

THE CATHOLIC UNIVERSITY OF AMERICA

SELF-SUFFICIENT HOUSE DESIGN
FOR TURKISH VILLAGERS

A DISSERTATION

Submitted to the Faculty of the
School of Engineering and Architecture
Of the Catholic University of America
in Partial Fulfillment of the Requirements
For the Degree
Doctor of Architecture

C

Copyright

All Rights Reserved

Mehret Resat Gecit

Washington, D. C.

1979

I wish to express my gratitude to Dr. Forrest Wilson, Chairman of the Architecture Department of the Catholic University of America, who has guided me in every aspect of my work.

I would also like to express my appreciation to Professor Joseph Miller, who showed me the "human face" of architecture.

I wish also to express my thanks to Dr. Bertrand Chatel, Chief of Technology Applications, Office for Science and Technology, United Nations, New York, for his constant and rewarding training.

And a special thanks to my fiancée who waited for this work to be completed for the last six years.

This dissertation was approved by Dr. Forrest Wilson
as Director, and by Dr. Peter Lizon and Dr. Bertrand Chatel as
Readers.

Forrest Wilson 6/7/79
Director

Bertrand Chatel 6.2.79
Reader

Peter Lizon 7 June 79
Reader

CONTENTS

INTRODUCTION		iv
CHAPTER I	TURKISH RURAL LIFE	1
	Geography	
	Population	
	Rural Settlements	
	Household and Family Structure	
	Turkish Shelter	
CHAPTER II	TURKISH VERNACULAR ARCHITECTURE AND ENVIRONMENTAL FACTORS	36
	Environment and Man	
	Environmental Forces	
	Environment and Building	
CHAPTER III	CLIMATIC DATA FOR TURKEY AND APPLICATION OF DATA TO BUILDING DESIGN	71
	Climate in Turkey	
	Climatic Data for Building Construction	
	Building Survey	
	Selection of Architectural Program Elements	
	Heat Loss Calculation and Methodology	
CHAPTER IV	IMPROVED SELF-SUFFICIENT HOUSE CONSTRUCTION FOR TURKISH RURAL FAMILIES	127
	Building Construction	
	Earthquake Resistant Structural System and Methodology for Seismic Analysis	
	Energy	
	Wind Energy	
	Water Power	
	Wood Energy	
	Bio-Power	
	Solar Radiation	
CHAPTER V	HANDEBOOK: TURKISH VILLAGE HOUSE DESIGN PARAMETERS	218
CONCLUSION		244
BIBLIOGRAPHY		248

INTRODUCTION

The problems faced by developing countries are drawing increasing attention, as two thirds of the world's population is located in the developing countries and increasing at twice the pace of that of developed countries. In the developing countries, although 80 percent of the population is living in rural areas, few architectural projects are devoted to improving the standard of living of these inhabitants. There are 1.5 million villages which are not connected with the electric grid and use "non-commercial sources of energy," such as wood for heating and cooling. As a result, deforestation has been progressing rapidly and oil has been generally the substitute fuel in many cases.

In this context, energy crisis and increase of oil prices has had a disastrous effect particularly upon the rural areas of developing countries. Consequently, the purpose of the present project is to reshape buildings intended for villages, utilizing alternative sources of energy such as solar, wood, and biological sources of energy.

The project is located in Turkey, taken as an example of a developing country where problems of the rural population require a unique solution. The design proposed is based upon traditional taste and cultures of Turkish villages. It also aims at utilizing local raw materials, such as adobe rather than bricks, as well as local sources of energy such as the sun, the wind and biomass.

In addition, the building is earthquake-resistant, as many Turkish villages are located in areas where earthquakes appear periodically.

The type of construction has been chosen so that it can be erected by villagers, as a labor-intensive technology. The architectural concept is the result of the many factors which converged to identify an "appropriate design."

This project is intended for application in Turkey. However, the principles which have been utilized may also be considered for the preparation of similar projects in rural areas of other developing countries. This will require in each case an adaptation to the local conditions prevailing in that country.

In addition, the project may be used for educational purposes in architectural schools, as an example of the adaptation of buildings to local conditions, needs and cultures, taking into account the energy resources available in each country.

