50

The large windows required for good internal air movement will allow direct solar radiation to penetrate into the interior if the conditions are cold and humid. If the conditions are hot humid, the protection from direct solar radiation are needed to reduce solar heat gain. But it should be large in order to provide ventilation. So, in this case the opening must be large and protected from direct solar radiation.

For tropical climates with high annual and diurnal ranges in air temperature the smaller openings are suitable, although openings must provides adequate internal air movement.

Natural ventilation should be reduced as far as possible to minimize discomfort when conditions are hot and dry , but when high temperatures are combined with high humidities ventilation may be more important than reducing heat gain.

The indoor air motion increases by increasing the opening area related to the floor area. The size of inlet and outlet openings also affect the internal air motion (figure 4-22). Also the width variation of opening causes variation in the indoor air motion (figure 4-23).

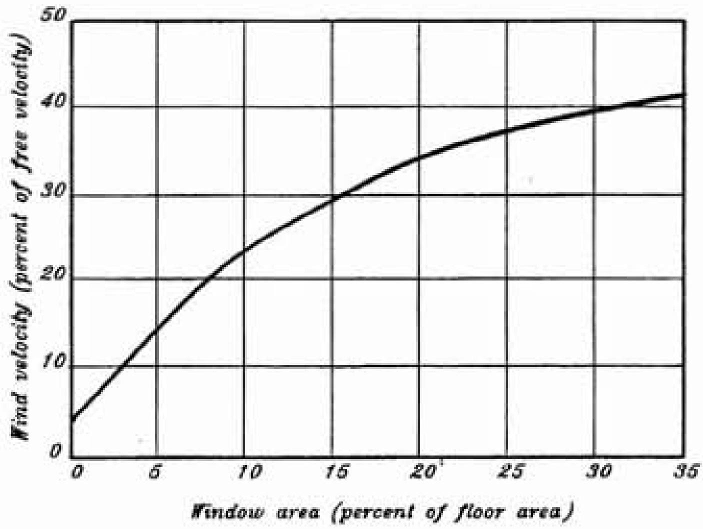


FIG. 4-22 (*)

Effect of size of inlet and outlet on internal air motion

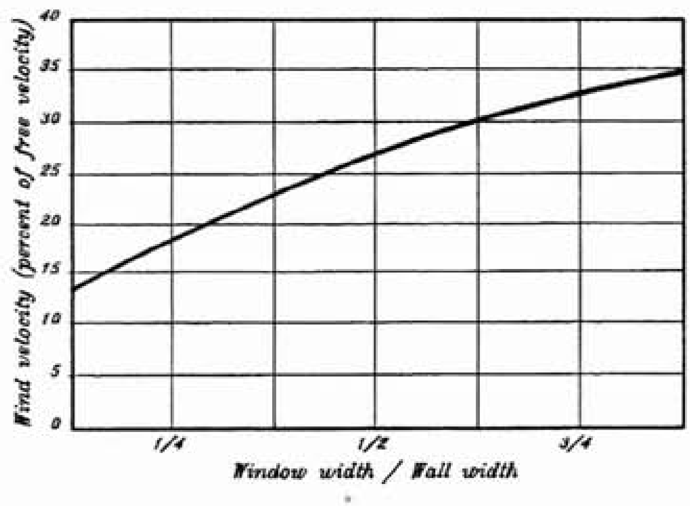


FIG. 4-23 (**)

The effect of window width on wind velocity

(*) TROPICAL ARCHITECTURAL C.P. Kukreja P. 97
(**) TROPICAL ARCHITECTURAL C.P. Kukreja P. 96

In many climates the terms window and glazed area will not necessarily be synonymous. In a temperate climate windows will be fully glazed and partially openable. But in a warm humid climate windows might be partially glazed and fully openable , opaque and possibly insulated louvers being used for part of the opening. In hot dry and mediterranean climates, fully openable and fully glazed openings are the rule.(*)

The positioning of the inlet and outlet windows has an important effects on the pattern of indoor air motion (figure 4-24). The external shaded devices of outer openings also has effects on indoor air motion (figure 4-25).

The climatic design recommendations of opening design are simplified in figure(4-26) with its purposes of climate control strategies. Also the bioclimatic chart is shown for every climatic design recommendation in order to specify the climatic conditions where those recommendations are needed to confirm human comfort.

(*) HOUSING, CLIMATE AND COMFORT Martin Evans P. 109

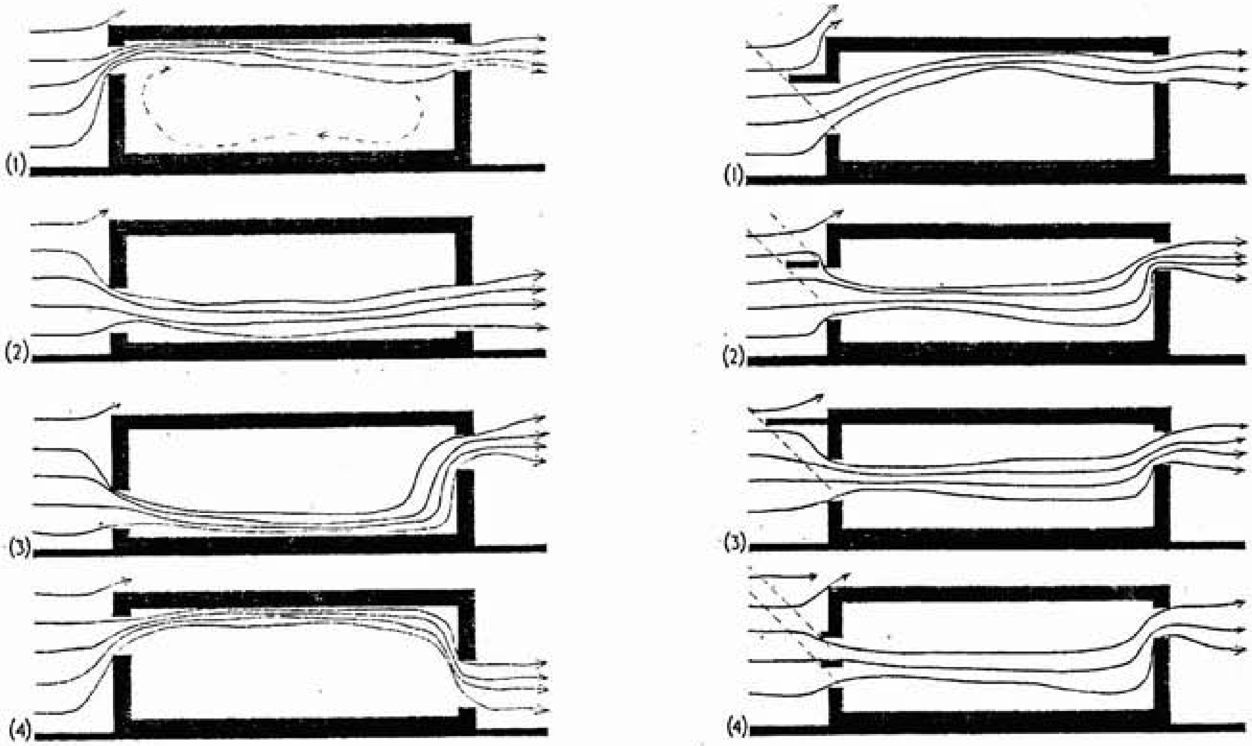


FIG. 4-24(*)
Effect of openings position on indoor air motion

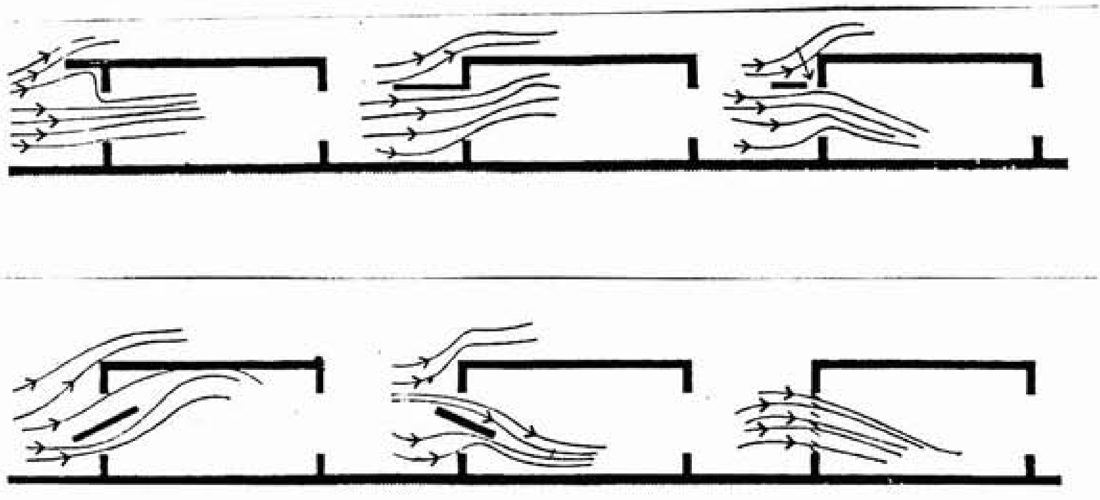


FIG. 4-25(**)
Effect of external shading devices on indoor air motion

(*) HOUSING, CLIMATE AND COMFORT Martin Evans P. 129
(**) TROPICAL ARCHITECTURAL C.P. Kukreja P. 94

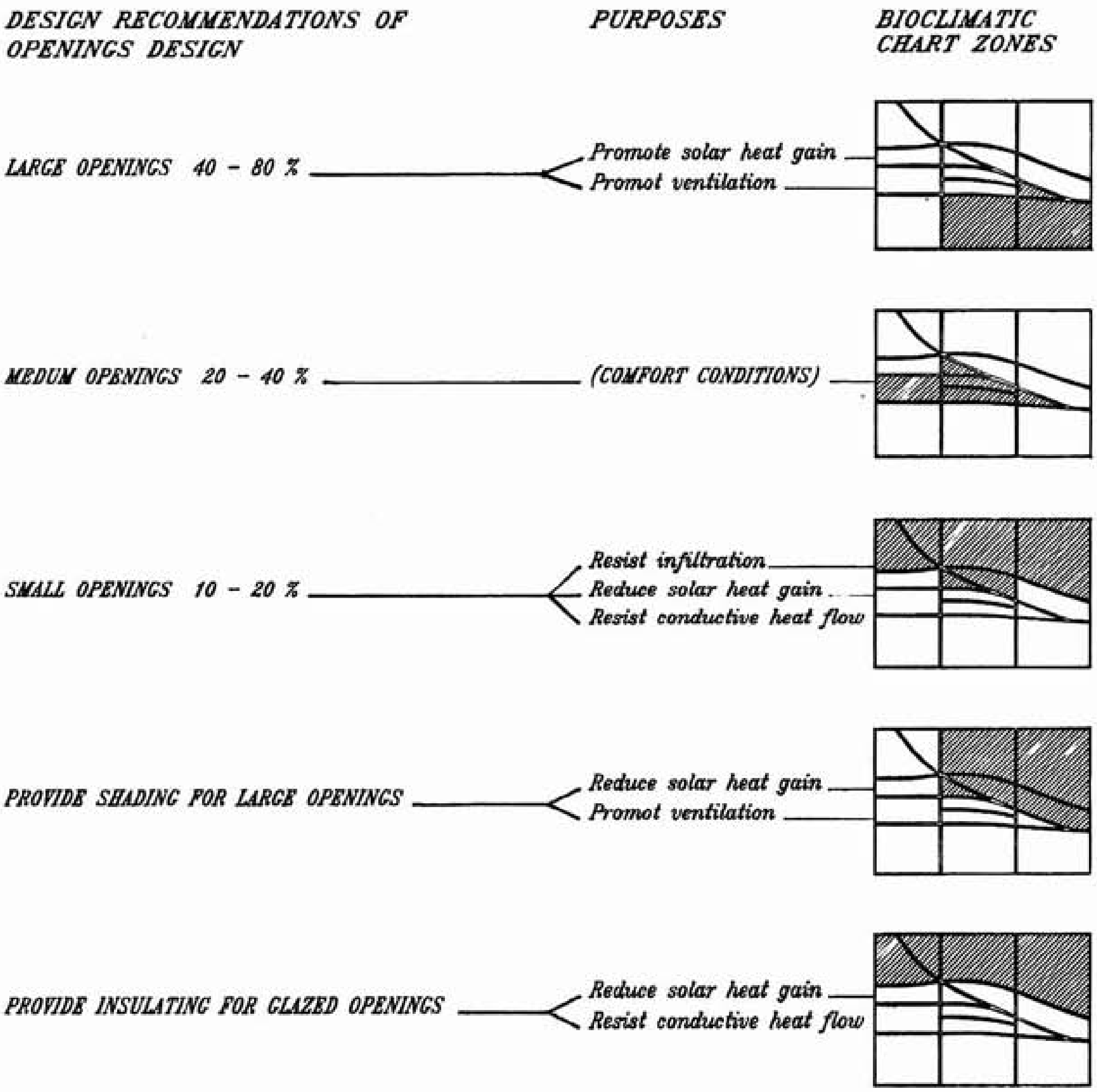


FIG. 4-26

Climatic design recommendations of openings design

4.7- HOUSING LAYOUT

DESIGN of housing layout has a useful role in confirming the human comfortable living conditions. When the housing layout designed in harmony with the local climatic environment, the climate effects can be controlled.

> *"A narrow winding street with a closed vista has the same function as the courtyard in a house: to regulate temperature. In a wide straight street the cool air deposited during the night is swept away by the first breath of wind. A wide street offers no shade, and heats up more rapidly than a narrow one."(*)*

In hot dry climates, the housing layout should be designed to provide protection from direct solar radiation and shelter from hot dusty wind. The compact layout and low rise building can provide these requirements (figure 4-27). Also, using courtyards will provide outdoor spaces sheltered from the direct solar radiation and wind turbulence.

(*) HOUSING, CLIMATE AND COMFORT Martin Evans P. 154

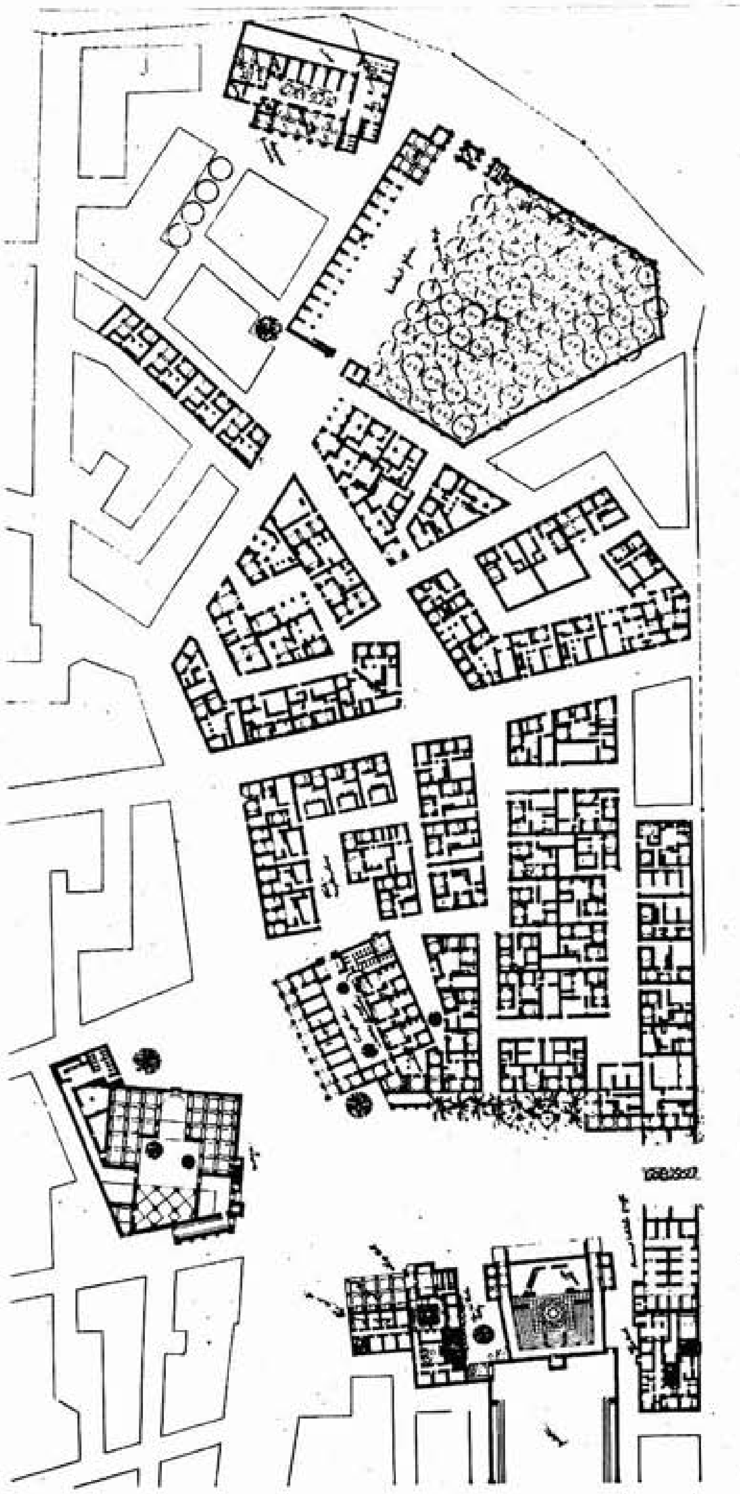


FIG. 4-27 [*]
The compact layout

[*] HASSAN FATHY J.M. Richards, I. Serageldin, D. Rastafer P. 95

In hot dry climates the tendency is to have close groups of houses, narrow roads and streets, arcades, colonnades and small enclosed courtyards , in order to get the minimum amount of direct solar radiation and provide the protection of hot dusty wind.

For warm humid conditions catching the prevailing breeze is required, while some protection should be provided against hot dusty wind, which blow from a different direction in the dry season. Also, very wide spaces between buildings are required for few months of the year and these spaces still require shade in order to reduce solar heat gain. So, in climates with long warm humid seasons , the layout requirements for this season predominate. Figure (4-28) shows a typical layout that suitable for warm humid and cold conditions.

The climatic design recommendations of housing layout design are simplified in figure (4-29) with its purposes of climate control strategies. Also, the bioclimatic chart is shown for every climatic design recommendation for the purpose of specifying the climatic conditions where those recommendations are needed to confirm human comfort.