GEOGRAPHY

The Land

Turkey is situated between 36° and 42° , i.e. in the temperate middle latitudes of the northern hemisphere. The area of Turkey is $779,452 \text{ km}^2$ including lakes. It spreads over two large peninsulas, covering $755,688 \text{ km}^2$ of the Anatolian Peninsula in Asia and $23,764 \text{ km}^2$ of the Thracian Peninsula in Europe.

Geographically, it is a link between Europe and Asia; and as such, it has been the home of successive civilizations reaching back to the dawn of history and has served as a bridge for the migration of peoples.

The Peninsula of Thrace is a land of wide, undulating plains. In the Marmara and Aegean regions, high horst-formations stretching east-west divide wide plateaus which are sometimes broken by valleys or depressions.

Central Anatolia is a country of undulating plateaus lying at an average altitude of 1200-1500 meters, while in Eastern Anatolia plateaus of volcanic origin are separated by high mountain ranges. Finally, southeastern Anatolia consists largely of undulating plains with anticlinal and synclinal characteristics.

Climate

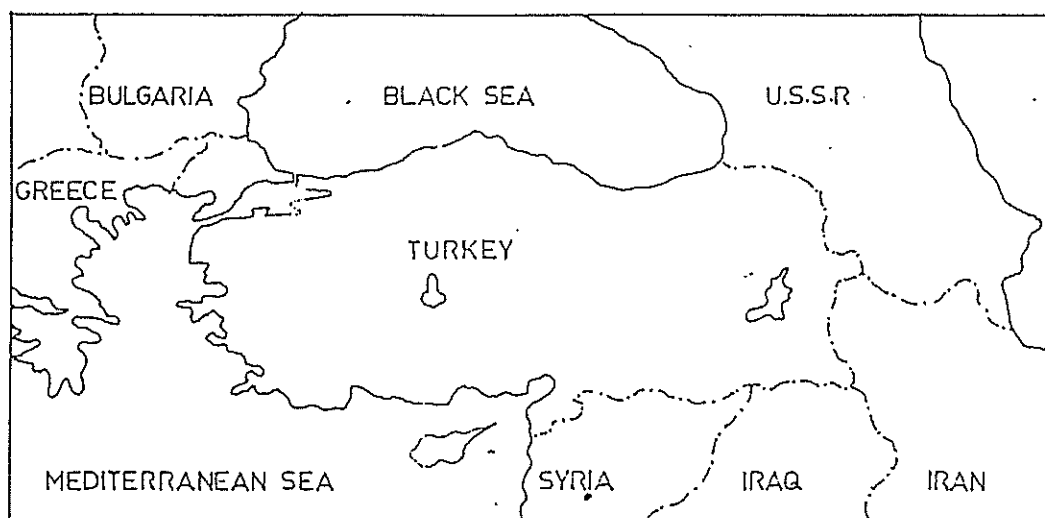
Turkey as a whole lies in the temperate zone, although its climate exhibits considerable regional variations. On three sides the coastal areas enjoy a mild sea climate, while in the

interior severe continental conditions prevail. The south has a typical Mediterranean climate, with hot, dry summers and mild, wet winters. The average annual temperature is 19-20° C. The average for July is 28° C. and for January, 8-11° C.

On the other hand, in Central Anatolia summers are hot and dry, and winters cold with frequent snowfalls. In this area of steppes, the average annual temperature is between 10 and 12° C. In eastern Anatolia even the summers are cool, while the winters are extremely severe with heavy snowfalls.

Southeastern Anatolia is influenced by the desert climate of the Middle East with hot, dry summers and winters that lack the severity of the interior of the country.

The eastern Black Sea coast of Turkey has the fewest seasonal variations. Here the annual rainfall reaches approximately 2,500 mm. and is fairly evenly distributed throughout the year. The temperature changes little from month to month and season to season.



POPULATION

The population of Turkey is over 50,000,000 today, an increase of 300 percent in 50 years.

Ethnology

The word "Turk" means "strong," spelled "Turuk" in the 8th century Orkhon inscriptions. It is known that in the 6th century under the "Göktürk" Dynasty, all those who spoke Turkish were already known as Turks.