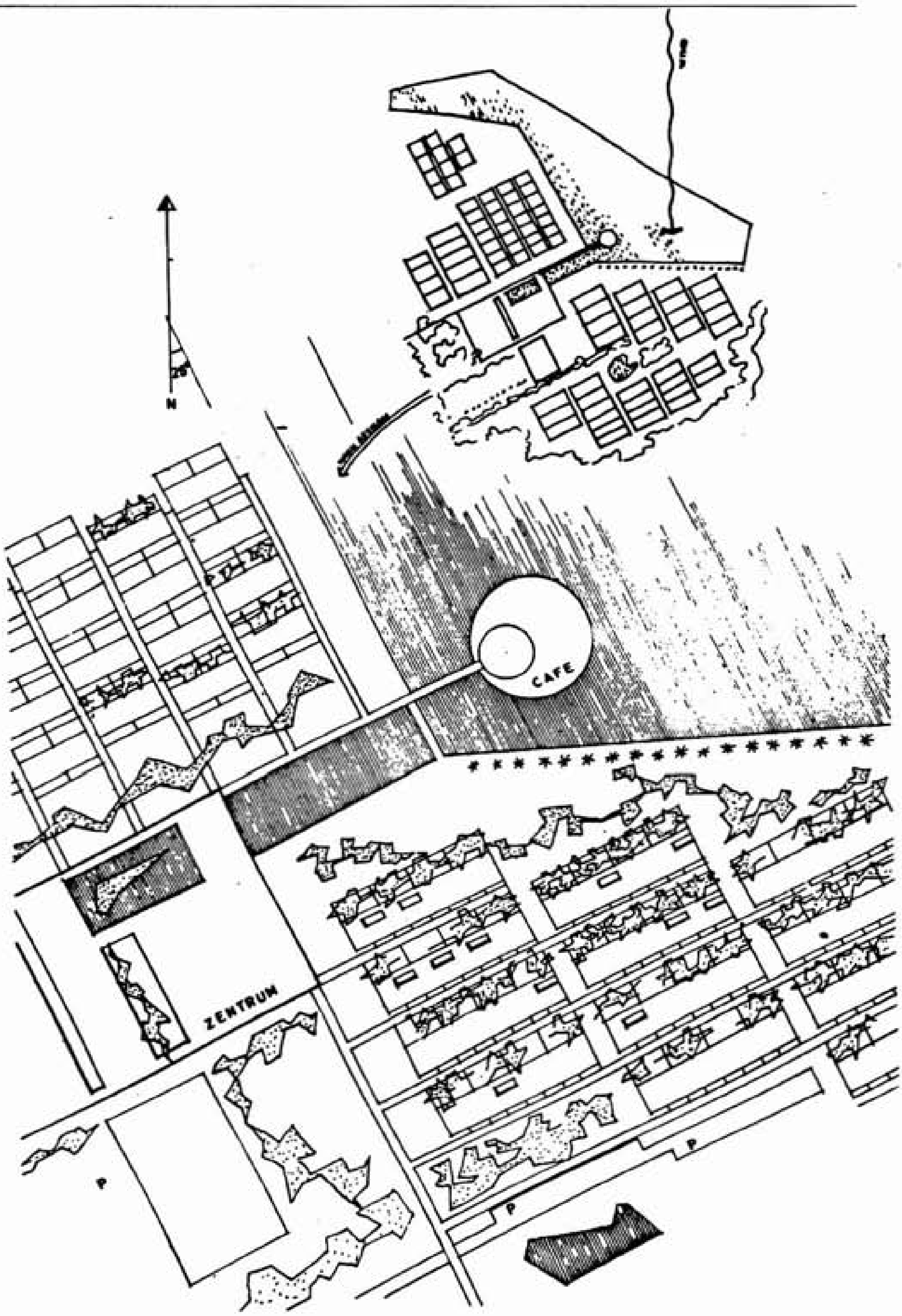


FIG. 4-28 (*)
The wide spacing layout

(*) KLIMAGERECHTES BAUEN Sedky Karam P. 73

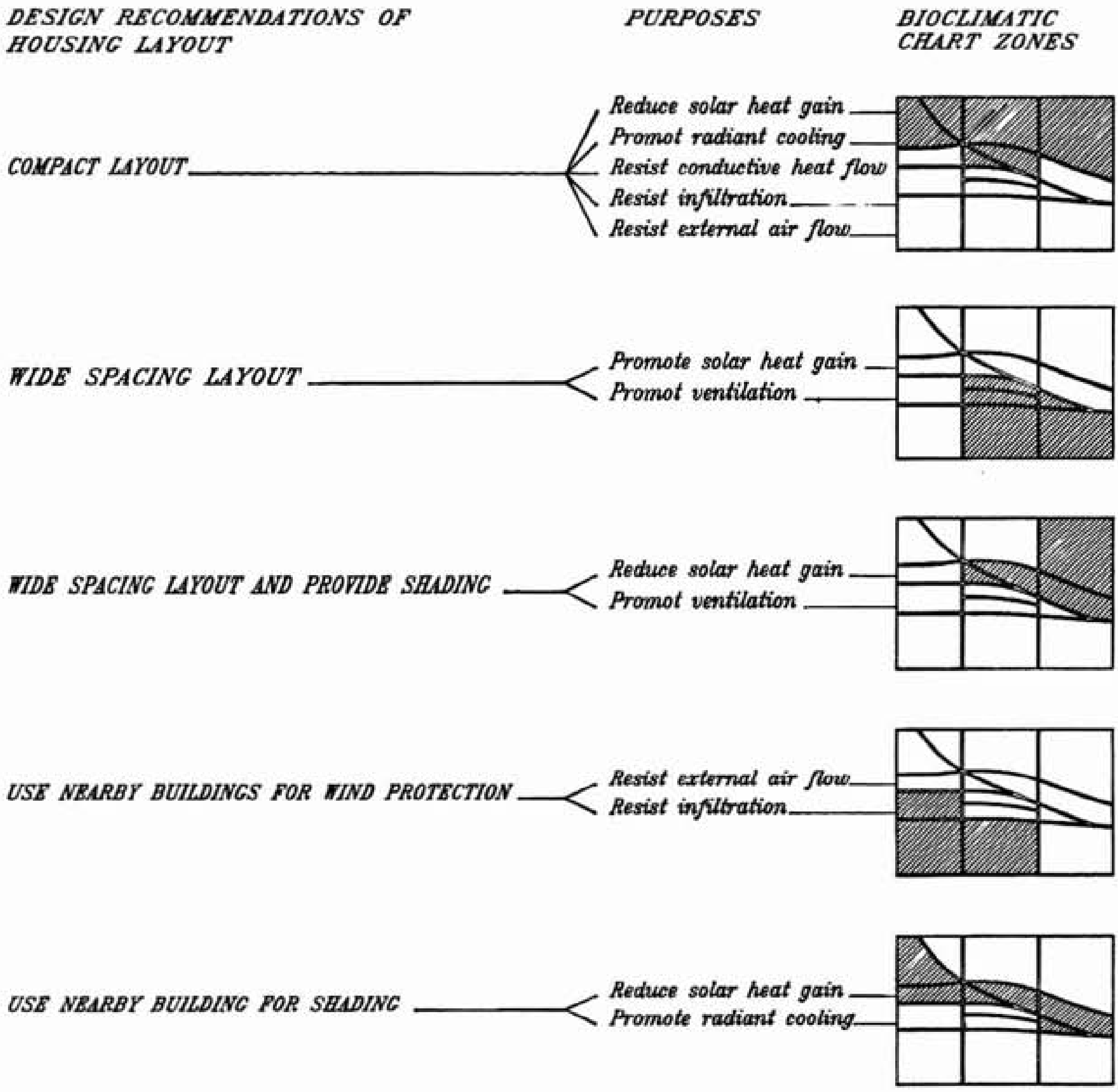


FIG. 4-29

Climatic design recommendations of housing layout

4.8- LANDSCAPING

THE nature of the ground surfaces on a given building site has a great effects on the microclimatic conditions of the building site. Air temperatures above the ground level are changed in the same building site according to the nature of the ground surfaces. There are various factors that should be considered when trying to control microclimate by the effects of the landscaping.

Solar radiation transmitted through windows may be either direct, diffuse, or reflected from exterior surfaces. Increasing the reflectivity of the surface materials, outside of the south-facing windows and walls, will slightly increase the amount of total radiation which entering through outer openings. (figure 4-30).

The latent heat of water evaporation may be used to cool building environment of the house. This is because the water has a very high volumetric heat capacity. Water, plants and trees in the courtyards and external spaces will cool the air by evaporation effect.(figure 4-31).

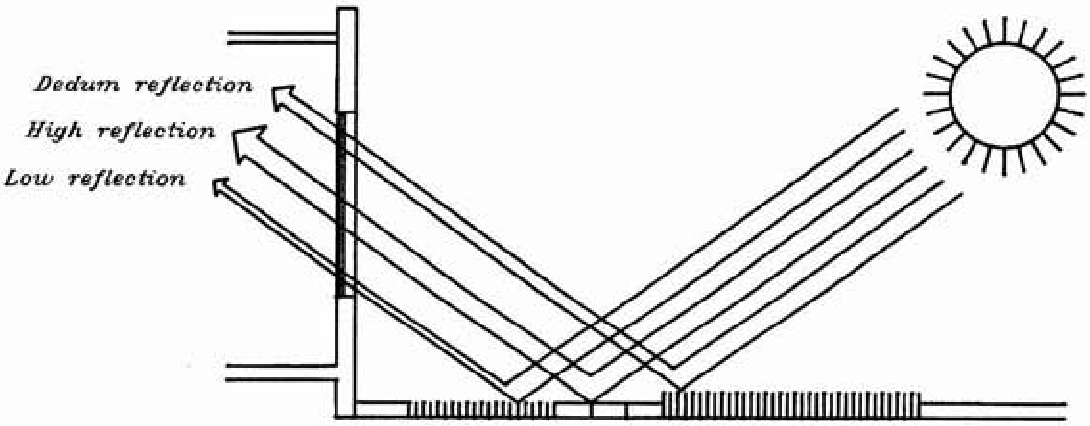


FIG. 4-30(*)

The amount of solar heat reflection on various surfaces

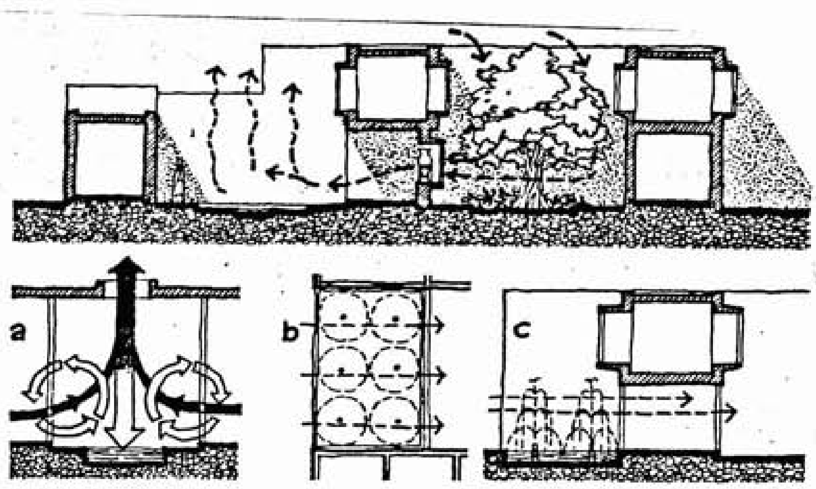


FIG. 4-31(**)

Water and plants effect on courtyard climatic conditions

(*) CLIMATIC DESIGN Donald Watson, FAIA, and Kenneth labs P. 83

(**) DESIGN PRIMER FOR HOT CLIMATES Allan konya P. 57

When the warm air passing over water surface evaporates the water and the air is cooled. For this reason evaporative coolers can only be used in relatively dry climates.

Physical features such as neighboring buildings, walls, trees etc., which may influence air movement or cast shadow, must be taken into account. There is a difference between the shelter offered by windbreaks composed of plants and that offered by solid screens or buildings, as the extent of shelter depends not only on height but also on the degree of permeability. Plant material, which permits a certain amount of air to path through, causes less turbulence than solid screens and, as a result, a greater total area of shelter.[*]

The landscaping surroundings house building have definite effects both on air-flow patterns and on wind velocities. The landscaping design elements, including plant materials, trees and shurbs can create high and low pressure areas around a house building.

Air flow patterns produced by various planting combinations are shown in figure (4-32). The most protected part behind a windbreak is fairly close to the windbreak; it becomes more exposed as the distance from the windbreak increases.

[*] DESIGN PRIMER FOR HOT CLIMATES Allan konya P. 36

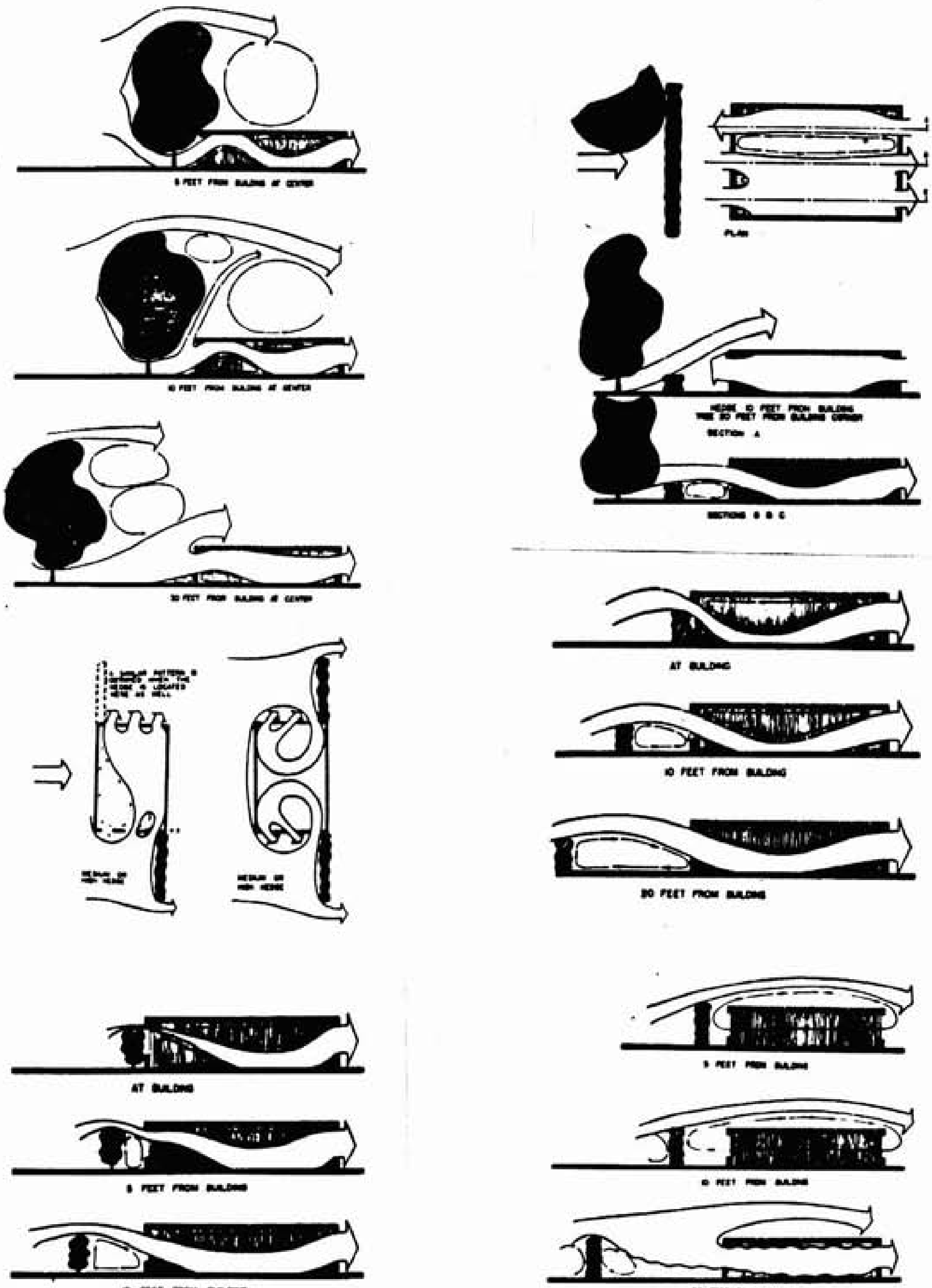


FIG. 4-32[*]
Air-flow patterns produced by planting

[*] DESIGN WITH CLIMATE Vector Olgyay. P. 102

The natural cover of the ground with plants and grassy cover can reduce the air temperatures at the building site. Trees and shrubs can provide the simplest way of protecting a low building from direct solar radiation. The ground cover properties tends to moderate air temperatures and stabilize conditions through the reflective qualities of various surfaces. In summer the surface of grass and leaves absorb solar radiation, and their evaporation processes can cool air temperature.

Plants and trees also will cool the air by evaporation effect , provide shade and help to keep the dust down. Plant grassy covers reduce air temperature by absorption and cool by evaporation. Dry ground heat up quickly , causing reflected heat radiation towards the building during the day , and at night the ground will re-radiate the heat stored during the day. Man-made surfaces tend to elevate air temperatures, as the materials used are usually of thermal properties.

The climatic design recommendations of landscaping design are simplified in figure(4-33) with its purposes of climate control strategies. Also the bioclimatic chart are shown for every climatic design recommendation in order to specify the climatic conditions where that recommendation are needed to confirm human comfort.

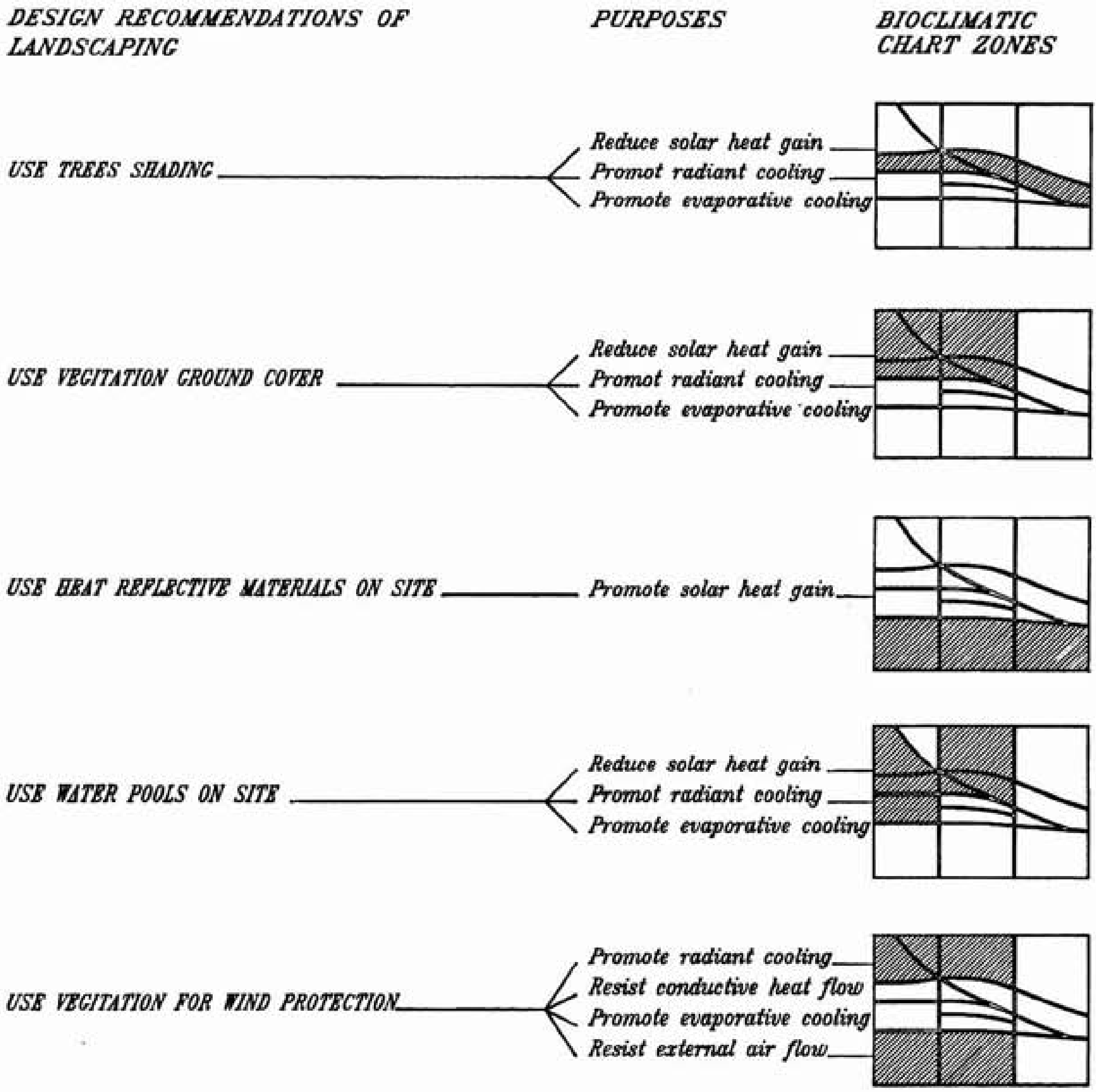


FIG. 4-33

Climatic design recommendations of landscaping

4.9- SUMMARY

IN order to confirm human comfortable living conditions with the minimum cost of mechanical heating and cooling, the house building should be designed according to the local climatic conditions. There are many climatic design applications which can provide the indoor comfortable living conditions. By the aid of the biological evaluation results the appropriate climatic design recommendations can be defined. The basic climatic design applications can be grouped under seven headings which represent the most climatic design recommendations, they are:

Building form
Building orientation
Building envelop
House plan
Openings design
Housing layout
Landscaping.

For each of the above groups, the basic climatic recommendations are specified related to the bioclimatic chart zones. These correlations are described in figures (4-6, 4-11, 4-15, 4-18, 4-26, 4-29, 4-33).

The next chapter will present the programming pattern of the climatic design of house executed by a computer program. The concluded correlations between the bioclimatic chart and the climatic design recommendations will be used to execute the specify recommendations process of the proposed climatic design of house program.

Chapter 5
CLIMATIC DESIGN PROGRAM

5.1- INTRODUCTION

THE preceding chapters provide much of the background information needed for climatic design of house. The basic traditional climatic design of house procedure is a multi-step process. It starts with the collection of available climatic data and terminates with award of the appropriate climatic design recommendations. One of the most striking effects of computer aided architectural design techniques in practice is likely to be a very substantial reduction in the total length of the design process. For this reason, the climatic design process will be presented, in this chapter, as a practical application of the computer aided architectural design. This practical application will be applied through a computer program. The proposed program will be processed according to the programming pattern for climatic design of house. The form of this programming pattern was presented previously in study concept section.

So the purpose of this chapter is to present a computer program which perform or execute the climatic design of house process. The most important step to program a computer in order to resolve any problem is understanding the problem in need of a solution. Also, defining the objective that must be reached. The previous chapters has covered the fundamental theoretical principles of climatic design of house as a problem solving process.

The following sections will illustrate the program process which execute the programming pattern of climatic design of house. For example the location of cairo will be used as an application example to illustrate the program process.

5.2- PROGRAM CONCEPT

THIS section illustrate the general concept of the climatic design of house program. The information that is processed in the performance of architectural design tasks may be in numeric form, in the form of English text, or in graphic format.

> *One of the most striking effects of the large-scale introduction of computer-aided architectural design techniques in practice is likely to be a very substantial reduction in the total length of the design and construction process.*(*)

The proposed climatic design of house program require input of numerical climatic data, and output a specified list of the appropriate climatic design recommendations.

The program processed through a sequence of stages which are required to execute the climatic design of house process. These stages are simplified in the programming procedure which has four basic stages.

(*) COMPUTER-AIDED ARCHITECTURAL DESIGN William J. Mitchell P. 87

These stages are generally taken in sequence which illustrated in the following sections.

5.2.1- INPUT STAGE

The input stage is to read the required climatic data represented by the air temperature and relative humidity for each of the year months. These data can be entered to the computer memory through the input device of the computer (keyboard) or by reading it from a data file. The required climatic data was discussed previously in chapter 1.

5.2.2- EVALUATION STAGE

The evaluation stage is to evaluate a given climatic data according to comfortable human living conditions. In chapter 2 the biological evaluation excuted by using the bioclimatic chart. The evaluation process should repeated as long as the climatic data are available.

5.2.3- RESOLVING STAGE

The resolving stage is to select the appropriate climatic design recommendations, which specified according to the results of the evaluation stage. Specifing the required climatic design recommendations according to a given climatic conditions was discussed previously in chapter 4.

5.2.4- OUTPUT STAGE

The output stage is to output a specified list of the climatic design recommendations which can be sorted according to its importance. The results may be put in a result file or printed by printout device.

The flow chart of the climatic design of house program has been simplified in figure(5-1) for the purpose of illustrating and explaining the program concept which execute the climatic design of house procedure.