In classical times, the Turks inhabited in Asia the land between the Volga River and the Ural Mountains, where there are still large numbers of them to be found today.

Historically, Turkish ethnology has been divided into five periods, as follows:

1. Ancient period: From prehistoric times to the 4th Century B. C.
2. The period of the Huan Confederation and its dissolution: 4th Century B. C. to 6th Century A. D.
3. The period of the Göktürk Confederation and its dissolution: 6th to 13th centuries.
4. The period of the Mongol conquests: 13th and 14th centuries.
5. The period of tribal regrouping and settlement: 14th to 20th centuries.

Racial Origin

The Turks came from Asia and their race originated there. Philological research has shown on the one hand a definite link between old Turkish and the linguistic substratum of the Urals, and on the other hand, cross-borrowings between the Turkish and Sanskrit. It follows that the Turks lived in an area where they were in contact with the original Ural people and where Indian influences penetrated, between western Asia and the country north of the Aral Sea. We can say that the original home of the Turks was in the northern part of the Steppe lying between the Ural and the Altai Mountains.

Language

Turkish belongs to the Uralo-Altaic group of languages.

Religion

The religion of the Turks is "Islam," which came to Anatolia in the 7th century. It was founded by the prophet "Hazret'i Muhammet" in the same century. The religious book is known as the Kuran. It is a monotheistic religion, requiring belief in six fundamentals:

1. The unity of one God
2. Angels
3. Sacred Scriptures
4. Prophets
5. An after life
6. The predetermining will of God.

RURAL SETTLEMENTS

Turkey is a vast country with an area of 780,580 square kilometers. About 35,000 villages have been established in the permanently inhabitable parts of this country. These rural settlements, each forming the smallest administrative center, are composed of a few houses in certain places. The number of permanent rural settlements not yet having an autonomous administration is about 50,000.

Fifty percent of Turkey's population lives in those rural settlements. Without having knowledge about the environments of village man, we can not understand his shelter, which is our main interest.

Village Structure

The Turkish village itself is the most striking social group. No village forms part of any larger indigenous organization. Villages are self-contained, clusters of buildings separated from each other by stretches of unfenced land.

Each village is composed of distinct patrilineal, patrilocal households. Although several households often occupy one block of buildings, the physical and social boundaries between them are never vague. Village and household are the main social units.

Every village is divided into a number of quarters or wards (Mahalle). These have no clear boundaries and are not

corporate. People acknowledge loyalty to their quarters, and may speak or fight in the village as fights between quarters. Because close neighbors often intermarry and close agnates and sometimes other close kin live near each other, these quarters often have some kinship unity. Close neighbors, whether kin or not, will tend to form informal groups for recreation and conservation.

A person's position in society is mainly determined by:

- sex and age
- kinship
- occupation and wealth
- piety and learning
- personal honor
- (for a man) the range and strength of his urban contacts

The sexual distinction is (as an Islamic society) strongly emphasized, and for most normal social life the sexes are sharply segregated. Age is not a criterion for any formal groups, but it carries respect and authority.

Kinship relations are both the most intimate and intense, and also the commonest type of social relation. The personal kin ties of man through men form the core of the lineage groups. Extra lineage kin ties form strong and numerous relationships between both households and individuals. This kinship network extends from village to village and provides vital channels for all sorts of activities -- economic, political, religious -- and for the

arranging of marriages which will, in turn, forge new kin ties.

Distinctions of wealth are not conspicuous. All households in the village live in the same way. All who can, work. There are no permanent rentier households; the elderly are always supported by their sons. This is the reason Turkish family structure shows great differentiation from the other examples of the west. The wealthiest and most urbanized households have a comfortable sufficiency, while the poor are badly housed and clothed. But though differences in wealth are not conspicuous in the way of life, they are of great social importance. The rich are the leaders of the village, carry weight in village councils, employ their neighbors, and are able by gifts and loans to exercise influence and even direct control, especially among their own kin.