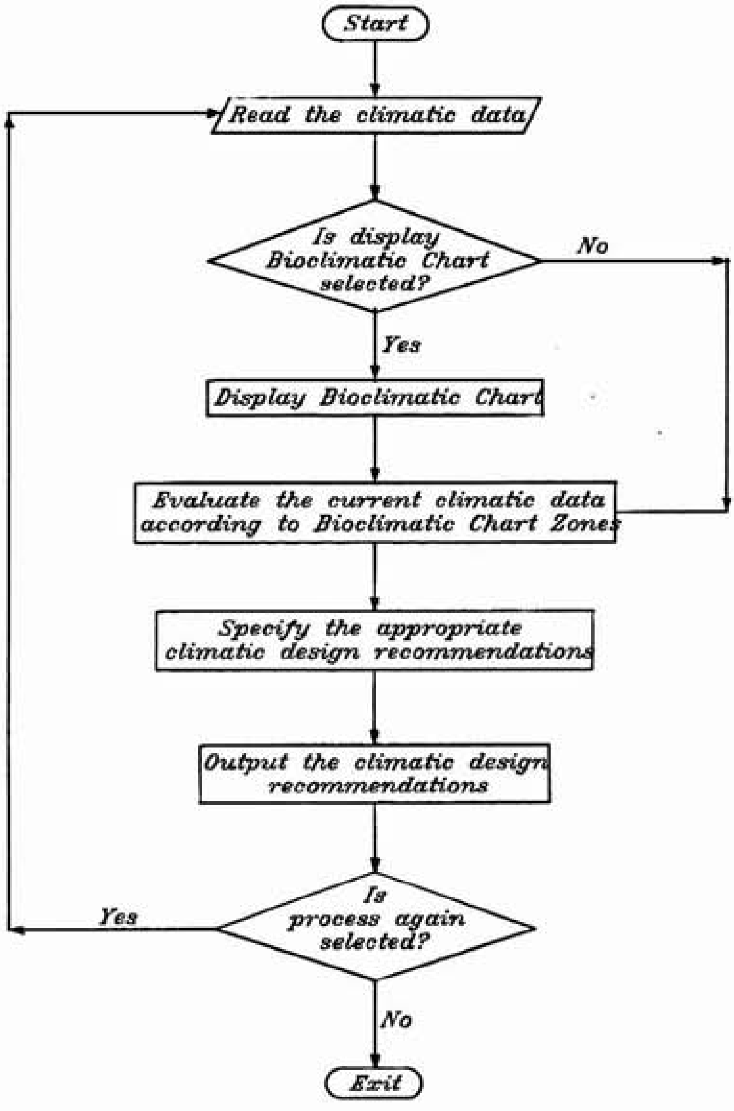


FIG. 5-1
Flow chart of the Climatic Design of House Program

5.3- PROGRAM STRUCTURE

IN order to program a computer there are many different programming languages that can be used to write the sequence of instructions which execute the program purpose. These sequence of instructions are called a computer program.

In the last years, the C. programming language has become the overwhelming choice of serious programmers. So, the C. language is firmly established as the favorite programming language which will be used to write the proposed computer program. It is allow programmers to creat better tools, utilities, and applications more quickly and more easily than they could in any other language development environment.(*)

All C. programs are divided into units called "functions". A function is a unit of a program that performs a single action. All functions start with the name of the function, followed by parentheses. Following this, braces enclose the body of the function, which may consist of one or many statements. The only function that absolutely must be presented is called main() , and it is the first function called

(*) TURBO C. PROGRAMMING FOR THE PC. Robert Lafore P. XVI when program execution begins.

The general form of a C. program is illustrated in figure (5-2), where **Function-1()** through **Function-N()** represent user-defined functions. For our purpose, the form of climatic design of house program is illustrated in figure(5-3).

```
global declarations

main()
       {
       local variables.
       statement sequence.
       }

Function-1()
       {
       local variables.
       statement sequence.
       }

Function-2()
       {
       local variables.
       statement sequence.
       }
.
.
.
.
Function-N()
       {
       local variables.
       statement sequence.
       }
```

FIG. 5-2[*]

The general form of a C. Program

[*] THE C. PROGRAMMING TUTOR Leon A. Wortman & Thomas O. Sidebottom P. 12

```
global declarations

main()
      {
      local variables.
      .
      statement sequence.
      }

INPUT DATA FUNCTION()
      {
      local variables.
      .
      statement sequence.
      }

EVALUATION FUNCTION()
      {
      local variables.
      .
      statement sequence.
      }

SPECIFY RECOMMENDATION FUNCTION()
      {
      local variables.
      .
      statement sequence.
      }

OUTPUT RESULTS FUNCTION()
      {
      local variables.
      .
      statement sequence.
      }
```

FIG. 5-3

The general form of the Climatic Design of House Program

5.3.1- GLOBAL DECLARATION

In the C. programs, there are two basic places where declarations are declared: inside functions and outside all functions. These declarations are, respectively, local variables and global declarations.

Unlike local variables, global declarations are known throughout the entire program and may be used by any function. Also, global declaration contains global variables which will hold their values during the entire execution of the program. Global declaration are created by declaring them outside any function.

5.3.2- LOCAL VARIABLES

A variable is a name that represents a number or a string. Variables that are declared inside a function are called local variables. The local variables are not known outside their own function and they are exist only while the function in which they are declared is executing. Because local variables are created and destroyed with each entry and exit from their own functions, their content is lost after the function is exited.

5.3.3- STATEMENT SEQUENCE

The function body is a series of statements that describe what the function is to do. So, statement sequence means the sequence of instructions that execute the purpose of the function or program.

The C. programming language has many statements which can be used to perform the climatic design of house process. The following sections will present, through climatic design process, the sequence of the program functions.

5.4- MAIN FUNCTION OF THE PROGRAM

AS noted previously any C.program must has main function which is the first function executed when the program run. In other words the main function usually contains the sequence of instructions which execute the program purpose.

The flow chart of the main function has been simplified in figure(5-4) for the purpose of illustrating and explaining the process of the main function.

In our purpose of climatic design of house the program processed through four major functions. One of the loops structure available in C.language is while loop. This loop can be used to produce the operation of our program according to the user selections.

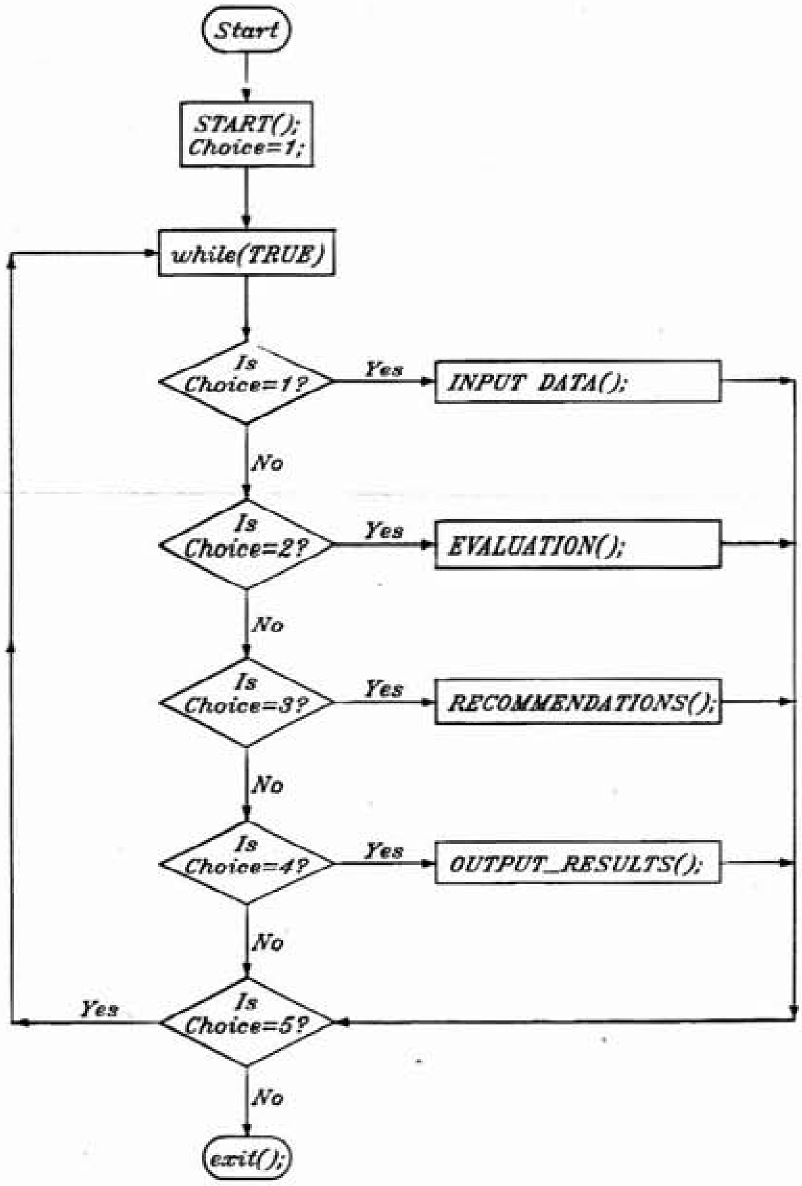


FIG. 5-4
Flow chart of the main program function

5.5- INPUT DATA FUNCTION

FOR any programming process, the input data is the first phase of this process. In our purpose of programming the climatic design of house, the climatic data is the input data phase of the proposed program.

Previously in chapter(1), the climatic data are discussed and simplified in numerical and graphical forms. The numeric form of these data will be used as input data for the climatic design of house program.

The climatic data of cairo in the form which used as the input data and saved in a data file are shown in table (5-1).

This section will illustrate the program process which execute the input data function. The computer memory get the data by entering it through computer keyboard or by reading it from a data file.

So, the input data phase of the climatic design program can be executed by some sub-functions. The flow chart which illustrate the process sequence of the input data function are shown in figure(5-5).

TABLE 5-1[*]

Climatic data of CAIRO.

MONTHS	AIR TEMP. degC. max.	min.	HUMIDITY %	RAIN mm/d	WIND DIR.
1	19.10	8.60	59.00	3.70	0
2	20.70	9.10	56.00	4.20	180
3	23.70	11.30	52.00	2.30	270
4	28.20	13.90	48.00	0.60	90
5	32.40	17.40	44.00	0.50	0
6	34.50	19.90	48.00	0.30	0
7	35.40	21.50	52.00	0.00	180
8	34.80	21.60	56.00	0.00	180
9	32.30	19.90	58.00	0.00	45
10	29.80	17.80	58.00	0.10	315
11	25.10	13.90	61.00	3.50	135
12	20.70	10.40	64.00	8.60	225

(*) CLIMATE AND ARCHITECTURE a national evaluation Samir H. Hosni

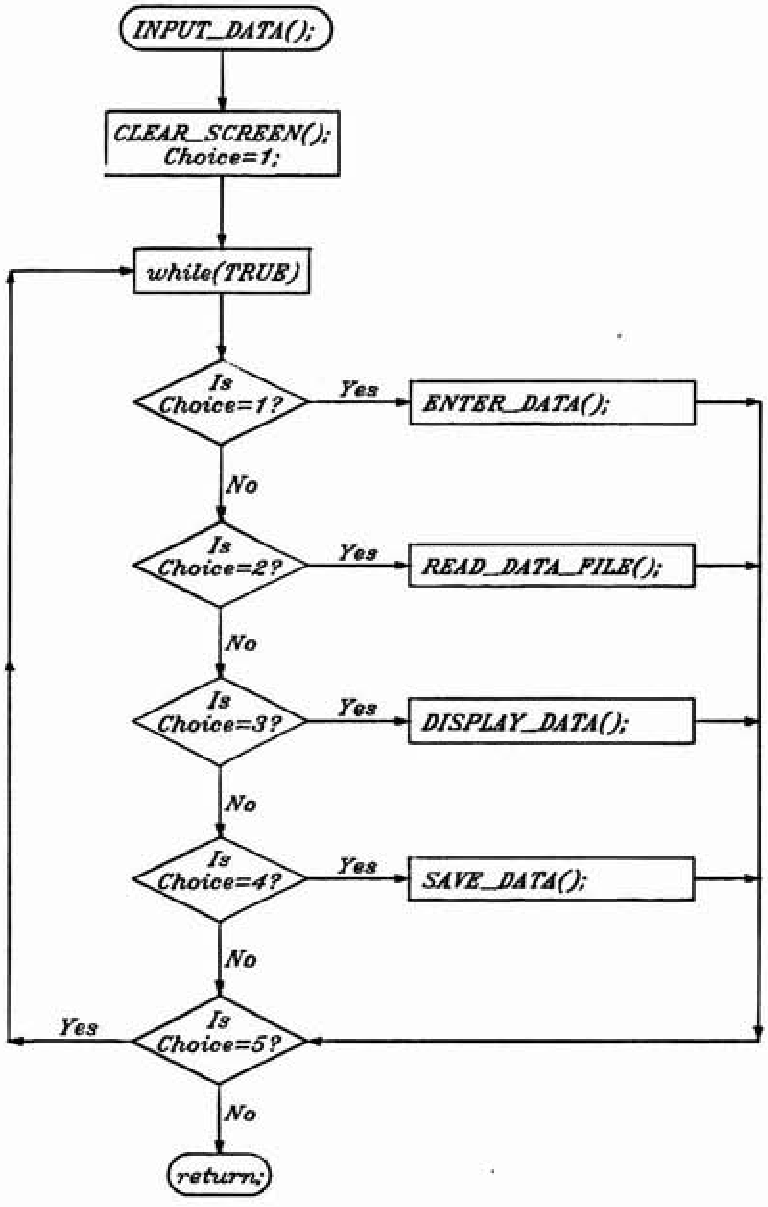


Fig. 5-5
Flow chart of the input data function

5.6- EVALUATION FUNCTION

THE second phase of the programming pattern for climatic design of house is to evaluate a given climatic data according to human comfortable conditions. Most of computer programs reading the input data which are necessary to generate its process in numeric form. The program process may transfer the numeric data into graphic format to give the user an easy understanding of these data and the program process.

Hence, in our purpose of biological evaluation,the bioclimatic chart should be transferred into a mathematical method processed in numeric form. All curves of the bioclimatic chart can be transferred into numeric equation by using Curve Fitting technique. This technique defines the coefficients of a polynomial formed from the data in vector X (Relative humidity) of degree N that fits the data in vector Y (Air temperature).

To apply the Curve Fitting technique on the bioclimatic chart curves, coordinates of some points on every curve should be defined. (figure 5-6). Next, the curve fitting technique can be processed according to these coordinates to produce the numeric equation of every curve. The coordinates of some point for every curve and its equations are shown in table (5-2).

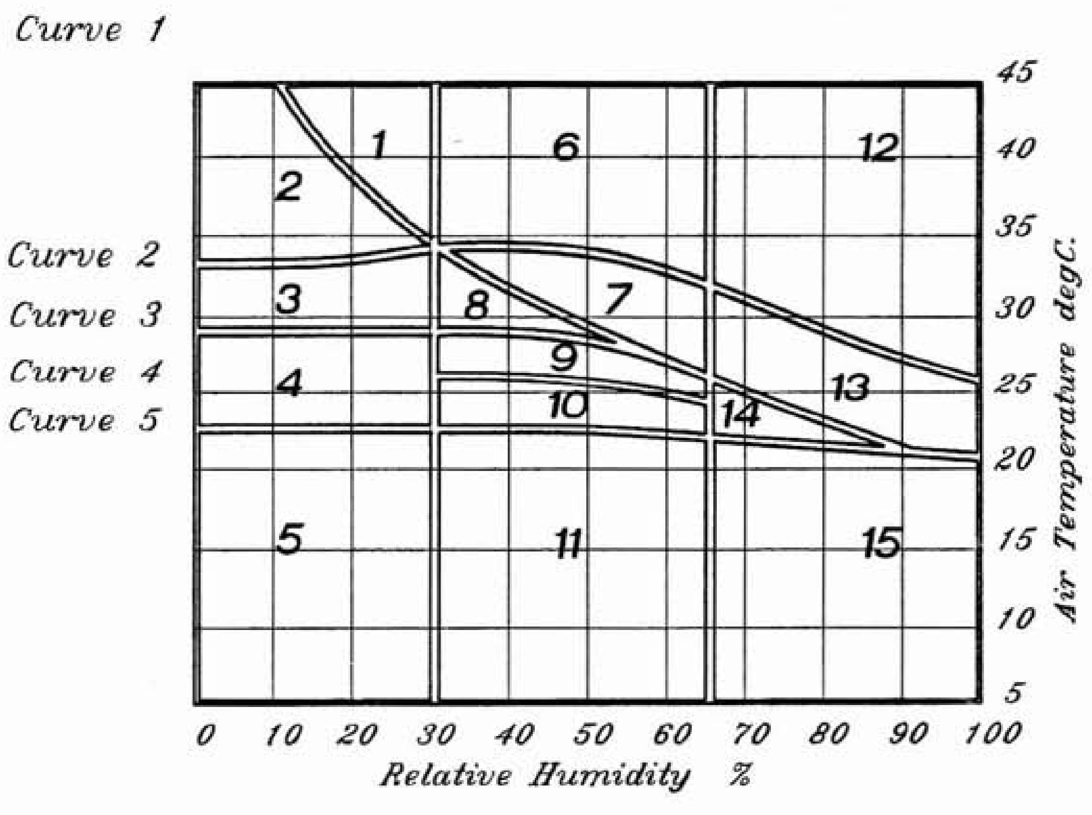


FIG. 5-6
Bioclimatic chart curve and zones

TABLE 5-2

Coordinates and equations of Bioclimatic Chart Curves

RH (X)	AIR TEMPERATURE (Y)				
	Curve 1	Curve 2	Curve 3	Curve 4	Curve 5
0	55.00	33.63	29.44	26.48	23.33
10	44.50	33.63	29.44	26.48	23.33
20	38.50	33.70	29.44	26.48	23.33
30	34.70	34.07	29.44	26.48	23.33
40	32.00	34.70	29.44	26.48	23.33
50	29.70	34.44	29.00	26.10	23.33
60	27.60	33.33	27.60	25.37	22.96
70	25.30	31.48	25.30	24.07	22.59
80	23.33	29.44	23.30	22.22	22.22
90	21.50	27.59	21.50	21.85	21.85
100	19.70	26.11	19.70	21.48	21.48

Equation of curve 1

$P1 = 1.142E-6 * X^4 - 2.881E-4 * X^3 + 2.627E-2 * X^2 - 1.2378 * X + 54.852 - Y$

Equation of curve 2

$P2 = 7.427E-7 * X^4 - 1.518E-4 * X^3 + 8.031E-3 * X^2 - 1.036E-1 * X + 33.732 - Y$

Equation of curve 3

$P3 = 5.879E-7 * X^4 - 1.153E-4 * X^3 + 5.362E-3 * X^2 - 6.804E-2 * X + 29.509 - Y$

Equation of curve 4

$P4 = 5.544E-7 * X^4 - 1.026E-4 * X^3 + 4.874E-3 * X^2 - 6.610E-2 * X + 26.565 - Y$

Equation of curve 5

$P5 = 1.078E-7 * X^4 - 2.156E-5 * X^3 + 1.024E-3 * X^2 - 1.310E-2 * X + 23.342 - Y$

The biological evaluation method can processed in sequence of steps. These steps are:-

Step 1

Locate on the bioclimatic chart the point that represent a given climatic conditions terminated by its air temperature (Y variable) and relative humidity (X variable). An example of these data was shown previously in table (5-1).

Step 2

Define in which zone the climatic data point located on the bioclimatic chart zones. This process is executed by using the previous curve equations. When the X and Y values applied for any curve equation, if the left value of the equation was less than 0, then the point located above the curve. If the left value was more than 0, then the point located below the curve. This application should be applied for all curve equations in order to define a group of zones where the point located. If the relative humidity is less than 30, then the point located in one of the zones 1, 2, 3, 4 or 5. If the relative humidity is more than 30 and less than 65, then the point located in one of the zones 6, 7, 8, 9, 10 or 11. If the relative humidity is more than 65, then the point located in one of the zones 12, 13, 14 or 15.

For example if the air temperature (Y) is 35 and relative humidity (X) is 50 and apply them on Curve 1 equation, then the left side of the equation (P1) equal -5.25. This is mean that the point located above the curve 1 in one of the zones 1, 6 or 12. Because the relative humidity is more than 30 and less than 65, then the point located in zone 6.

Step 3

Repeat the previous steps as long as the climatic data available. The repetation should executed for the day and night data. The maximum air temperature and relative humidity is the day data. The minimum air temperature and relative humidity is the night data.

Step 4

Count the number of points falling in every zone of the bioclimatic chart zones. This number may be called **BIOCLIMATIC INDICATOR**. The count process should be executed for the evaluation process of the day data and the night data.

Figure (5-7) shows the results of the above process in graphical form by using the climatic data of cairo. In numerical form these results can be tabled as shown in table (5-3).