Religious learning carries high prestige in the villages. Village children receive some kind of special religious training from special schools outside of government schools, but religious schools are the ones which give children prestige in the society.

Urban contacts have probably always conferred great influence and prestige in the villages. Nowadays, because of their contact with urban life, many villagers have high standing in the urban world. These links give great prestige in the village.

Village Solidarity

People belong to their village in a way they belong to no other social group. On any definition of community, the village is a community -- a social group with many functions, not all of them explicit, and to which people are committed by birth or marriage, and bound by many ties.

The virtues of the village are an eternal topic of conversation with outsiders and of banter between men of different villages. Every village has the best drinking water, best climate; every village is more hospitable, more honorable, more virile, more peaceable, gives better weddings, than any of its neighbors. Other villages are savage, mean, dishonorable and lazy.

Each village possesses a territory recognized by the state as its administrative area. Villages normally own common land and sometimes meadow or crop land which can be let, but in the civil code it has no rights to land within its territory owned by individuals, and unoccupied land belongs to the state.

Village populations are highly stable. Almost all men and more than half the adult women in a village were born there. If we could measure the intensity of social relationships in terms of emotional strength, the number of rights and duties involved, and the frequency of contact, we would find that all residents except the more newly arrived wives had their more intense social relationships almost exclusively inside the village. All the villagers belong to one another. Even enemies inside the village are intimate enemies.

Village Organizations

There are two kinds of village organizations: The formal institutions laid down by the state; and the informal institutions run by the village for its own purposes to meet the actual needs of its members.

The village is ruled by a headman (Muhtar), elected every two years. He is in short, the agent, guarantor and communications channel for all village business with the government.

The council of elders (ihtiyarlar heyeti) is elected with the headman. It is supposed to meet every month to discuss problems of the village.

HOUSEHOLD AND FAMILY STRUCTURE

The household is much more than an economic "firm." Within it, the main human physiological needs are met (rest, love, sex, etc.) and the most intimate and emotionally important social relations played out.

Unrelated men do not enter the households of other families. Private, personal feelings are not publicly discussed. Sex and anything to do with it is taboo.

The most striking structural feature of the household is the division between the sexes. We can classify them by these criteria:

- Relations between men
- Relations between women
- Relations between men and women

Village Organizations

There are two kinds of village organizations: The formal institutions laid down by the state; and the informal institutions run by the village for its own purposes to meet the actual needs of its members.

The village is ruled by a headman (Muhtar), elected every two years. He is in short, the agent, guarantor and communications channel for all village business with the government.

The council of elders (ihtiyarlar heyeti) is elected with the headman. It is supposed to meet every month to discuss problems of the village.

HOUSEHOLD AND FAMILY STRUCTURE

The household is much more than an economic "firm." Within it, the main human physiological needs are met (rest, love, sex, etc.) and the most intimate and emotionally important social relations played out.

Unrelated men do not enter the households of other families. Private, personal feelings are not publicly discussed. Sex and anything to do with it is taboo.

The most striking structural feature of the household is the division between the sexes. We can classify them by these criteria:

- Relations between men
- Relations between women
- Relations between men and women

very often maintain a flow of daily contact and mutual services throughout life. Seniority among brothers confers authority. They help each other in the harvest and take care of each other's families during absences from the village, stand by each other in sickness, and support each other in fights; serious quarrels between brothers are not common.

Relations between women: In simple households only mothers and daughters are present, but in large joint households, a number of women from diverse origins may live and work together.

Relations between them are not easy to observe.

Mothers and daughters: Women want sons, but this does not mean they do not love their daughters. Girls learn their most important lessons from their mother, helping her in all the household tasks. Marriage is a time of acute grief to the bride's mother. After marriage, a girl still looks to her own mother for help, advice and friendship.

Relationship between sisters: Before their marriage, sisters are as close to each other as brothers. Their relations after marriage depend on the physical distance and social relations between the households into which they marry.

Mother-in-law and daughter-in-law: The most critical relationships among the women within the household are between the incoming strangers. The relationship between a bride and her mother-in-law is far more important for the stability and success

of her marriage than her relationship to her husband. A bride, "the one who comes," is expected to do all in the household. But she is under no formal restrictions or taboos, and many mothers-in-law believe that the bride must be treated as if she were their own daughter.