Table 5-3

Biological Evaluation results of cairo location

Bioclimatic Chart Zones	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Indicators for Day	–	–	–	–	–	3	3	–	2	1	3	–	–	–	–
Indicators for Night	–	–	–	–	–	–	–	–	–	–	12	–	–	–	–

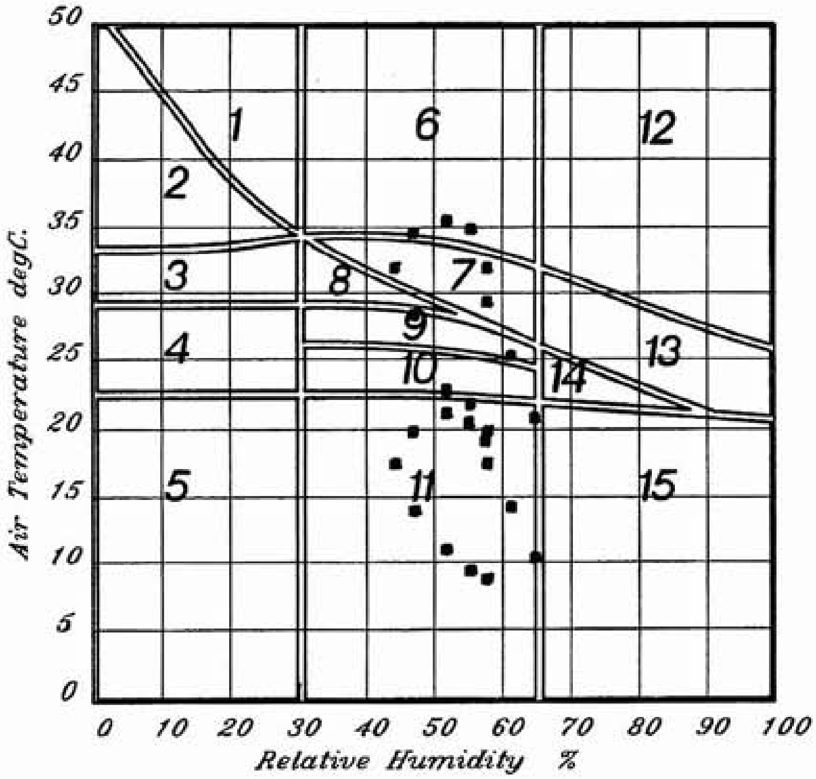


FIG. 5-7

The climatic data of cairo evaluated by bioclimatic chart

The flow chart of the Evaluation function is shown in figure(5-8).

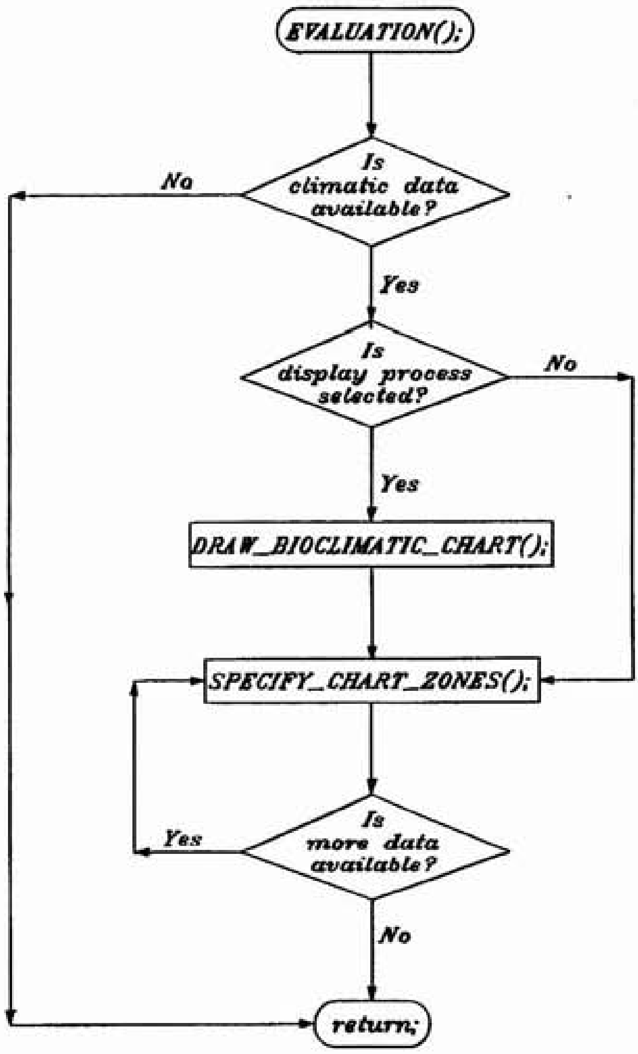


FIG. 5-8
Flow chart of the evaluation function

5.7- SPECIFY RECOMMENDATIONS FUNCTION

THE specify recommendations method have been produced in order to estimate the climatic design recommendations which are required for a given building site with its climatic conditions. The estimate process should be based on the **BIOCLIMATIC INDICATOR** which is defined by biological evaluation process. Feasibility analysis technique is one of the computer-added architectural design techniques which can be used to execute the specify recommendations process.

> *Undoubtedly the simplest and most general of all useful feasibility analysis techniques is morphological analysis. To perform a morphological analysis the design variables to be considered are first listed to gether with the range of potintial allternatives for each one.*(*)

The climatic design recommendations which are discussed previously in the fourth chapter (figures 4-6, 4-11, 4-15, 4-18, 4-26, 4-29 and 4-33) can be

(*) COMPUTER-AIDED ARCHITECTURAL DESIGN William J. Mitchell P. 387

assembled and formed in a simple table which can be called **RECOMMENDATIONS TABLE.** This table can be described as a simple matrix illustrating the relative proximity required by various climatic design recommendations and bioclimatic indicators. This matrix includes at the first left vertical column of the matrix a set of the climatic design recommendations divided under seven heading according to the climatic design applications.

Some of the climatic design recommendations are not effective at night such as which based on sun radiation. For this reason these recommendations should be provided in two sections. The first one shows the correlation between the design recommendations and the bioclimatic zones for the day time. The other section shows the above correlations for the night time.

The first horizontal row includes the fifteen bioclimatic chart zones for the both sections.

The second horizontal row includes the **BIOCLIMATIC INDICATOR** for the day and night data. At every vertical column of the matrix some cells are signed with a black square symbol. This signed cells means that the recommendation at the same horizontal row is required if the climatic data falling at the bioclimatic chart zone which is located at the same vertical column of the signed cell. (table 5-4).

TABLE 5-4

Climatic design recommendations table

CLIMATIC DESIGN RECOMMENDATIONS	The needed Recommendations related to Bioclimatic Zones For the day time														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
BUILDING FORM															
Compact form	■	■				■	■	■				■			
Compact courtyard form			■				■	■	■	■			■	■	
Elongated form					■						■				■
Use pitched or curved roofs	■	■				■						■			
Use earth sheltring	■					■						■			
BUILDING ORIENTATION															
Long axis East West			■				■	■					■		
Long axis North South					■						■				■
Long axis North-East South-West			■				■	■					■	■	
Long axis North-West South-East				■	■						■				■
BUILDING ENVELOP															
Use high thermal capacity materials	■	■				■						■			
Use double elements	■	■				■					■	■			■
Use heavy materials with long time lag	■	■				■						■			
Use reflectivity materials on surfaces			■	■			■	■					■	■	
Use high well insulated materials			■	■	■						■		■	■	■
Use plants next to building envelop	■	■	■			■	■	■				■	■		
HOUSE PLAN															
Open plan												■	■	■	■
Provide air shafts			■				■	■					■		
Orient low use spaces to South or West	■	■	■			■	■	■				■	■	■	
Provide outdoor semi-protected areas			■				■	■					■		
Provied solar oriented rooms					■						■				■
Provide outdoor sleeping areas						■						■			
OPENINGS DESIGN															
Large openings 40 - 80 %											■			■	■
Medum openings 20 - 40 %				■				■	■	■				■	
Small openings 10 - 20 %	■	■				■	■	■				■			
Provide shading for larg openings						■	■	■				■	■		
Provide insulating for glazed openings	■	■				■						■			
HOUSING LAYOUT															
Compact layout	■	■	■			■	■	■	■			■			
Wide spacing layout					■						■	■	■	■	■
Wide spacing layout and provide shading												■	■		
Use nearby buildings for wind protection					■										
Use nearby buildings for shading	■	■				■						■	■	■	
LANDSCAPING															
Use trees shading			■				■	■					■		
Use vegitation ground cover	■	■	■			■	■	■	■						
Use heat reflective materials on site					■						■				■
Use water pools on site		■	■	■		■	■	■	■						
Use vegitation for wind protection	■	■			■	■					■				

CLIMATIC DESIGN RECOMMENDATIONS	The needed Recommendations related to Bioclimatic Zones For the night time															DESIGN INDECATORS
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
BUILDING FORM																
Compact form	■	■				■	■	■				■				
Compact courtyard form			■				■	■	■	■			■	■		
Elongated form																
Use pitched or curved roofs																
Use earth sheltring	■					■						■				
BUILDING ORIENTATION																
Long axis East West			■				■	■					■			
Long axis North South																
Long axis North-East South-West			■				■	■					■			
Long axis North-West South-East																
BUILDING ENVELOP																
Use high thermal capacity materials	■	■				■						■				
Use double elements	■	■			■	■					■	■			■	
Use heavy materials with long time lag	■	■				■						■				
Use reflectivity materials on surfaces																
Use high well insulated materials																
Use plants next to building envelop			■	■	■		■	■			■		■	■	■	
HOUSE PLAN																
Open plan												■	■	■	■	
Provide air shafts			■				■	■			■					
Orient low use spaces to South or West																
Provide outdoor semi-protected areas																
Provied solar oriented rooms																
Provide outdoor sleeping areas						■						■				
OPENINGS DESIGN																
Large openings 40 - 80 %														■		
Medum openings 20 - 40 %				■					■	■				■		
Small openings 10 - 20 %	■	■				■	■	■				■				
Provide shading for larg openings																
Provide insulating for glazed openings	■	■				■						■				
HOUSING LAYOUT																
Compact layout	■	■			■	■			■			■				
Wide spacing layout												■	■	■	■	
Wide spacing layout and provide shading																
Use nearby buildings for wind protection				■	■											
Use nearby buildings for shading																
LANDSCAPING																
Use trees shading																
Use vegitation ground cover	■	■	■			■	■	■								
Use heat reflective materials on site																
Use water pools on site		■	■	■			■	■	■							
Use vegitation for wind protection	■	■	■													

By using the **RECOMMENDATIONS TABLE**, The specify recommendations method can be processed through sequence of steps illustrated as follows:-

Step 1

Transfer BIOCLIMATIC INDICATOR values from biological evaluation process to the first row of the **RECOMMENDATIONS TABLE** for the both sections.

Step 2

For every column of the RECOMMENDATIONS TABLE, enter in all signed cells the value of BIOCLIMATIC INDICATOR, which is located in the first cell of the same column.

Step 3

For every row of the RECOMMENDATIONS TABLE, by adding the values in all signed cells find the DESIGN INDICATOR value and locate this value in the last cell of the same row.

Step 4

Compare the DESIGN INDICATOR values of every climatic design recommendation with each other, and sort these recommendations descending according to its DESIGN INDICATOR value.

An application of the above process by using the climatic data of cairo are shown in table (5-5).

The final result of the specify recommendations method is a sorted list of climatic design recommendations. This list refers to the importance of appropriate climatic design recommendations for a given climatic conditions.

TABLE 5-5

Climatic design recommendations table for Cairo location

CLIMATIC DESIGN RECOMMENDATIONS	The needed Recommendations related to Bioclimatic Zones For the day time															The needed Recommendations related to Bioclimatic Zones For the night time															DESIGN INDICATORS
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
						3	3		2	1	3															12					
BUILDING FORM																															
Compact form	■	■				3	3	■				■				■	■				■	■	■				■				6
Compact courtyard form			■				3	■	2	1			■	■				■				■	■	■	■			■	■		6
Elongated form					■						3				■																3
Use pitched or curved roofs	■	■				3						■																			3
Use earth sheltring	■					3						■				■					■						■				3
BUILDING ORIENTATION																															
Long axis East West			■				3	■					■					■				■	■					■			3
Long axis North South					■						3				■																3
Long axis North-East South-West			■			3	3	■					■	■				■				■	■					■			6
Long axis North-West South-East				■	■						3				■																3
BUILDING ENVELOP																															
Use high thermal capacity materials	■	■				3						■				■	■				■						■				3
Use double elements	■	■				3					3	■			■	■	■			■	■					12	■			■	18
Use heavy materials with long time lag	■	■				3						■				■	■				■						■				6
Use reflectivity materials on surfaces			■	■			3	■					■	■																	3
Use high well insulated materials			■	■	■						3		■	■	■																3
Use plants next to building envelop	■	■	■			3	3	■				■	■					■	■	■		■	■			12		■	■	■	18
HOUSE PLAN																															
Open plan												■	■	■	■												■	■	■	■	-
Provide air shafts			■				3	■					■					■				■	■			12					15
Orient low use spaces to South or West	■	■	■			3	3	■				■	■	■																	6
Provide outdoor semi-protected areas			■				3	■					■																		3
Provied solar oriented rooms					■						3				■																3
Provide outdoor sleeping areas						3						■									■						■				3
OPENINGS DESIGN																															
Large openings 40 - 80 %											3			■	■														■		3
Medum openings 20 - 40 %				■				■	2	1				■					■					■	■				■		3
Small openings 10 - 20 %	■	■				3	3	■				■				■	■				■	■	■				■				6
Provide shading for larg openings						3	3	■				■	■																		6
Provide insulating for glazed openings	■	■				3						■				■	■										■				3
HOUSING LAYOUT																															
Compact layout	■	■	■			3	3	■	2			■				■	■			■	■						■				8
Wide spacing layout					■						3	■	■	■	■												■	■	■	■	3
Wide spacing layout and provide shading												■	■																		-
Use nearby buildings for wind protection					■														■	■											-
Use nearby buildings for shading	■	■				3						■	■	■																	3
LANDSCAPING																															
Use trees shading			■				3	■					■																		3
Use vegitation ground cover	■	■	■			3	3	■	2							■	■	■			■	■	■								8
Use heat reflective materials on site					■						3				■																3
Use water pools on site		■	■	■		3	3	■	2								■	■	■			■	■	■							8
Use vegitation for wind protection	■	■			■	3					3					■	■	■													6

5.8- OUTPUT RESULTS FUNCTION

THE final stage of any program is to get the process results. So, the last function of the climatic design program is to output the sorted list of climatic design recommendations. Some other informations may be added to these recommendations.

In our purpose the proposed program has many ways to output the program results. The designer can get the sorted list of climatic design recommendations in three ways, they are:-

First

Display results on the computer screen, which mean display a list of sorted recommendations on computer screen up to the user choice.

Second

Save results in a file, which mean write the results on a file. This file could be considered as a document used out of the program.

Third

Get a hard copy on a printer, which mean print the climatic data and a list of sorted recommendations on a paper document.

The program function which execute the output results process is simplified in flow chart shown in figure (5-9).

Table (5-6) shows the sorted list of climatic design recommendations which produced by the program application for the climatic data of cairo.

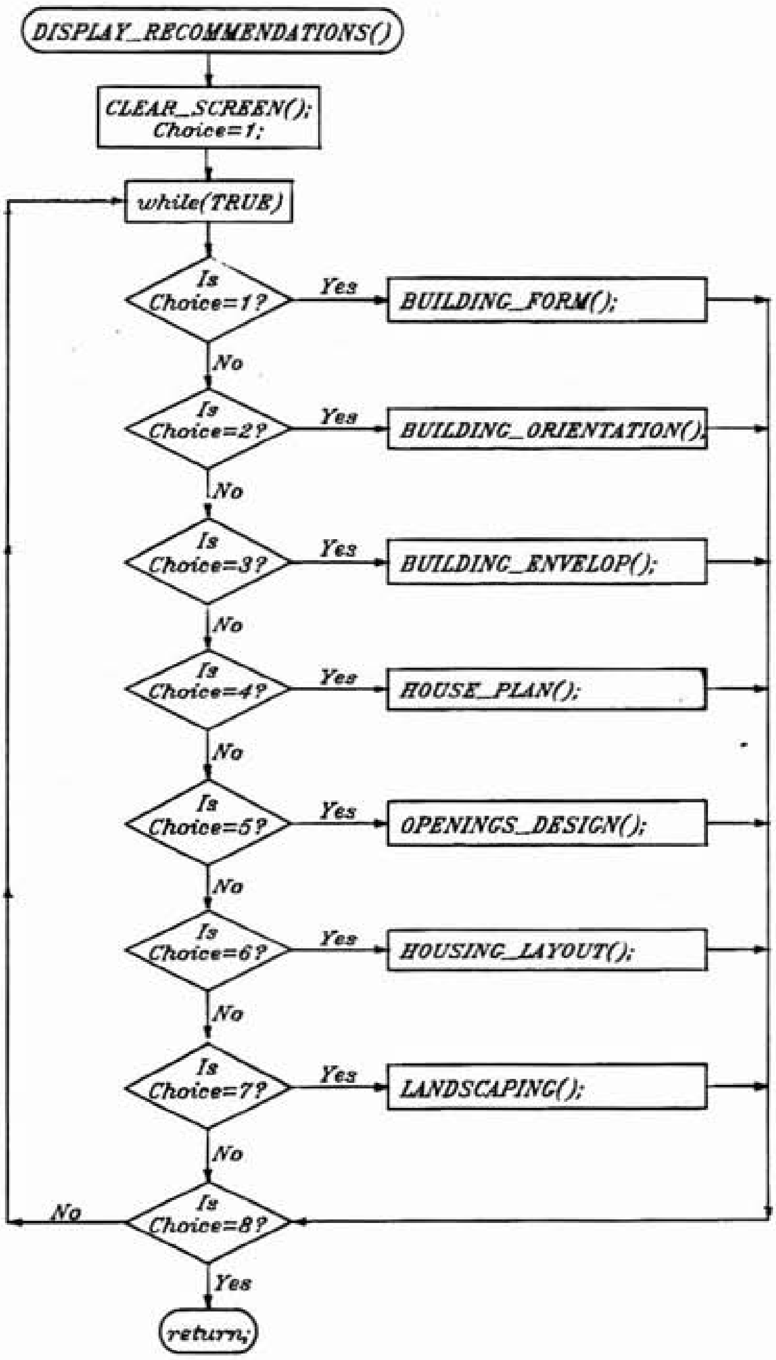


Fig. 5- 9
Flow chart of display recommendations function

5.9- SUMMARY

THE previous analysis of climatic data, biological evaluation and the climatic design applications are the needed informations for the climatic design of house process. The purpose of the present chapter is to create a computer program based on the previous analysis to execute the pattern of climatic design of house process.

The general concept of the proposed program starts with the input climatic data and terminates with an output of a specified list of climatic design recommendations. The program processed through the sequence of stages, which are defined in the study concept section. These stages are: input stage, evaluation stage, resolving stage and output stage.

Some computer-based mathematical techniques can be used to perform the program process. One of the most computer programming languages is the C. language which used to create the proposed climatic design of house program.

Chapter 6
CONCLUSION AND FUTURE WORK

6.1- CONCLUSION

THE traditional climatic design of house procedure is a multi-step design process. With the aiding of biological evaluation results, a range of appropriate climatic design recommendations for a given climatic conditions can be specified.

Before design decision, the designer should get a good understanding of the local climatic conditions and the occupancy pattern of the building. The residential building is occupied during all time of the day while most of the other buildings are occupied during shorter time period of the day. For this reason, the designer must adapt his design decision according to occupancy pattern. Hence, before designing of a house building can be started, a programming pattern is needed.

Architectural programming has become a given prerequisite to the climatic design of house process. The architect can, however, be aware of the fundamental objectives and techniques of programming and apply them appropriately to climatic design of house.

The main intent of programming the climatic design of house is identify the key problems to be solved in house design process. Programming is therefore a type of management information system that seeks to translate a given conditions into climatic design recommendations.

The range of types of analysis which might be carried out at the feasibility study and programming stage of housing design are virtually unlimited. Traditionally, feasibility analysis techniques for building design has relied primarily upon experience and informed professional judgment.

Today, there are very powerful computed-based mathematical techniques are available to assist such as curve fitting technique, which used in the Evaluation function, and feasibility analysis technique,which used in the specify recommendations function of the proposed program. So, the point made in this thesis is that the computer-dided architectural design has an important role in the process of climatic design of house.

It is hoped that the proposed study will open a new insights into relationship of local climatic environment to housing design, and will contribute to architect by a simple climatic design program in order to achieve the goal of human comfort.

The conclusion of the proposed dissertation can be described as a programming pattern of the climatic design of house. This pattern is simplified as shown in figure(6) and it can illustrated step by step as follow:-

STEP 1:

Plot on the BIOCLIMATIC CHART the points which represent the given climatic data.

STEP 2:

Define the values of BIOCLIMATIC INDICATOR (the number of the points that located in every zone of the Bioclimatic Chart Zones).

STEP 3:

Locate the values of BIOCLIMATIC INDICATOR at the first row of the RECOMMENDATIONS TABLE.

STEP 4:

Locate the values of BIOCLIMATIC INDICATOR in all the signed cells at the same vertical column of the RECOMMENDATIONS TABLE.

STEP 5:

Define the values of DESIGN INDICATOR for every recommendation (the summation of the values of BIOCLIMATIC INDICATOR in all signed cells at the horizontal row of that recommendation.

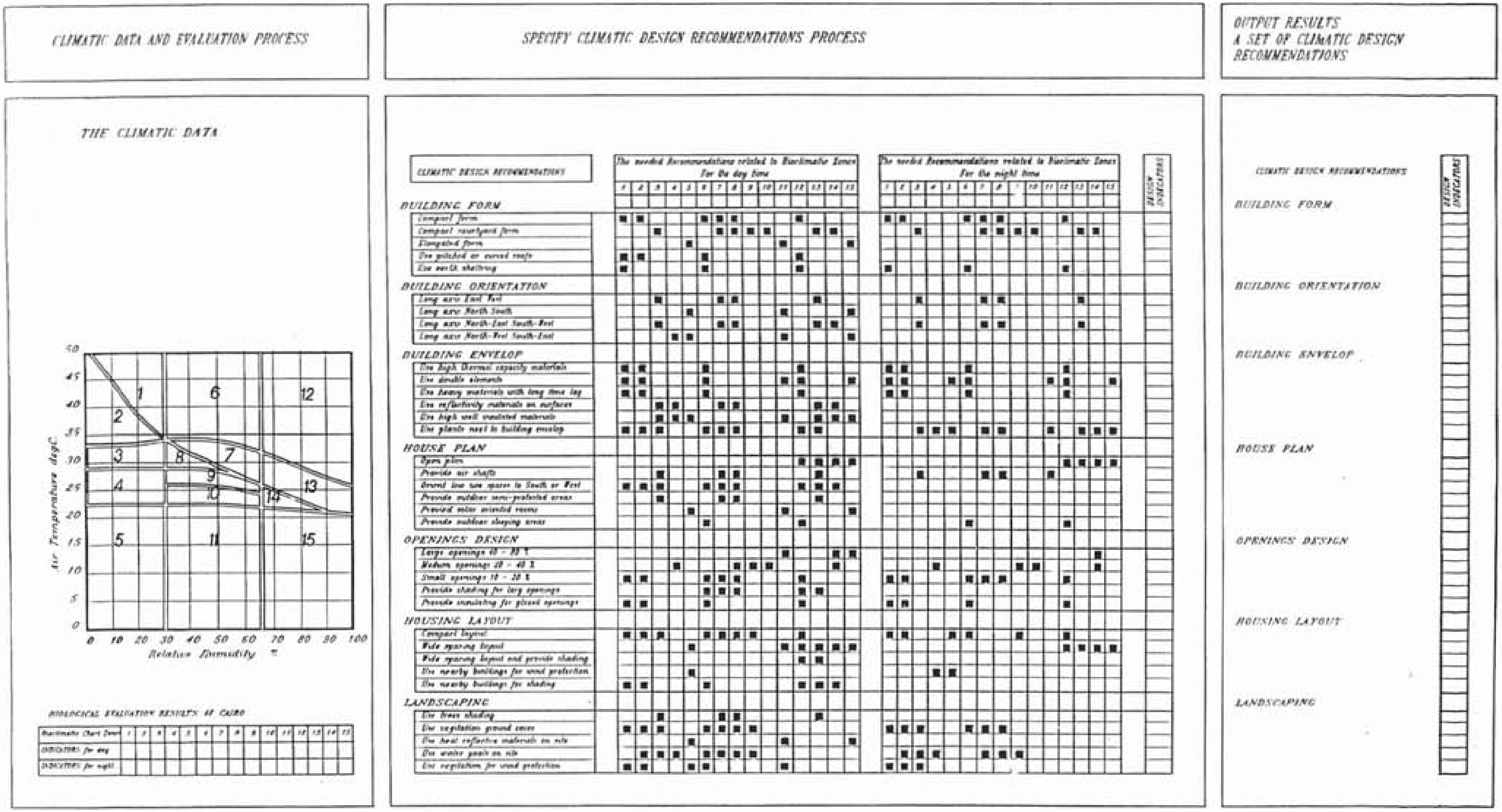
STEP 6:

Produce a set of CLIMATIC DESIGN RECOMMENDATIONS sorted according to its DESIGN INDICATOR values. The produced set is grouped under seven heading (Building Form, Building Orientation, Building Envelop, House Plan, Openings Design, Housing Layout, Landscaping).

The produced CLIMATIC DESIGN RECOMMENDATIONS can be used to help the designer to make his decision during the sketch plan stage of housing design.

The proposed program is built upon the concluded programming pattern of the climatic design of house. The following appendixes contains the complete package of the proposed climatic design of house program, and some application examples.

FIG 6
The programming pattern of the climatic design of house



6.1- FUTURE WORK

THE possibilities to development the proposed climatic design of house program are virtually limitless. These possibilities might be used to produce more detailed climatic design recommendations.

As future work the climatic design applications, which outlined in chapter four, can be presented in details related to more detailed existing conditions in order to provide more specified design recommendations. a wide variety of computer-aided architectural design techniques can be used to execute detailing analysis of the climatic design applications.

The proposed climatic design program is able to add any addition functions which execute some detailed climatic design processes. Each recommendations group (building form, building orientation, building envelop, house plan, opening design, housing layout, and landscaping) can be analyzed in extension program functions or in sub-program of the proposed program.

APPENDIX A
THE COMPLETE PACKAGE OF THE CLIMATIC DESIGN OF HOUSE PROGRAM

A-1- THE MAIN SOURCE FILE WRITTEN BY THE C. PROGRAMMING LANGUAGE.

IN order to create the climatic design of house program by using the C. programming language the sequence of instructions, which execute the desired process, should be written in a file. There are many compilers which can be used to translate that file into a machine code which will executed by the computer machine.

The present program will compiled by "C++" compiler. Some existing file of that compiler will be used through the compiling process. These files are includede in the main source file which named "CDH.C" and presented in the following pages.

CDH.C file

```
#include <dos.h>
#include <math.h>
#include <conio.h>
#include <stdio.h>
#include <fcntl.h>
#include <graphics.h>
#include <stdarg.h>

#define TRUE 1
#define FALSE 0
#define UPKEY 72
#define DOWNKEY 80
#define ENTER 13

FILE *RecDay_file;
FILE *RecN_file;
FILE *Data_file;
FILE *Result_file;
FILE *Save_Data_File;

float X,Y,x,y;
float X1,X2,X3,X4,X5;
float P1,P2,P3,P4,P5,P6,P7;
float Data[6][120];
char filename[12];
unsigned char *(Rec_Table[1][37])[40];

int Recom_D[19][37];
int Recom_N[19][37];
int Total[37];
int data=0;
int display=0;
int Choice;
int ch,col,row;

static char *item[5]=
      {
      " INPUT DATA              ",
      " DISPLAY EVALUATION      ",
      " DISPLAY RECOMMENDATIONS ",
      " OUTPUT RESULTS          ",
      " EXIT                    ",
      };
```

```
static char *input[5]=
       {
       " ENTERING DATA              ",
       " READ DATA FILE             ",
       " DISPLAY CURRENT DATA       ",
       " SAVE CURRENT DATA          ",
       " RETURN TO MAIN MENU        ",
       };

static char *recom[8]=
       {
       " BUILDING FORM              ",
       " BUILDING ORIENTATION       ",
       " BUILDING ENVELOP           ",
       " HOUSE PLAN                 ",
       " OPENING DESIGN             ",
       " HOUSING LAYOUT             ",
       " LANDSCAPING                ",
       " RETURN TO MAIN MENU        ",
       };

void Swrite (int col, int row, int color, int bcolor,\
                va_list arg_list, ...);
void Write (int col, int row, int color, int bcolor,\
               int width, va_list arg_list, ...);



main()        /* The main function of the program */
{
CLEAR_SCREEN();
START();
Write(1,1,14,4,80,\
"PROGRAMMING THE CLIMATIC DESIGN OF HOUSE  Ph.D. Program \
 M.A.EISSA  1991");
Write(1,25,14,1,79,"Current file:          Data(months):");
Window(1,4,27,10,11,1);
cputs("        MAIN MENU");
Choice=1;
while(TRUE)
       {
       MENU(item-1,5,Choice);
       switch(getch())
              {
              case UPKEY:
                     if(Choice>=1)  --Choice;
                     if(Choice<1)   Choice=5;
                     break;
              case DOWNKEY:
                     if(Choice<=5) ++Choice;
                     if(Choice>5)  Choice=1;
                     break;
              case ENTER:
                     ACTION(Choice);
                     CLEAR_SCREEN();
```

```
          Window(1,4,27,10,1,1);
                        Choice=1;
                        break;
                  }
         }
}

ACTION(int Choice)
{
switch(Choice)
        {
        case 1:
                INPUT_DATA();
                break;
        case 2:
                DISPLAY_EVALUATION();
                MENU(item-1,5,Choice);
                Write(1,1,14,4,80," PROGRAMMING THE CLIMATIC DESIGN OF
                HOUSE    Ph.D. Program        M.A.EISSA  1991");
                Write(1,25,14,1,79,"Current file:    Data(months):");
                Window(1,4,27,10,11,1);
                break;
        case 3:
                if(Data[1][1]==NULL) NO_DATA();
                else
                        {
                        DISPLAY_RECOMMENDATIONS();
                        }
                break;
        case 4:
                SAVE_RESULTS();
                break;
        case 5:
                clr();
                _setcursortype(_NORMALCURSOR);
                exit();
        }
}

INPUT_DATA()        /* Input data function */
{
Choice=1;
CLEAR_SCREEN();
Window(1,4,27,10,1,2);
cputs("     INPUT DATA MENU");
while(TRUE)
        {
        MENU(input-1,5,Choice);
        switch(getch())
                {
                case UPKEY:
                        if(Choice>=1)  --Choice;
                        if(Choice<1)   Choice=5;
                        break;
```

```
            case DOWNKEY:
                  if(Choice<=5) ++Choice;
                  if(Choice>5)  Choice=1;
                  break;
            case ENTER:
                  if(Choice==5)     return;
                  else  ACTION_INPUT(Choice);
                  break;
            }
      }
}


ACTION_INPUT(int Choice)
{
switch(Choice)
      {
      case 1:
            ENTER_DATA();
            SPECIFY_ZONES();
            SPECIFY_RECOMMENDATIONS_DAY();
            SPECIFY_RECOMMENDATIONS_NIGHT();
            CLEAR_SCREEN();
            Window(1,4,27,10,1,2);
            cputs("      INPUT DATA MENU");
            break;
      case 2:
            READ_DATA_FILE();
            SPECIFY_ZONES();
            SPECIFY_RECOMMENDATIONS_DAY();
            SPECIFY_RECOMMENDATIONS_NIGHT();
            break;
      case 3:
            if(Data[1][1]==NULL) NO_DATA();
            else
                  {
                  DISPLAY_DATA();
                  getch();
                  }
            CLEAR_SCREEN();
            Window(1,4,27,10,1,2);
            cputs("      INPUT DATA MENU");
            break;
      case 4:
            SAVE_DATA();
            CLEAR_SCREEN();
            Window(1,4,27,10,1,2);
            cputs("      INPUT DATA MENU");
            break;
            break;
      }
}
```

```
DISPLAY_EVALUATION()        /* Display graphical evaliuation */
{
if(Data[1][1]==NULL) NO_DATA();
else
        {
        display=1;
        CLEAR_RESULTS();
        BIOCLIMATIC_CHART();
        SPECIFY_CHART_ZONES();
        SPECIFY_RECOMMENDATIONS_DAY();
        SPECIFY_RECOMMENDATIONS_NIGHT();
        getch();
        closegraph();
        }
}


DISPLAY_RECOMMENDATIONS()  /* Display sorted list of climatic
                                    design recommendations */
{
Choice=1;
CLEAR_SCREEN();
Window(1,4,27,13,1,13);
cputs("  RECOMMENDATIONS MENU");
while(TRUE)
        {
        MENU(recom-1,8,Choice);
        switch(getch())
                {
                case UPKEY:
                        if(Choice>=1)  --Choice;
                        if(Choice<1)   Choice=8;
                        break;
                case DOWNKEY:
                        if(Choice<=8) ++Choice;
                        if(Choice>8)  Choice=1;
                        break;
                case ENTER:
                        if(Choice==8) return;
                        else
                                {
                                CLEAR_SCREEN();
                                Window(1,8,80,21,14,4);
                                ACTION_RECOM(Choice);
                                }
                        break;
                }
        }
}

graph()
{
int graphdriver=DETECT;
int graphmode;
initgraph(&graphdriver,&graphmode,"");
}
```

```
START()
{
int x,MaxX,MaxY;
graph();
  MaxX = getmaxx();
  MaxY = getmaxy();
settextstyle(1,0,6);
setcolor(14);
line(0,MaxY/4+2,MaxX,MaxY/4+2);
setcolor(3);
for(x=0;x<8;x++)
       {
       outtextxy(MaxX/2.6+x,MaxY/4+x,"C D H");
       line(0,MaxY/2.7+4*x,MaxX,MaxY/2.7+4*x);
       }
setlinestyle(0,1,3);
line(0,MaxY/2.7+4*x,MaxX,MaxY/2.7+4*x);
line(0,MaxY/1.65,MaxX,MaxY/1.65);
setcolor(14);
for(x=0;x<5;x++)
       {
       outtextxy(MaxX/2.6-x,MaxY/4-x,"C D H");
       }
settextstyle(0,0,1);
outtextxy(MaxX/5.5,MaxY/1.8,\
          "PROGRAMMING THE CLIMATIC DESIGN OF HOUSE");
outtextxy(MaxX/2.4,MaxY/1.6,"EISSA  -  1991");
setcolor(15);
outtextxy(MaxX/3,MaxY/1.1,"PRESS ANY KEY TO CONTINUE");
Sound(2,2);
getch();
closegraph();
}


BIOCLIMATIC_CHART()       /* Draw bioclimatic chart on screen*/
{
graph();
for(X=0;X<101;X=X+.5)
{
CURVE_EQUATIONS();
Y=X1;         putpixel(4*X+200,3*(50-Y),2);
Y=X2;         putpixel(4*X+200,3*(50-Y),3);
Y=X3;         putpixel(4*X+200,3*(50-Y),4);
Y=X4;         putpixel(4*X+200,3*(50-Y),5);
Y=X5;         putpixel(4*X+200,3*(50-Y),6);
if(X==30 || X==65)
       {
       for(Y=0;Y<50;Y++)
              {
              putpixel(4*X+200,3*(50-Y),7);
              }
       }
if(X>30 && X<65 )
       {
```

```
        for(Y=0;Y<50;Y=Y+.5)
              {
              if(Y<X4 && Y>X5)  putpixel(4*X+200,3*(50-Y),15);
              }
        }
}
moveto(200,0);
lineto(602,0);
lineto(602,150);
lineto(200,150);
lineto(200,0);
outtextxy(180,0,"50");
outtextxy(180,28,"40");
outtextxy(180,57,"30");
outtextxy(180,86,"20");
outtextxy(180,115,"10");
outtextxy(180,144," 0");
outtextxy(200,155,"0  10  20  30  40  50  60  70  80  90  100");
outtextxy(320,165,"Relative Humidity  %");
setcolor(14);
outtextxy(200,180,"OLGYAY'S   BIOCLIMATIC   CHART");
outtextxy(230,20,"2        1          6              12");
outtextxy(230,52,"3             8         7 ");
outtextxy(230,63,"              9                  13 ");
outtextxy(230,68,"4");
outtextxy(230,73,"              10              14 ");
outtextxy(230,93,"5             11              15 ");
setcolor(15);
settextstyle(2,1,0);
outtextxy(160,15,"Air Temperature DegC.");
}

CURVE_EQUATIONS()
{
X1 = 1.14219114E-6 * pow(X,4) - 2.88189588E-4 * pow(X,3) +
     2.62715617E-2 * pow(X,2) - 1.2378360528 * X + 54.8524475524;
X2 = 7.42716517E-7 * pow(X,4) - 1.51824009E-4 * pow(X,3) +
     8.03143939E-3 * pow(X,2) - 1.0369988E-1 * X + 33.7327272727;
X3 = 5.87995337E-7 * pow(X,4) - 1.15365190E-4 * pow(X,3) +
     5.36217948E-3 * pow(X,2) - 6.80439005E-2 * X + 29.5093706293;
X4 = 5.5448717948E-7 * pow(X,4) - 1.02647630E-4 * pow(X,3) +
     4.87462121E-3 * pow(X,2) - 6.61058663E-2 * X + 26.5651048951;
X5 = 1.0780885780E-7 * pow(X,4) - 2.1561771561E-5 * pow(X,3) +
     1.02418414E-3 * pow(X,2) - 1.31095571E-2 * X + 23.3429370629;
}

EVALUATION_DAY()
{
CURVE_EQUATIONS();
P1=X1-Y;
P2=X2-Y;
P3=X3-Y;
P4=X4-Y;
P5=X5-Y;
```

```
if(X<=30 && P1<=0)                        {Recom_D[1][0]++; }
if(X<=30 && P2<=0 && P1>0)                {Recom_D[2][0]++; }
if(X<=30 && P2>=0 && P3<0)                {Recom_D[3][0]++; }
if(X<=30 && P3>=0 && P5<0)                {Recom_D[4][0]++; }
if(X<=30 && P5>=0)                        {Recom_D[5][0]++; }
if(X>30 && X<65 && P2<0  && P1<0)         {Recom_D[6][0]++; }
if(X>30&&X<65&&P1<0&&P2>=0&&P7>=0)        {Recom_D[7][0]++; }
if(X>30&&X<65&&P1>=0&&P3<0&&P2>=0)        {Recom_D[8][0]++; }
if(X>30 && X<65 && P3>=0 && P4<0)         {Recom_D[9][0]++; }
if(X>30 && X<65 && P4>=0 && P5<0)         {Recom_D[10][0]++;}
if(X>30 && X<65 && P5>=0)                 {Recom_D[11][0]++;}
if(X>=65 && P2<0)                         {Recom_D[12][0]++;}
if(X>=65 && P2>=0 && P1<0)                {Recom_D[13][0]++;}
if(X>=65 && P1>=0 && P5<0)                {Recom_D[14][0]++;}
if(X>=65 && P1>=0 && P5>=0)               {Recom_D[15][0]++;}
}

EVALUATION_NIGHT()
{
CURVE_EQUATIONS();
P1=X1-Y;
P2=X2-Y;
P3=X3-Y;
P4=X4-Y;
P5=X5-Y;
if(X<=30 && P1<=0)                        {Recom_N[1][0]++; }
if(X<=30 && P2<=0 && P1>0)                {Recom_N[2][0]++; }
if(X<=30 && P2>=0 && P3<0)                {Recom_N[3][0]++; }
if(X<=30 && P3>=0 && P5<0)                {Recom_N[4][0]++; }
if(X<=30 && P5>=0)                        {Recom_N[5][0]++; }
if(X>30 && X<65 && P2<0  && P1<0)         {Recom_N[6][0]++; }
if(X>30&&X<65&&P1<0&&P2>=0&&P7>=0)        {Recom_N[7][0]++; }
if(X>30&&X<65&&P1>=0&&P3<0&&P2>=0)        {Recom_N[8][0]++; }
if(X>30 && X<65 && P3>=0 && P4<0)         {Recom_N[9][0]++; }
if(X>30 && X<65 && P4>=0 && P5<0)         {Recom_N[10][0]++;}
if(X>30 && X<65 && P5>=0)                 {Recom_N[11][0]++;}
if(X>=65 && P2<0)                         {Recom_N[12][0]++;}
if(X>=65 && P2>=0 && P1<0)                {Recom_N[13][0]++;}
if(X>=65 && P1>=0 && P5<0)                {Recom_N[14][0]++;}
if(X>=65 && P1>=0 && P5>=0)               {Recom_N[15][0]++;}
}

GRAPH_EVALUATION_DAY()
{
CURVE_EQUATIONS();
P1=X1-Y;
P2=X2-Y;
P3=X3-Y;
P4=X4-Y;
P5=X5-Y;
if(X<=30 && P1<=0)                     {Recom_D[1][0]++; setcolor(1);}
if(X<=30 && P2<=0 && P1>0)             {Recom_D[2][0]++; setcolor(2);}
if(X<=30 && P2>=0 && P3<0)             {Recom_D[3][0]++; setcolor(3);}
if(X<=30 && P3>=0 && P5<0)             {Recom_D[4][0]++; setcolor(4);}
```

```
if(X<=30 && P5>=0)                      {Recom_D[5][0]++; setcolor(5);}
if(X>30 && X<65 && P2<0  && P1<0)  {Recom_D[6][0]++; setcolor(6);}
if(X>30 && X<65 && P1<0 && P2>=0 && P7>=0)
                                        {Recom_D[7][0]++; setcolor(7);}
if(X>30&&X<65&&P1>=0&&P3<0&&P2>=0) {Recom_D[8][0]++; setcolor(8);}
if(X>30 && X<65 && P3>=0 && P4<0)  {Recom_D[9][0]++; setcolor(9);}
if(X>30 && X<65 && P4>=0 && P5<0)
                                   {Recom_D[10][0]++; setcolor(10);}
if(X>30 && X<65 && P5>=0)          {Recom_D[11][0]++; setcolor(11);}
if(X>=65 && P2<0)                  {Recom_D[12][0]++; setcolor(12);}
if(X>=65 && P2>=0 && P1<0)         {Recom_D[13][0]++; setcolor(13);}
if(X>=65 && P1>=0 && P5<0)         {Recom_D[14][0]++; setcolor(14);}
if(X>=65 && P1>=0 && P5>=0)        {Recom_D[15][0]++; setcolor(15);}
if (display==1)
      circle(4*X+200,3*(50-Y),1);
}


GRAPH_EVALUATION_NIGHT()
{
CURVE_EQUATIONS();
P1=X1-Y;
P2=X2-Y;
P3=X3-Y;
P4=X4-Y;
P5=X5-Y;
if(X<=30 && P1<=0)             {Recom_N[1][0]++; setcolor(1);}
if(X<=30 && P2<=0 && P1>0)     {Recom_N[2][0]++; setcolor(2);}
if(X<=30 && P2>=0 && P3<0)     {Recom_N[3][0]++; setcolor(3);}
if(X<=30 && P3>=0 && P5<0)     {Recom_N[4][0]++; setcolor(4);}
if(X<=30 && P5>=0)             {Recom_N[5][0]++; setcolor(5);}
if(X>30 && X<65 && P2<0  && P1<0)
                               {Recom_N[6][0]++; setcolor(6);}
if(X>30 && X<65 && P1<0 && P2>=0 && P7>=0)
                               {Recom_N[7][0]++; setcolor(7);}
if(X>30 && X<65 && P1>=0 && P3<0 && P2>=0)
                               {Recom_N[8][0]++; setcolor(8);}
if(X>30 && X<65 && P3>=0 && P4<0)
                               {Recom_N[9][0]++; setcolor(9);}
if(X>30 && X<65 && P4>=0 && P5<0)
                               {Recom_N[10][0]++; setcolor(10);}
if(X>30 && X<65 && P5>=0)      {Recom_N[11][0]++; setcolor(11);}
if(X>=65 && P2<0)              {Recom_N[12][0]++; setcolor(12);}
if(X>=65 && P2>=0 && P1<0)     {Recom_N[13][0]++; setcolor(13);}
if(X>=65 && P1>=0 && P5<0)     {Recom_N[14][0]++; setcolor(14);}
if(X>=65 && P1>=0 && P5>=0)    {Recom_N[15][0]++; setcolor(15);}
if (display==1)
      circle(4*X+200,3*(50-Y),1);
}


SPECIFY_CHART_ZONES()
{
for(row=1;row<data-1;row++)
      {
      X=Data[3][row];
```

```
        Y=Data[1][row];
        GRAPH_EVALUATION_D();
        Y=Data[2][row];
        GRAPH_EVALUATION_N();
        }
}


SPECIFY_ZONES()
{
for(row=1;row<data-1;row++)
        {
        X=Data[3][row];
        Y=Data[1][row];
        EVALUATION_D();
        Y=Data[2][row];
        EVALUATION_N();
        }
}


SPECIFY_RECOMMENDATIONS_DAY()
{
if((RecDay_file=fopen("Recommen.D","r"))==0)
        {
        printf("File not found\n");
        getch();
        }
else
{
for(row=1;row<37;row++)
        {
        fgets(&Rec_Table[0][row],43,RecDay_file);
        for(col=1;col<16;col++)
                {
                fscanf(RecDay_file,"%ld",&Recom_D[col][row]);
                }
        fscanf(RecDay_file,"\n");
        }
}
fclose(RecDay_file);
for(col=1;col<16;col++)
        {
        for(row=1;row<37;row++)
                {
                if(Recom_D[col][row]==1)
                        {
                        Recom_D[col][row]=Recom_D[col][0];
                        Total[row]=Total[row]+Recom_D[col][row];
                        }
                }
        }
}
```

```
SPECIFY_RECOMMENDATIONS_NIGHT()
{
if((RecN_file=fopen("Recommen.N","r"))==0)
        {
        printf("File not found\n");
        getch();
        }
else
{
for(row=1;row<37;row++)
        {
        fgets(&Rec_Table[0][row],43,RecN_file);
        for(col=1;col<16;col++)
                {
                fscanf(RecN_file,"%ld",&Recom_N[col][row]);
                }
        fscanf(RecN_file,"\n");
        }
}
fclose(RecN_file);
for(col=1;col<16;col++)
        {
        for(row=1;row<37;row++)
                {
                if(Recom_N[col][row]==1)
                        {
                        Recom_N[col][row]=Recom_N[col][0];
                        Total[row]=Total[row]+Recom_N[col][row];
                        }
                }
        }
}


CLEAR_INPUT()
{
for(row=0;row<=120;row++)
        {
        for(col=0;col<6;col++)
                { Data[col][row]=NULL; }
        }
}


CLEAR_RESULTS()
{
for(row=0;row<=37;row++)
        {
        for(col=0;col<18;col++)
                { Recom_D[col][row]=NULL; }
        }
}
```

```
FORM()
{
Sort(1,5);
cputs("BUILDING FORM RECOMMENDATIONS          RELATIVE IMPORTANCE");
Display(1,5);
}


ORIENTATION()
{
Sort(6,9);
cputs("BUILDING ORIENTITION RECOMMENDATIONS RELATIVE IMPORTANCE");
Display(6,9);
}


BUILDING_ENVELOP()
{
Sort(10,15);
cputs("BUILDING ENVELOP RECOMMENDATIONS       RELATIVE IMPORTANCE");
Display(10,15);
}


HOUSE_PLAN()
{
Sort(16,21);
cputs("HOUSE PLAN RECOMMENDATIONS             RELATIVE IMPORTANCE");
Display(16,21);
}


OPENINGS()
{
Sort(22,26);
cputs("OPENINGS RECOMMENDATIONS               RELATIVE IMPORTANCE");
Display(22,26);
}


HOUSING_LAYOUT()
{
Sort(27,31);
cputs("HOUSING LAYOUT RECOMMENDATIONS         RELATIVE IMPORTANCE");
Display(27,31);
}


LANDSCAPING()
{
Sort(32,36);
cputs("LANDSCAPING RECOMMENDATIONS            RELATIVE IMPORTANCE");
Display(32,36);
}
```

```
SAVE_RESULTS()
{
Write(29,Choice+4,1,11,50," ");
Result_file=FOpen(29,Choice+4,"Enter Results file name: ",'w');
Write(29,Choice+4,0,0,50," ");
fprintf(Result_file,"\nCLIMATIC DESIGN OF HOUSE  Location: %s\n",\
                    filename);
fprintf(Result_file,"MONTHS   AIR TEMP. degC.   HUMIDITY %   RAIN
mm/d  WIND DIR.\n         max.      min.\n");
for(row=1;row<data-1;row++)
      {
      fprintf(Result_file,"\n %4d %8.2f %8.2f %7.2f %10.2f  %8.0f"
      , row, Data[1][row], Data[2][row], Data[3][row],
      Data[4][row], Data[5][row]);
      }
fprintf(Result_file,"\n\nBiological evaluation results\n");
fprintf(Result_file,"Zones  1  2  3  4  5  6  7  8  9 10 11 12 13\
      14 15\n");
for(col=1;col<16;col++)
      {
      fprintf(Result_file,"%3d",Recom_D[col][0]);
      }
fprintf(Result_file,"\n      ");
for(col=1;col<16;col++)
      {
      fprintf(Result_file,"%3d",Recom_N[col][0]);
      }
fputs("\n\n BUILDING FORM RECOMMENDATIONS ",Result_file);
Save(1,5);
fputs("\n\n BUILDING ORIENTITION RECOMMENDATIONS",Result_file);
Save(6,9);
fputs("\n\n HOUSE PLAN RECOMMENDATIONS ",Result_file);
Save(10,15);
fputs("\n\n BUILDING ENVELOP RECOMMENDATIONS ",Result_file);
Save(16,21);
fputs("\n\n OPENINGS RECOMMENDATIONS ",Result_file);
Save(22,26);
fputs("\n\n HOUSING LAYOUT RECOMMENDATIONS",Result_file);
Save(27,31);
fputs("\n\n LANDSCAPING RECOMMENDATIONS ",Result_file);
Save(32,36);
fclose(Result_file);
}


ACTION_RECOM(int Choice)
{
switch(Choice)
      {
      case 1:
            Form();
            break;
      case 2:
            Orientition();
            break;
      case 3:
```

```
                Building_Envelop();
                break;
        case 4:
                House_Plan();
                break;
        case 5:
                Openings();
                break;
        case 6:
                Housing_Layout();
                break;
        case 7:
                Landscaping();
                break;
        }
}

MENU(char *arr[], int size, int Choice)
{
int j;
_setcursortype(_NOCURSOR);
if(data!=0)
        {
        Write(14,25,1,11,10," %s ",filename);
        Write(38,25,1,11,10," %d ",data-2);
        }
window(2,4,26,5+size);
cputs("\n\r");
for(j=1;j<=size;j++)
        {
        TB(1,11);
        if(j==Choice)  TB(14,4);
        cputs(*(arr+j));
        }
}

READ_DATA_FILE()
{
Write(29,Choice+4,1,11,50," ");
Data_file=FOpen(29,Choice+4,"Enter data file name: ",'r');
Write(29,Choice+4,0,0,50," ");
CLEAR_INPUT();
CLEAR_RESULTS();
data=1;
while(!feof(Data_file))
        {
        fscanf(Data_file,"%f %f %f %f %f",& Data[1][data],&\
Data[2][data], &Data[3][data],&Data[4][data],&Data[5][data]);
        data++;
        }
fclose(Data_file);
if(data!=0)
        {
        Write(1,25,14,1,79,"Current file:            Data(months):");
```

```
        {
        Write(1,25,14,1,79,"Current file:           Data(months):");
        Write(14,25,1,11,10," %s ",filename);
        Write(38,25,1,11,10," %d ",data-2);
        }
}


NO_DATA()
{
Write(1,Choice+4,14,1,15," No data ");
Sound(2,10);
}


DISPLAY_DATA()
{
int i=14;
CLEAR_SCREEN();
Window(1,3,63,6,1,15);
cputs(" Bioclimatic chart evaluation results  \n\n\r");
cputs("Zones 1  2  3  4  5  6  7  8  9 10 11 12 13 14 15  Scor");
for(col=1;col<16;col++)
        {
        printf(" %2d ",Recom_D[col][0]);
        }
Window(1,8,63,9,14,4);
cputs("MONTHS  AIR TEMP. degC.  HUMIDITY %   RAIN mm/d  WIND DIR.\
       \n\r     max.    min.");
Window(1,10,8,23,4,15);
cputs("\r\n 1-JAN.\r\n 2-FEB.\r\n 3-MAR.\r\n 4-ABR.\r\n 5-MAY\r\n
       6-JUNE\r\n 7-JULY\r\n 8-OGU.\r\n 9-SEP.\r\n10-OKT.\r\n11-
       NOV.\r\n12-DEC.");
Window(9,10,63,23,14,1);
for(row=1;row<13;row++)
        {
        Write(10,row+10,14,1,53,"%6.2f %7.2f %10.2f %10.2f %8.0f",\
                Data[1][row], Data[2][row], Data[3][row],
                Data[4][row], Data[5][row]);
        }
}


Sort(int First, int End)
{
int v,c;
for(c=1;c<End-First+2;c++)
        {
        v=0;
        for(row=First;row<=End;row++)
                {
                if(Total[row]>v && Recom_D[17][row]==0)  v=Total[row];
                }
        for(row=First;row<=End;row++)
                {
                if(Total[row]== v && Recom_D[17][row]==0)
```

```
                Recom_D[17][row]=c;
            }
        }
}


Display(int First, int End)
{
int c;
int t=0;
Write(20,23,14,4,40,"     Press any key to contenue    ");
Window(5,10,80,21,14,1);
for(row=First;row<=End+1;row++)
        {
        Recom_D[18][row]=0;
        }
for(c=1;c<=End-First+1;c++)
        {
        for(row=1;row<End+1;row++)
                {
                if(Recom_D[17][row]==c && Recom_D[18][row]==0)
                        {
                        t++;
                        if(Total[row]!=0)
                                printf("\n %2d %s %4d",t,\
                                        Rec_Table[0][row], Total[row]);
                        Recom_D[18][row]=1;
                        }
                }
        }
getch();
CLEAR_SCREEN();
Window(1,4,27,13,1,13);
cputs("  RECOMMENDATIONS MENU");
}


Save(int First, int End)
{
int c;
int t=0;
for(row=First;row<=End+1;row++)
        {
        Recom_D[18][row]=0;
        }
Sort(First,End);
for(c=1;c<=End-First+1;c++)
        {
        for(row=1;row<End+1;row++)
                {
                if(Recom_D[17][row]==c && Recom_D[18][row]==0)
                        {
                        t++;
                        if(Total[row]!=0)
                                fprintf(Result_file,"\n   %2d %s %4d",t,\
                                        Rec_Table[0][row], Total[row]);
```

```
                    Recom_D[18][row]=1;
                    }
                }
        }
fprintf(Result_file,"\n");
}


CLEAR_SCREEN()
{
window(1,2,80,24);
TB(7,0);
clrscr();
}


ENTER_DATA()
{
int x,y;
int i=14;
CLEAR_SCREEN();
_setcursortype(_SOLIDCURSOR);
Write(1,8,14,4,80,"MONTHS  AIR TEMP. degC.  HUMIDITY %  RAIN mm/d\
                 WIND DIR.");
Write(1,9,14,4,80,"          max.    min.");
Window(1,10,8,23,4,15);
cputs("\r\n 1-JAN.\r\n 2-FEB.\r\n 3-MAR.\r\n 4-ABR.\r\n 5-MAY\r\n\
       6-JUNE\r\n 7-JULY\r\n 8-OGU.\r\n 9-SEP.\r\n10-OKT.\r\n\
       11-NOV.\r\n12-DEC.");
data=1;
Window(9,10,63,23,14,1);
for(row=1;row<13;row++)
        {
        for(col=1;col<6;col++)
                {
                x=wherex();
                y=wherey();
                scanf("%f",&Data[col][row]);
                gotoxy(x+10,y);
                }
        gotoxy(1,y+1);
        data++;
        }
}


SAVE_DATA()
{
Save_Data_File=FOpen(29,Choice+4,"Enter Data file name: ",'w');
Write(29,Choice+4,0,0,50," ");
for(row=1;row<data-1;row++)
        {
        fprintf(Save_Data_File,"\n %8.2f %8.2f %9.2f %12.2f %8.0f",\
                Data[1][row], Data[2][row], Data[3][row],\
                Data[4][row], Data[5][row]);
        }
```

```
fclose(Save_Data_File);
}


FOpen(int col,int row,char *Masage,char at)
{
if(at=='w' || at=='a')
       {
       do{
              Swrite(col,row,14,1,"%30s",Masage);
              scanf("%s",filename);
              if(!access(filename,0))
                     {
                     Swrite(col+28,row,14,0,"Y ");
                     Swrite(col,row,15,4,"FILE EXIST  Overwrite? ");
                     Sound(2,4);
                     ch=getch();
                     }
              }while(ch!='y'&& !access(filename,0));
if(at=='w')   fopen(filename,"w");
if(at=='a')   fopen(filename,"a");
       }
if(at=='r')
       {
       do{
              Swrite(col,row,14,1,"%30s",Masage);
              scanf("%s",filename);
              if(access(filename,0))
                     {
                     Swrite(col+28,row,14,0,"N ");
                     Swrite(col,row,14,4,"FILE NOT FOUND    Rtray ");
                     Sound(2,4);
                     ch=getch();
                     }
              }while(ch!='n' && access(filename,0));
       fopen(filename,"r");
       }
}


Window(int tcol,int trow,int bcol,int brow,int textc,int backc)
{
textcolor(textc);
textbackground(backc);
window(tcol,trow,bcol,brow);
clrscr();
}


void Swrite(int col,int row,int color,int bcolor,\
              va_list arg_list, ...)
{
va_list arg_ptr;
char *format;
char output[81];
int len;
```

```
window(1,1,80,25);
va_start(arg_ptr, arg_list);
format = arg_list;
vsprintf(output, format, arg_ptr);
TB(color,bcolor);
gotoxy(col, row);
cprintf(output);
}


void Write (int col, int row, int color, int bcolor,\
            int width, va_list arg_list, ...)
{
va_list arg_ptr;
char *format;
char output[81];
int len;
window(1,1,80,25);
va_start(arg_ptr, arg_list);
format = arg_list;
vsprintf(output, format, arg_ptr);
output[width] = 0;
if ((len = strlen(output)) < width)
setmem(&output[len], width - len, ' ');
TB(color,bcolor);
gotoxy(col, row);
cprintf(output);
} /* Write */


clr()
{
window(1,1,80,25);
TB(7,0);
clrscr();
}


TB(int t, int b)
{
textcolor(t);
textbackground(b);
}


Sound(int i,int o)
{
sound(i*1000);    delay(i*100);
nosound();
delay(o*100);
}
```