Brothers' wives: They normally begin married life by sharing the same household. Even when the husband's father is dead, brothers often remain together until they are all married. In this case, each of the younger wives had their own room, and the senior couple used the main living room, which is the best room of the house.

Relationship between men and women:

Husband and wife: The basis of the household is the relationship of a husband and wife for the procreation of children. Marriage is a sharply defined status with a clear-cut ceremonial beginning, and only a married woman is permitted to have sexual relations. Men are mostly unreasonable and selfish; women are quiet and helpless. Women do influence their husbands sometimes in decisions. A man never shows affection for his wife in front of anyone else. Nobody talks about "love," except occasionally in cases of adultery and elopement. The relationship is limited to economic cooperation and to sexual intimacy.

If a wife runs away or dies, her husband normally loses no time in replacing her. A new wife may be installed in no more

than a week. Men will have a reason: "Every household needs efficient women to clean, cook, and care for the small children."

Mother and son: Every woman has to give birth to a son. The new bride's position in the household depends on this. Birth of a baby son makes everyone pleased.

Adult men treat mothers with respect and have an unshakable duty to care for them. The son can give orders to his mother when necessary. Widows are assured of a place in their son's household until death.

A woman and her male affines: Girls are deferential and distant with their husband's father. To her husband's brothers, who may at the beginning be part of the same household, respect is due; and from them, if need be, help is expected.

Father and daughter: Fathers are disappointed in the birth of a daughter, but most fathers are affectionate towards their daughters. A father and daughter are not intimate in the way a father and son can be, because their socially prescribed fields of interest and activity are wide apart.

Brother and sister relationships: When they are children, they play together. Small girls act as nursemaids to the young of both sexes. The sexes tend to separate for play quite young. Boys tend to go with their fathers and girls with their mothers.

SHELTER

As James Marston Fitch points out in his book "American Building," civilization introduces two artificial membranes to man. They are clothing (which lifts the environmental load off the individual) and architecture (which takes the environmental load off both man and his institutions).

Prehistoric man was aware of the necessity of clothing when he was in natural caves. He kept his clothing but he moved out from the cave. Here we are face to face with an answer which shaped the life of human beings for centuries.

Necessary activity for Survival

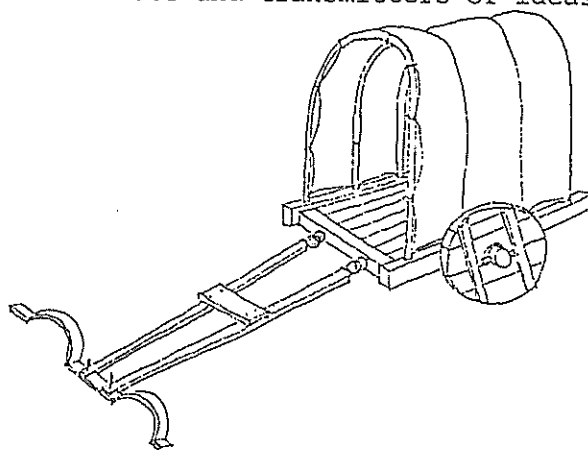
Prehistoric man left the cave because he had to hunt for survival and he had to go where animals go, related to climate, available food, or water. Man first created the idea of "mobility of shelter" and after with his available materials he made the tent.

Because of domestication of hunting animals, man became a nomad. This gave him less movement in his daily activities. This difference in "activity for survival" reflects itself in his shelter (huts, yoruk tents, alacik).

As mentioned earlier, the Turks were nomads. Evidently, we would not expect, nor do we find, complex building techniques among these people, and by the same token, since they were not forest dwellers, they were not involved in the creation of large wooden

structures either in the form of buildings or of mechanical devices. Also, we would not expect the nomads to be responsible for the production of either sophisticated ceramics or of glassware. When we attempt to assess the role of the nomads in the development of other technologies such as metal working or the evolution of the wheeled vehicle, the situation is totally different. Our problem is chiefly to assess whether the nomads were responsible for certain innovations or merely the borrowers and transmitters of ideas.