A-2- THE RECOMMENDATIONS TABLE FILES

PREVIOUSLY in chapter 5 the climatic design recommendations for the day and night time are simplified in table (5-4). This table should be translated into a matrix form which can be used be the proposed program. This matrix will presented in tow files written by the C. programming language. The first file named "Recommen.D" for the day section of the climatic design recommendations table. The second file named "Recommen.N" for the night section of the climatic design recommendations table. These tow files are presented in the following pages.

A.2.1- Recommen.D file.

```
-Compact form___________________________ 1 1 0 0 0 1 1 1 0 0 0 1 0 0 0
-Compact courtyard form_________________ 0 0 1 0 0 0 1 1 1 1 0 0 1 0 0
-Elongated form_________________________ 0 0 0 0 1 0 0 0 0 0 1 0 1 1 1
-Use pitched or curved roofs____________ 1 1 0 0 0 1 0 0 0 0 0 1 0 0 0
-Use earth sheltring____________________ 1 0 0 0 0 1 0 0 0 0 0 1 0 0 0

-Long axis East West____________________ 0 0 1 0 0 0 1 1 0 0 0 0 1 0 0
-Long axis North South__________________ 0 0 0 0 1 0 0 0 0 0 1 0 0 0 1
-Long axis North-east South-west________ 0 0 1 0 0 1 1 1 0 0 0 0 1 1 0
-Long axis North-west South-east________ 0 0 0 1 1 0 0 0 0 0 1 0 0 0 1

-Select high thermal capacity materials___ 1 1 0 0 0 1 0 0 0 0 0 1 0 0 0
-Use double elements____________________ 1 1 0 0 1 1 0 0 0 0 1 1 0 0 1
-Use heavy materials with long time lag___ 1 1 0 0 0 1 0 0 0 0 0 1 0 0 0
-Use reflective materials on surfaces_____ 0 0 1 1 0 0 1 1 0 0 0 0 1 1 0
-Use light well insulated materials_______ 0 0 1 1 1 0 0 0 0 0 1 0 1 1 1
-Use plants next to building envelope_____ 1 1 1 0 0 1 1 1 0 0 0 0 0 0 0

-Open plan______________________________ 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
-Provide air shafts_____________________ 0 0 1 0 0 0 1 1 0 0 0 0 1 0 0
-Orient low use spaces to south and west__ 1 1 1 0 0 1 1 1 0 0 0 1 1 1 0
-Provide outdoor semi-protected areas_____ 0 0 1 0 0 0 1 1 0 0 0 0 1 0 0
-Provide solar oriented rooms___________ 0 0 0 0 1 0 0 0 0 0 1 0 0 0 1
-Provide outdoor sleeping areas_________ 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0

-Large openings  40-80%_________________ 0 0 0 0 0 0 0 0 0 0 1 0 0 1 1
-Medum openings  20-40%_________________ 0 0 0 1 0 0 0 1 1 1 0 0 0 1 0
-Small openings  10-20%_________________ 1 1 0 0 0 1 1 1 0 0 0 1 0 0 0
-Provide shading for large openings_______ 0 0 0 0 0 1 1 1 0 0 0 1 1 0 0
-Provide insulating at glazed openings____ 1 1 0 0 0 1 0 0 0 0 0 1 0 0 0

-Compact layout_________________________ 1 1 1 0 0 1 1 1 1 0 0 1 0 0 0
-Wide spacing layout____________________ 0 0 0 0 1 0 0 0 0 0 1 1 1 1 1
-Wide spacing layout and provide shading__ 0 0 0 0 0 0 0 0 0 0 0 1 1 0 0
-Use nearby buildings for wind protection_ 1 1 0 0 1 0 0 0 0 0 0 0 0 0 0
-Use nearby buildings for shading________ 1 1 0 0 0 1 0 0 0 0 0 1 1 1 0

-Use trees shading______________________ 0 0 1 0 0 0 1 1 0 0 0 0 1 0 0
-Use vegitation ground cover____________ 1 1 1 0 0 1 1 1 1 0 0 0 0 0 0
-Use heat reflective materials on site____ 0 0 0 0 1 0 0 0 0 0 1 0 0 0 1
-Use water pools on site________________ 0 1 1 1 0 1 1 1 1 0 0 0 0 0 0
-Use vegitation for wind protection_______ 1 1 0 0 1 1 0 0 0 0 1 0 0 0 0
```

A.2.2- Recommen.N file

```
-Compact form_________________________ 1 1 0 0 0 1 1 1 0 0 0 1 0 0 0
-Compact courtyard form_______________ 0 0 1 0 0 0 1 1 1 1 0 0 1 0 0
-Elongated form_______________________ 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1
-Use pitched or curved roofs__________ 1 1 0 0 0 1 0 0 0 0 0 1 0 0 0
-Use earth sheltring__________________ 1 0 0 0 0 1 0 0 0 0 0 1 0 0 0

-Long axis East West__________________ 0 0 1 0 0 0 1 1 0 0 0 0 1 0 0
-Long axis North South________________ 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
-Long axis North-east South-west______ 0 0 1 0 0 0 1 1 0 0 0 0 1 0 0
-Long axis North-west South-east______ 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

-Select high thermal capacity materials___ 1 1 0 0 0 1 0 0 0 0 0 1 0 0 0
-Use double elements__________________ 1 1 0 0 1 1 0 0 0 0 1 1 0 0 1
-Use heavy materials with long time lag___ 1 1 0 0 0 1 0 0 0 0 0 1 0 0 0
-Use reflective materials on surfaces_____ 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
-Use light well insulated materials_______ 0 0 1 1 1 0 1 1 0 0 1 0 1 1 1
-Use plants next to building envelope_____ 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

-Open plan____________________________ 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
-Provide air shafts___________________ 0 0 1 0 0 0 1 1 0 0 1 0 0 0 0
-Orient low use spaces to south and west__ 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
-Provide outdoor semi-protected areas_____ 0 0 1 0 0 0 1 1 0 0 0 0 1 0 0
-Provide solar oriented rooms__________ 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
-Provide outdoor sleeping areas________ 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0

-Large openings  40-80%_______________ 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
-Medum openings  20-40%_______________ 0 0 0 1 0 0 0 0 1 1 0 0 0 1 0
-Small openings  10-20%_______________ 1 1 0 0 0 1 1 1 0 0 0 1 0 0 0
-Provide shading for large openings_______ 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
-Provide insulating at glazed openings____ 1 1 0 0 0 1 0 0 0 0 0 1 0 0 0

-Compact layout_______________________ 1 1 0 0 1 1 0 0 1 0 0 1 0 0 0
-Wide spacing layout__________________ 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1
-Wide spacing layout and provide shading__ 0 0 0 0 0 0 1 1 0 0 0 1 1 1 0
-Use nearby buildings for wind protection_ 0 0 0 1 1 0 0 0 0 0 0 0 0 0 0
-Use nearby buildings for shading_________ 0 1 1 0 0 0 1 1 0 0 0 0 1 1 0

-Use trees shading____________________ 0 0 1 0 0 0 1 1 0 0 0 0 1 0 0
-Use vegitation ground cover__________ 1 1 1 0 0 1 1 1 0 0 0 0 0 0 0
-Use heat reflective materials on site____ 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
-Use water pools on site______________ 0 1 1 1 0 0 1 1 1 0 0 0 0 0 0
-Use vegitation for wind protection_______ 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0
```

APPENDIX B
PROGRAM APPLICATIONS

PROGRAM APPLICATIONS

THE previous studies are concerned with investigations of the effects of climatic influence on human comfort and perform a programming pattern of climatic design of house executed by a computer program. In the following applications some locations in Egypt are used for examples to execute the proposed program applications.