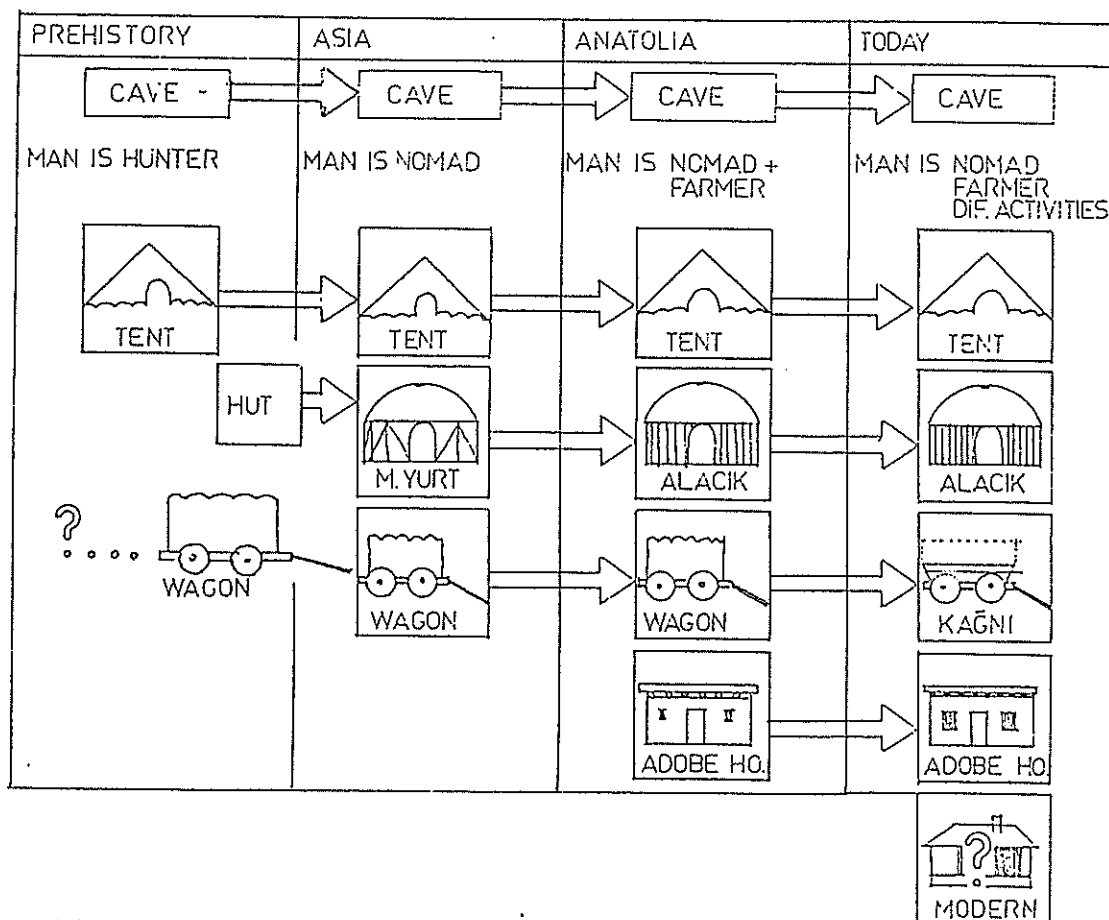
The home of the Asiatic nomad was either the ox-drawn wagon or the tent, both of which were commonly roofed with felt.



Nomad Turks, when they moved to Anatolia, learned how to become farmers. Some stayed as nomads as before. They kept their traditional home concept in plan and materials.

But the ones who became farmers, again because of the "necessary activity for survival," had to settle at the place where they found good soil and water together, and this made them move from tent to stable home.

Development of Turkish Shelter



Turkish Rural Shelter

It is necessary to give a brief account of the Turkish shelter and what it stands for before we proceed to examine them.

Turkish shelter is the type of shelter found where the Turks lived in Asia, in Europe, in Africa and Anatolia. The traditional shelter types and their hundreds of variations have in common a tight dependence on local, cheap materials, a hand technology and a form derived from need for relief from exposure to the forces of the climate.