For each application an existing climatic data of one year are used to execute the program(*). The output sorted list of climatic design recommendations are presented. Also a typical design of a house based on the program results are presented for each location.

(*) Data Source: CLIMATE AND ARCHITECTURE a national evaluation Samir H. Hosni

PROGRAM APPLICATION RESULTS

Location: ALEX.

INPUT CLIMATIC DATA

MONTHS	AIR TEMP. degC. max.	min.	HUMIDITY %	RAIN mm/d	WIND DIR.
1	18.30	9.30	71.00	48.30	240
2	19.20	9.70	70.00	28.40	330
3	21.00	11.20	67.00	14.00	330
4	23.60	13.50	68.00	2.70	330
5	26.50	16.70	70.00	1.50	330
6	28.20	20.20	72.00	0.00	330
7	29.60	22.70	73.00	0.00	330
8	30.40	22.90	73.00	0.50	330
9	29.40	21.30	69.00	0.40	330
10	27.70	17.80	68.00	7.90	0
11	24.40	14.80	72.00	32.20	330
12	20.40	11.20	74.00	56.20	240

BIOLOGICAL EVALUATION RESULTS

Zones	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Day Indicators	0	0	0	0	0	0	0	0	0	0	0	0	6	2	4
Night Indicators	0	0	0	0	0	0	0	0	0	0	0	0	0	2	10

CLIMATIC DESIGN RECOMMENDATIONS	RELATIVE IMPORTANCE
BUILDING FORM RECOMMENDATIONS	
1 -Elongated form	24
2 -Compact courtyard form	6
BUILDING ORIENTITION RECOMMENDATIONS	
1 -Long axis North-east South-west	8
2 -Long axis East West	6
3 -Long axis North South	4
4 -Long axis North-west South-east	4
BUILDING ENVELOP RECOMMENDATIONS	
1 -Use light well insulated materials	24
2 -Use double elements	14
3 -Use reflective materials on surfaces	8
HOUSE PLAN RECOMMENDATIONS	
1 -Open plan	24
2 -Orient low use spaces to south and west	8
3 -Provide air shafts	6
4 -Provide outdoor semi-protected areas	6
5 -Provide solar oriented rooms	4
OPENINGS RECOMMENDATIONS	
1 -Large openings 40-80%	8
2 -Provide shading for large openings	6
3 -Medum openings 20-40%	4
HOUSING LAYOUT RECOMMENDATIONS	
1 -Wide spacing layout	24
2 -Use nearby buildings for shading	10
3 -Wide spacing layout and provide shading	8
LANDSCAPING RECOMMENDATIONS	
1 -Use trees shading	6
2 -Use heat reflective materials on site	4

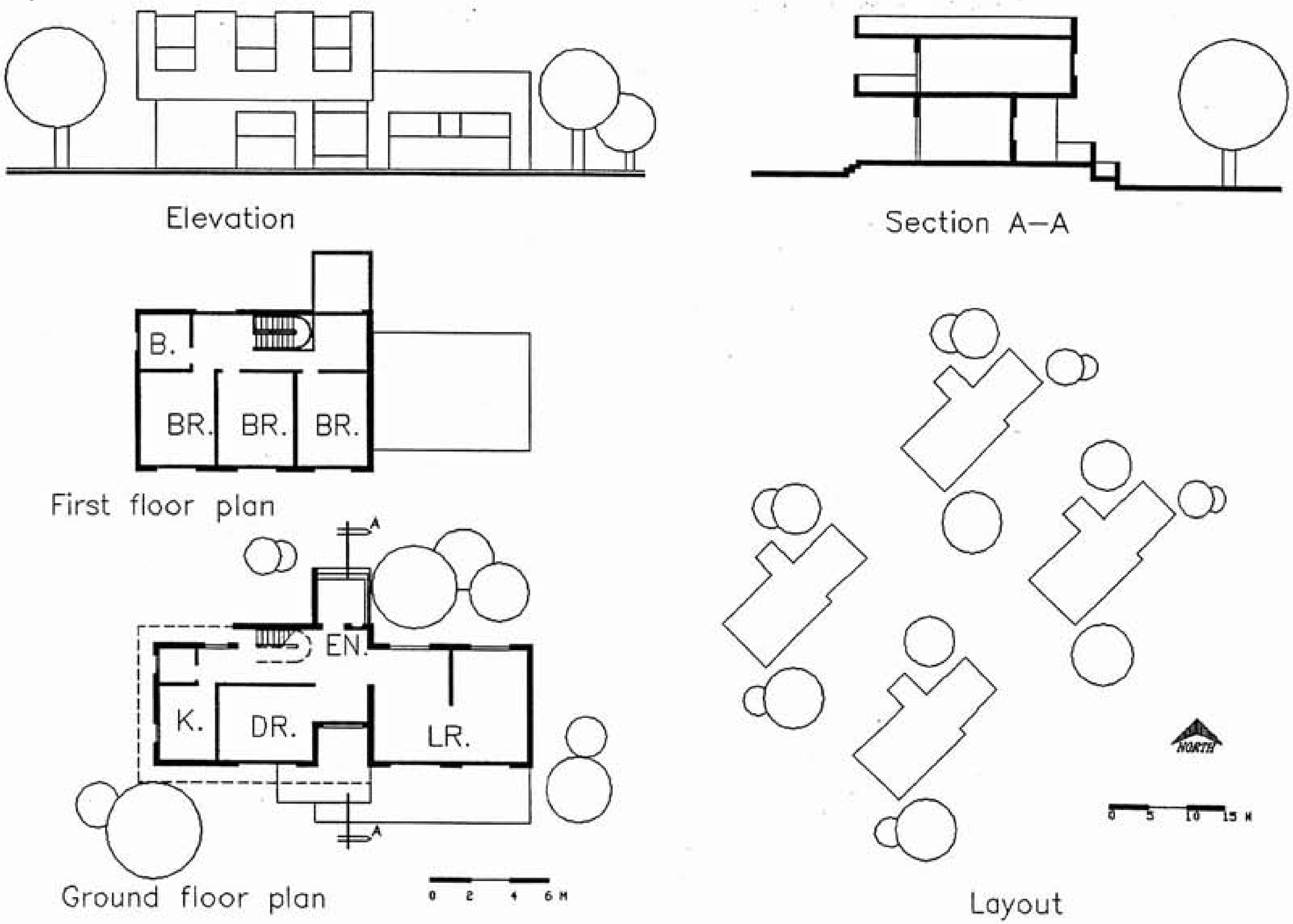


FIG. B-1

Typical design of a house based on the program results for Alex. location

PROGRAM APPLICATION RESULTS

Location: ASYOUT

INPUT CLIMATIC DATA

MONTHS	AIR TEMP. degC. max.	min.	HUMIDITY %	RAIN mm/d	WIND DIR.
1	20.80	6.60	43.00	0.00	270
2	22.80	7.50	40.00	0.40	270
3	26.40	10.50	32.00	0.00	270
4	31.90	14.80	24.00	0.00	330
5	36.40	19.40	23.00	0.00	330
6	37.40	21.30	27.00	0.00	330
7	36.90	22.30	32.00	0.00	330
8	37.00	22.40	35.00	0.00	330
9	35.10	20.10	38.00	0.00	330
10	30.90	18.00	47.00	0.00	330
11	26.60	12.90	48.00	0.00	270
12	22.40	8.90	50.00	0.00	270

BIOLOGICAL EVALUATION RESULTS

Zones	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Day Indicators	1	1	1	0	0	3	1	0	1	1	3	0	0	0	0
Night Indicators	0	0	0	0	3	0	0	0	0	0	9	0	0	0	0

CLIMATIC DESIGN RECOMMENDATIONS	RELATIVE IMPORTANCE
BUILDING FORM RECOMMENDATIONS	
1 -Compact form	6
2 -Use pitched or curved roofs	5
3 -Compact courtyard form	4
4 -Use earth sheltring	4
5 -Elongated form	3
BUILDING ORIENTITION RECOMMENDATIONS	
1 -Long axis North-east South-west	5
2 -Long axis North South	3
3 -Long axis North-west South-east	3
4 -Long axis East West	2
BUILDING ENVELOP RECOMMENDATIONS	
1 -Use double elements	20
2 -Use light well insulated materials	16
3 -Use plants next to building envelope	7
4 -Select high thermal capacity materials	5
5 -Use heavy materials with long time lag	5
6 -Use reflective materials on surfaces	2
HOUSE PLAN RECOMMENDATIONS	
1 -Provide air shafts	11
2 -Orient low use spaces to south and west	7
3 -Provide solar oriented rooms	3
4 -Provide outdoor sleeping areas	3
5 -Provide outdoor semi-protected areas	2
OPENINGS RECOMMENDATIONS	
1 -Small openings 10-20%	6
2 -Provide insulating at glazed openings	5
3 -Provide shading for large openings	4
4 -Large openings 40-80%	3
5 -Medum openings 20-40%	2
HOUSING LAYOUT RECOMMENDATIONS	
1 -Compact layout	11
2 -Use nearby buildings for wind protection	5
3 -Use nearby buildings for shading	5
4 -Wide spacing layout	3
LANDSCAPING RECOMMENDATIONS	
1 -Use vegitation ground cover	8
2 -Use vegitation for wind protection	8
3 -Use water pools on site	7
4 -Use heat reflective materials on site	3
5 -Use trees shading	2

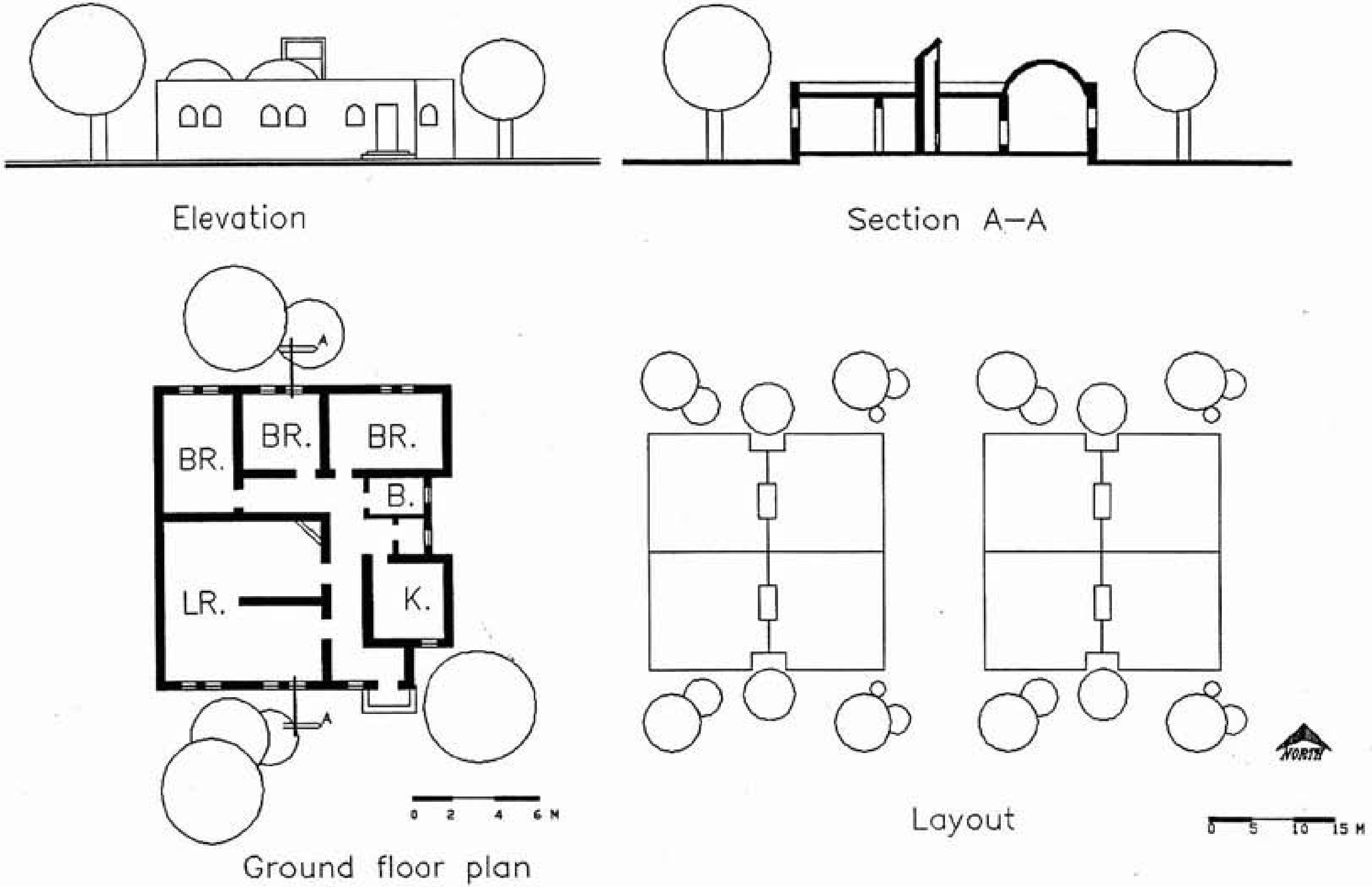


FIG. B-2
Typical design of a house based on the program results for Asyout location

PROGRAM APPLICATION RESULTS

Location: LUXOR

INPUT CLIMATIC DATA

MONTHS	AIR TEMP. degC. max.	min.	HUMIDITY %	RAIN mm/d	WIND DIR.
1	23.00	5.40	52.00	0.00	330
2	25.40	6.80	42.00	0.20	330
3	29.00	10.70	34.00	0.00	330
4	34.80	15.70	26.00	0.00	330
5	39.30	20.70	22.00	0.50	330
6	40.70	22.60	22.00	0.00	330
7	40.70	23.60	24.00	0.00	330
8	41.00	23.50	26.00	0.00	330
9	38.50	21.50	32.00	0.00	330
10	35.10	17.80	39.00	0.00	330
11	29.60	12.30	47.00	0.10	330
12	24.80	7.70	53.00	0.10	330

BIOLOGICAL EVALUATION RESULTS

Zones	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Day Indicators	4	1	0	0	0	2	0	1	1	2	1	0	0	0	0
Night Indicators	0	0	0	2	3	0	0	0	0	0	7	0	0	0	0

CLIMATIC DESIGN RECOMMENDATIONS	RELATIVE IMPORTANCE
BUILDING FORM RECOMMENDATIONS	
1 -Compact form	8
2 -Use pitched or curved roofs	7
3 -Use earth sheltring	6
4 -Compact courtyard form	4
5 -Elongated form	1
BUILDING ORIENTITION RECOMMENDATIONS	
1 -Long axis North-east South-west	3
2 -Long axis East West	1
3 -Long axis North South	1
4 -Long axis North-west South-east	1
BUILDING ENVELOP RECOMMENDATIONS	
1 -Use double elements	18
2 -Use light well insulated materials	13
3 -Use plants next to building envelope	8
4 -Select high thermal capacity materials	7
5 -Use heavy materials with long time lag	7
6 -Use reflective materials on surfaces	1
HOUSE PLAN RECOMMENDATIONS	
1 -Provide air shafts	8
2 -Orient low use spaces to south and west	8
3 -Provide outdoor sleeping areas	2
4 -Provide outdoor semi-protected areas	1
5 -Provide solar oriented rooms	1
OPENINGS RECOMMENDATIONS	
1 -Small openings 10-20%	8
2 -Provide insulating at glazed openings	7
3 -Medum openings 20-40%	6
4 -Provide shading for large openings	3
5 -Large openings 40-80%	1
HOUSING LAYOUT RECOMMENDATIONS	
1 -Compact layout	12
2 -Use nearby buildings for wind protection	10
3 -Use nearby buildings for shading	7
4 -Wide spacing layout	1
LANDSCAPING RECOMMENDATIONS	
1 -Use vegitation ground cover	9
2 -Use vegitation for wind protection	8
3 -Use water pools on site	7
4 -Use trees shading	1
5 -Use heat reflective materials on site	1

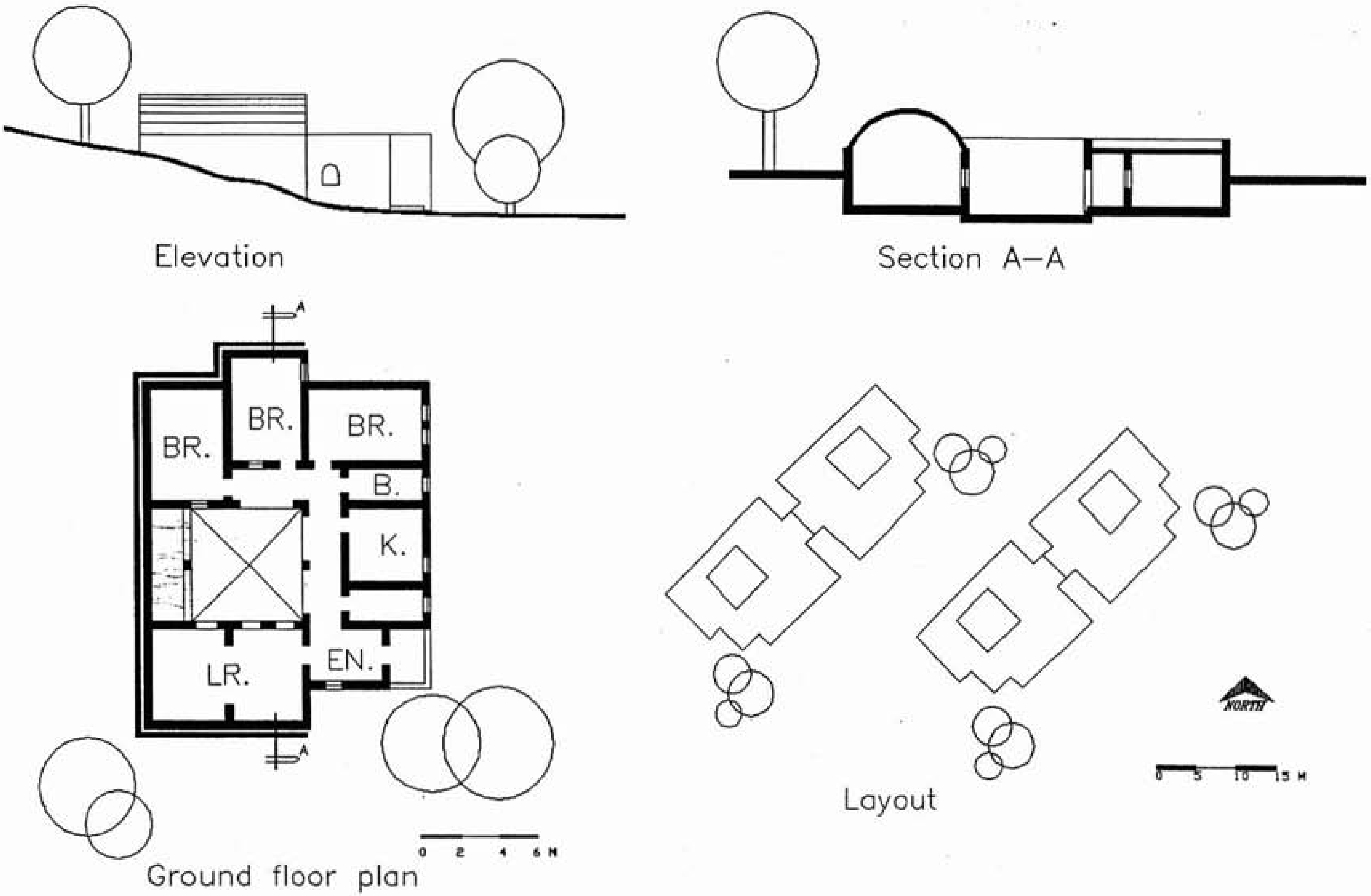


FIG. B-3

Typical design of a house based on the program results fo Luxor location

PROGRAM APPLICATION RESULTS

Location: ARISH

INPUT CLIMATIC DATA

MONTHS	AIR TEMP. degC. max.	min.	HUMIDITY %	RAIN mm/d	WIND DIR.
1	19.30	8.30	66.00	14.50	0
2	20.10	9.00	65.00	16.00	0
3	21.20	10.70	64.00	12.90	0
4	23.60	13.20	65.00	4.30	0
5	27.00	16.10	64.00	3.70	0
6	28.80	18.70	66.00	0.00	0
7	30.60	21.10	69.00	0.00	0
8	31.00	21.80	69.00	0.30	0
9	29.80	20.30	66.00	0.70	0
10	28.60	17.90	66.00	5.30	0
11	25.20	14.30	68.00	18.30	0
12	21.40	10.10	67.00	20.80	0

BIOLOGICAL EVALUATION RESULTS

Zones	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Day Indicators	0	0	0	0	0	0	1	0	0	0	1	0	5	2	3
Night Indicators	0	0	0	0	0	0	0	0	0	0	2	0	0	0	10

CLIMATIC DESIGN RECOMMENDATIONS	RELATIVE IMPORTANCE
BUILDING FORM RECOMMENDATIONS	
1 -Elongated form	21
2 -Compact courtyard form	6
3 -Compact form	1
BUILDING ORIENTITION RECOMMENDATIONS	
1 -Long axis North-east South-west	8
2 -Long axis East West	6
3 -Long axis North South	4
4 -Long axis North-west South-east	4
BUILDING ENVELOP RECOMMENDATIONS	
1 -Use light well insulated materials	23
2 -Use double elements	16
3 -Use reflective materials on surfaces	8
4 -Use plants next to building envelope	1
HOUSE PLAN RECOMMENDATIONS	
1 -Open plan	20
2 -Provide air shafts	8
3 -Orient low use spaces to south and west	8
4 -Provide outdoor semi-protected areas	6
5 -Provide solar oriented rooms	4
OPENINGS RECOMMENDATIONS	
1 -Large openings 40-80%	6
2 -Provide shading for large openings	6
3 -Medum openings 20-40%	2
4 -Small openings 10-20%	1
HOUSING LAYOUT RECOMMENDATIONS	
1 -Wide spacing layout	21
2 -Use nearby buildings for shading	7
3 -Wide spacing layout and provide shading	5
4 -Compact layout	1
LANDSCAPING RECOMMENDATIONS	
1 -Use trees shading	6
2 -Use heat reflective materials on site	4
3 -Use vegitation ground cover	1
4 -Use water pools on site	1
5 -Use vegitation for wind protection	1

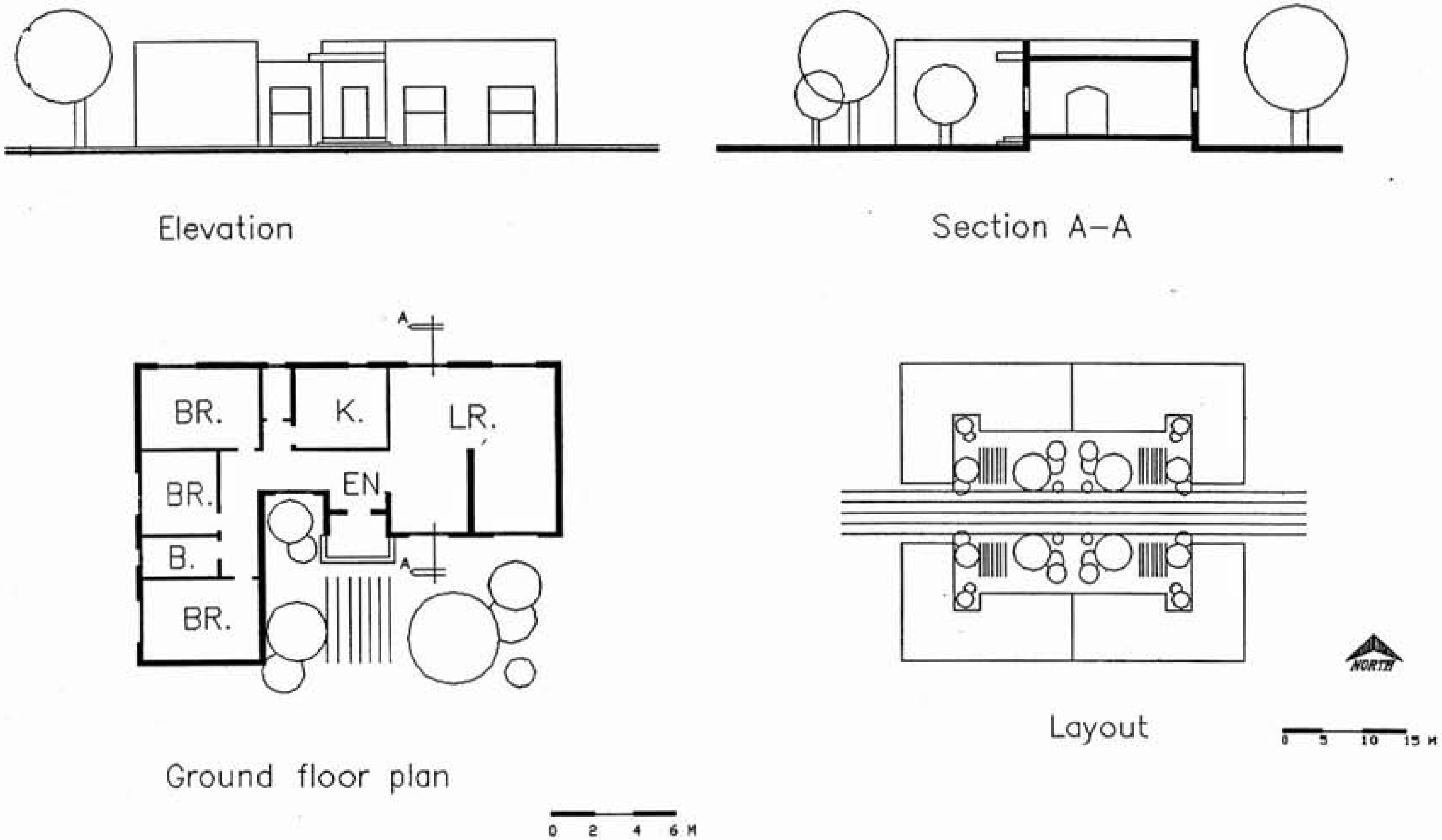


FIG. B-4

Typical design of a house based on the program results for Arish location

PROGRAM APPLICATION RESULTS

Location: DAKHLA

INPUT CLIMATIC DATA

MONTHS	AIR TEMP. degC. max.	min.	HUMIDITY %	RAIN mm/d	WIND DIR.
1	21.40	4.40	45.00	0.00	0
2	23.70	6.00	42.00	0.40	0
3	27.60	9.50	34.00	0.00	0
4	32.70	14.30	29.00	0.00	0
5	37.10	20.00	26.00	0.20	0
6	38.20	22.50	27.00	0.00	0
7	38.60	23.10	26.00	0.00	0
8	38.50	22.90	28.00	0.00	0
9	35.70	20.60	35.00	0.00	0
10	33.20	17.40	39.00	0.00	0
11	27.70	11.80	45.00	0.00	0
12	22.30	6.60	48.00	0.10	0

BIOLOGICAL EVALUATION RESULTS

Zones	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Day Indicators	4	0	1	0	0	1	1	0	2	1	2	0	0	0	0
Night Indicators	0	0	0	0	5	0	0	0	0	0	7	0	0	0	0

CLIMATIC DESIGN RECOMMENDATIONS	RELATIVE IMPORTANCE
BUILDING FORM RECOMMENDATIONS	
1 -Compact form	6
2 -Compact courtyard form	5
3 -Use pitched or curved roofs	5
4 -Use earth sheltring	5
5 -Elongated form	2
BUILDING ORIENTITION RECOMMENDATIONS	
1 -Long axis North-east South-west	3
2 -Long axis East West	2
3 -Long axis North South	2
4 -Long axis North-west South-east	2
BUILDING ENVELOP RECOMMENDATIONS	
1 -Use double elements	19
2 -Use light well insulated materials	15
3 -Use plants next to building envelope	7
4 -Select high thermal capacity materials	5
5 -Use heavy materials with long time lag	5
6 -Use reflective materials on surfaces	2
HOUSE PLAN RECOMMENDATIONS	
1 -Provide air shafts	9
2 -Orient low use spaces to south and west	7
3 -Provide outdoor semi-protected areas	2
4 -Provide solar oriented rooms	2
5 -Provide outdoor sleeping areas	1
OPENINGS RECOMMENDATIONS	
1 -Small openings 10-20%	6
2 -Provide insulating at glazed openings	5
3 -Medum openings 20-40%	3
4 -Large openings 40-80%	2
5 -Provide shading for large openings	2
HOUSING LAYOUT RECOMMENDATIONS	
1 -Compact layout	14
2 -Use nearby buildings for wind protection	9
3 -Use nearby buildings for shading	5
4 -Wide spacing layout	2
LANDSCAPING RECOMMENDATIONS	
1 -Use vegitation ground cover	9
2 -Use vegitation for wind protection	7
3 -Use water pools on site	5
4 -Use trees shading	2
5 -Use heat reflective materials on site	2

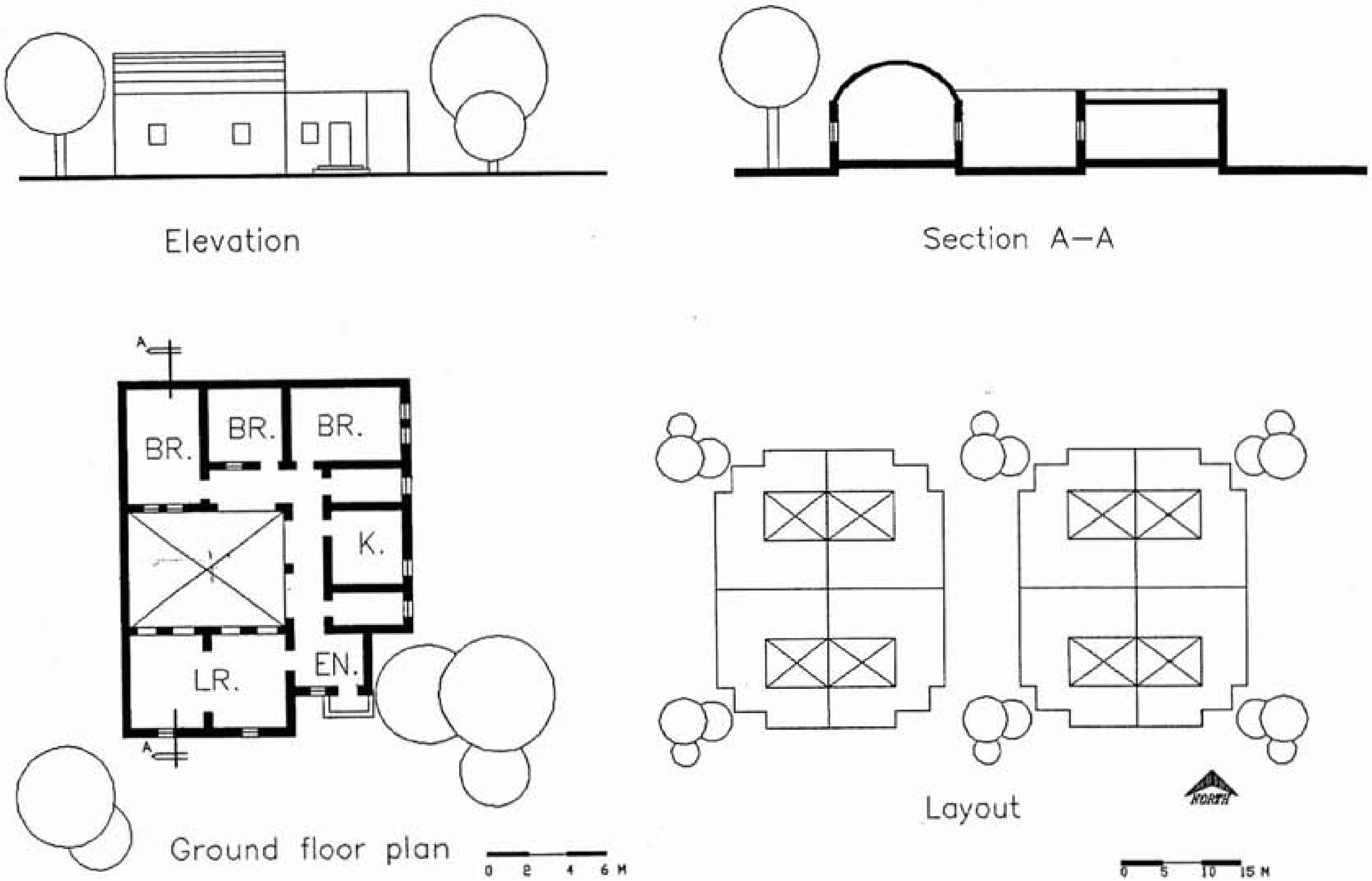


FIG. B-5

Typical design of a house based on the program results for Dakhla location

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SUMMARY

INTRODUCTION

THE purpose of the present study is to create a computer program to execute a programming pattern of climatic design of house, which must be considered during the sketch plan stage of housing design. The general concept of the proposed programming process starts with the input climatic data and terminates with an output of a specified list of climatic design recommendations sorted according to its relative importance.

The proposed thesis includes the sequence of all studies that should be considered through the process of climatic design of house. The sequence of these studies are presented as following.

Chapter 1, THE BASIC CLIMATIC DATA

The climatic conditions of a specific location are dominated by incoming solar radiations and the effects of latitude, altitude, wind, atmospheric impurities and manmade forms. The general principles of climatic variations and climatic elements are the considerations of the present chapter. This is because the first stage in the climatic design of house process is to obtain the basic climatic data. The climatic data should recorded related to a period of time by its specific values of air temperature, relative humidity, precipitation, and wind.

The numeric representation of the climatic data is the form of the required data which will used in the climatic design of house process.

Chapter 2, BIOLOGICAL EVALUATION

The impact of the climatic conditions on human body is the compound effects of the various climatic elements. The correlation between climatic elements should be considered to evaluate the biological effects of climate on human comfort.

The comfort limits does not depend only on the air temperature, but also on the relative humidity and air movement. So the impact of climatic conditions on human comfort should be considered in the climatic design of house process. It is necessary to evaluate the effect of climatic elements on human comfort by using a thermal comfort scale.

Chapter 3, THERMAL DESIGN PRINCIPLES

Heat exchange through the building envelope depends on the thermal properties of the used building materials. The basic thermal properties which determine the heat exchange through a building element are thermal admittance, thermal resistance, solar heat flow, time lag and thermal transmittance. The heat flow between indoor spaces and external environment should be controlled in order to create a comfortable indoor conditions.

The previous developed bioclimatic chart used in the present chapter to define the needed climate control strategies any given climatic conditions, determined by its air temperature and relative humidity. The produced correlations between the climate control strategies and the climatic conditions will be used in the next chapter to specify the needed climatic design recommendations.

Chapter 4, CLIMATIC DESIGN APPLICATIONS

In order to confirm human comfortable living conditions with the minimum cost of mechanical heating and cooling, the house building should be designed according to the local climatic conditions. There are many climatic design applications which can provide the indoor comfortable living conditions. By the aid of the biological evaluation results the appropriate climatic design recommendations can be defined.

The basic climatic design recommendations can be grouped under seven headings, they are: building form, building orientation, building envelop, house plan, openings design, housing layout and landscaping. For each group the basic climatic recommendations are specified related to the bioclimatic chart zones.

Chapter 5, CLIMATIC DESIGN PROGRAM

The previous analysis of climatic data, biological evaluation and the climatic design applications are the needed informations for the climatic design of house process. The purpose of the present chapter is to create a computer program based on the previous analysis to execute the pattern of climatic design of house process. The general concept of the proposed program starts with the input climatic data and terminates with an output of a specified list of climatic design recommendations.

The program processed through the sequence of stages, which are defined in the study concept section. These stages are: input stage, evaluation stage, resolving stage and output stage. Some computer-based mathematical techniques can be used to perform the program process. One of the most computer programming languages is the C. language which used to create the proposed climatic design of house program.

Chapter 6, CONCLUSION AND FUTURE WORK

The final chapter presents the concluded programming pattern of climatic design of house and describes the climatic design program. the future work possibilities are discussed also.

APPENDICES

The complete package of all files which are created to perform the climatic design program. Some applications of the proposed program for some locations in Egypt (for examples).

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قسم الهندسة المعمارية

منهجيــــة التصميــــم المناخى للمسكـــــن
(تطبيقات على الحاسب الآلى)

رسالة مقدمة من

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١٩٩٢

ملخص الرسالة باللغة العربية

المقدمة :

الهدف من الدراسة المقدمة هو تصميم برنامج حاسب آلى يقوم بتنفيذ نموذج لمنهجية التصميم المناخى للمسكن. التصور العام للمنهج المعروض فى الرسالة المقدمة يبدأ بمعرفة المعلومات المناخية الأساسية فى موقع البناء وينتهى بتقديم قائمة من توصيات التصميم المناخى مرتبة حسب ترتيب أهمية تحقيقها حتى يتلائم المسكن المصمم مع الظروف المناخية فى موقع بنائه.الرسالة تضم تسلسل الدراسات التى يجب تناولها خلال عملية التصميم المناخى للمسكن.

هذه الدراسات تتناولها الرسالة خلال عدة أبواب يمكن ايجاز محتواها على النحو التالى:-

البـاب الأول : -

المعلومات المناخية الاساسية :

الظروف المناخية لموقع ما تتحدد تبعاً لمدى تأثير الأشعة الشمسية التى تصل إليها إلى جانب تأثير الموقع الجغرافى من حيث خطوط الطول والعرض والإرتفاع عن مستوى سطح البحر وحركة الرياح ومحتوى الغلاف الجوى من الشوائب وكذلك المنشآت القائمة فى هذا الموقع. المرحلة الأولى من مراحل التصميم المناخى للمسكن هى معرفة المعلومات المناخية الأساسية لموقع البناء. هذه المعلومات يجب تسجيلها لفترة زمنية معينة بقيمها المختلفة من حيث درجات الحرارة والرطوبة النسبية ومعدل الأمطار وإتجاه وسرعة الرياح. التسجيل الرقمى لهذه المعلومات هو الصورة التى سوف تستخدم فى منهج التصميم المناخى للمسكن خلال البرنامج المصمم.

البـاب الثانى : -

التقييم البيولوجي:

تأثير الظروف المناخية على جسم الإنسان هو محصلة تأثير عناصر المناخ المختلفة على الإنسان.تأثير عناصر المناخ على بعضها البعض يجب أن تؤخذ فى الإعتبار عند دراسة تأثير المناخ على الإنسان وراحته. الراحة الحرارية للإنسان لاتتأثر فقط بدرجات الحرارة وإنما تتأثر

أيضاً بنسبة الرطوبة فى الهواء وكذلك حركة الهواء. نظراً لذلك فإن تأثير الظروف المناخية على الإنسان وراحته يجب أن تراعى عند إعداد التصميم المناخى للمسكن. من الضرورى تقييم تأثير الظروف المناخية على الإنسان بإستخدام أحد مقاييس الراحة الحرارية. البرنامج المقدم خلال هذه الرسالة يستخدم خريطة الراحة الحرارية كمقياس للراحة الحرارية بعد تطويرها بحيث يمكن إستخدامها كتطبيق على الحاسب الآلي .

البـــاب الثالث : -

مبادئ التصميم الحرارى :

إنتقال الحرارة خلال الغلاف الخارجى للمبنى يتأثر بالخواص الحرارية للمواد المستخدمة فى إنشائه. أهم الخواص الحرارية لمواد البناء والتى تؤثر على إنتقال الحرارة خلال عناصر المبنى هى إمتصاص الحرارة، المقاومة الحرارية، إنتقال الحرارة الشمسية، التخلف الزمنى وإنتقال الحرارة الكلى.

إنتقال الحرارة بين الوسط الداخلى والوسط الخارجى يجب التحكم فيه بهدف تحقيق الظروف المناخية الداخلية الملائمة لراحة الإنسان. بإستخدام خريطة الراحة المطورة فى الباب السابق يمكن تحديد أساليب التحكم فى الظروف المناخية القائمة فى موقع البناء. العلاقة بين الظروف المناخية وأساليب التحكم فيها سوف تستخدم فى تحديد توصيات التصميم المناخى اللازمة التى سيتناولها الباب التالى.

البـــاب الرابع : -

تطبيقات التصميم المناخى :

حتى يمكن تحقيق الظروف المناخية الملائمة لراحة الإنسان الحرارية بإستخدام الحد الأدنى من الوسائل الميكانيكية للتدفئة أو التبريد يجب أن يصمم المسكن تبعاً للظروف المناخية فى موقع بنائه. يمكن إستخدام العديد من تطبيقات التصميم المناخى والتى تساعد على تحقيق الظروف المناخية الداخلية الملائمة لراحة الإنسان. بمساعدة نتائج التقييم البيولوچى لتأثير المناخ على الإنسان التى تناولها الباب الثانى يمكن تحديد توصيات التصميم المناخى الواجب مراعاتها. توصيات التصميم المناخى يمكن تقسيمها الى سبعة مجموعات رئيسية هى : - شكل المبنى، توجيه المبنى، تصميم عناصر الغلاف الخارجى للمبنى، تصميم المسقط الأفقى للمسكن، تصميم الفتحات، تخطيط الموقع وعناصر تنسيق الموقع.

البـــاب الخامس : -

برنامج *التصميم المناخى*:

التحليلات السابقة للمعلومات المناخية، التقييم البيولوجى لتأثير المناخ على الإنسان وتطبيقات التصميم المناخى هى التحليلات والمعلومات اللازمة لعملية التصميم المناخى للمسكن. الهدف من هذا الباب هو تصميم برنامج الحاسب الآلى الذى ينفذ نموذج التصميم المناخى للمسكن مستخدماً المعلومات السابق تحليلها.

التصور العام للبرنامج المقدم يبدأ بإدخال البيانات والمعلومات المناخية وينتهى بإخراج مجموعة من توصيات التصميم المناخى الواجب مراعاتها . ينفذ البرنامج نموذج التصميم المناخى للمسكن خلال أربعة مراحل رئيسية هى : - مرحلة إدخال البيانات، مرحلة التقييم، مرحلة اختيار الحلول ومرحلة إخراج النتائج.

بإستخدام بعض نظم التحليل الرياضى على الحاسب الآلى أمكن تنفيذ نموذج التصميم المناخى للمسكن. كذلك بإستخدام أحد لغات الحاسب الآلى أمكن إعداد البرنامج الذى ينفذ نموذج التصميم المناخى للمسكن.

البـــاب السادس : -

الاستنتاج:

يعرض هذا الباب نموذج التصميم المناخى للمسكن المستنتج من الدراسة وبرنامج الحاسب الآلى الذى ينفذ هذا النموذج وكذلك الإضافات المستقبلية التى يمكن إضافتها للبرنامج.

الملاحـــق : -

يضم البحث أيضا ملحقين الأول يعرض البرنامج المصمم مكتوب بأحد لغات الحاسب الآلى. الملحق الثانى يعرض بعض تطبيقات البرنامج لبعض المواقع المصرية على سبيل المثال.