Turkish rural man has developed several traditional shelter types, each responding to distinct local living patterns. These types could be characterized as:

1. Stretched onto -- The light mobile skin and hair tents of the nomads.
2. Dug into -- Cave and hillside dwellings (prehistoric in origin).
3. Built up -- Dwellings built of earth with various materials.

Traditional Shelter Types

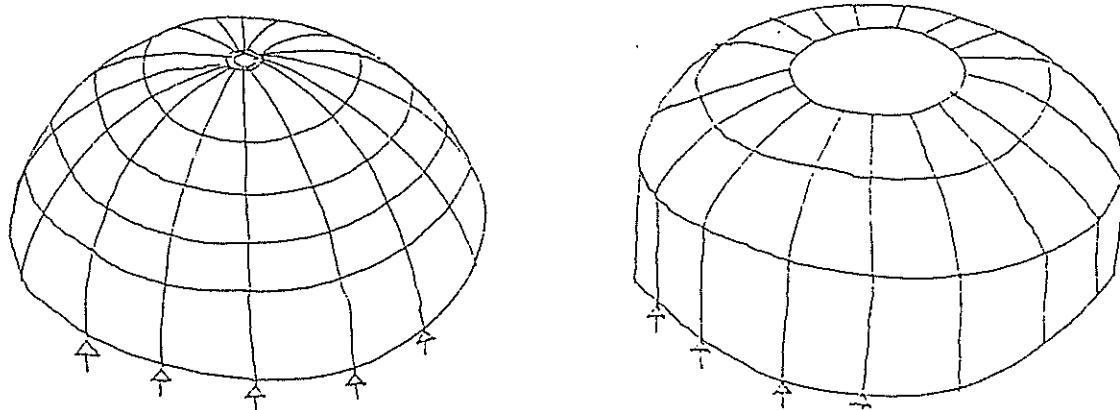
1. Stretched onto - tents: The reason Turkish nomadic shepherds kept tents as a shelter over thousands of years is:
 - to meet harsh environmental conditions with minimal resources;
 - the need to move frequently from one place to another.

Related to their construction materials, tent types could be characterized as:

- skin tents;
- hair tents.

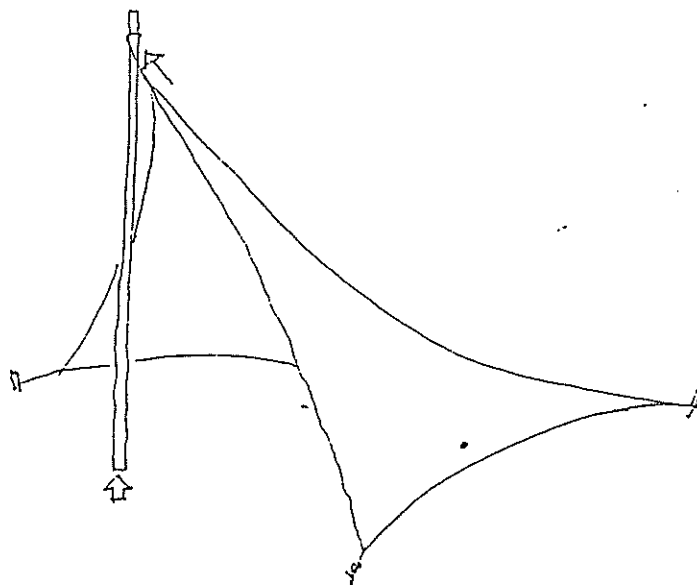
There are advantages and disadvantages in those two types. During the very hot season skin tents are the most unpleasant ones. But they are normally erected quicker than hair tents, and they protect efficiently against rain. Because of climatic reasons, skin and hair tents are used by Turkish nomads only in specific regions where climate fits the needs of skin or hair tents.

Related to their construction systems, skin and hair tents also show big differences. One is "domical shell construction" (skin tents), and the other "tension construction" (hair tents). In skin tents, the system is an element in which there is no bending, and the principal tensions and compressions are distributed continuously over the wooden skeleton.

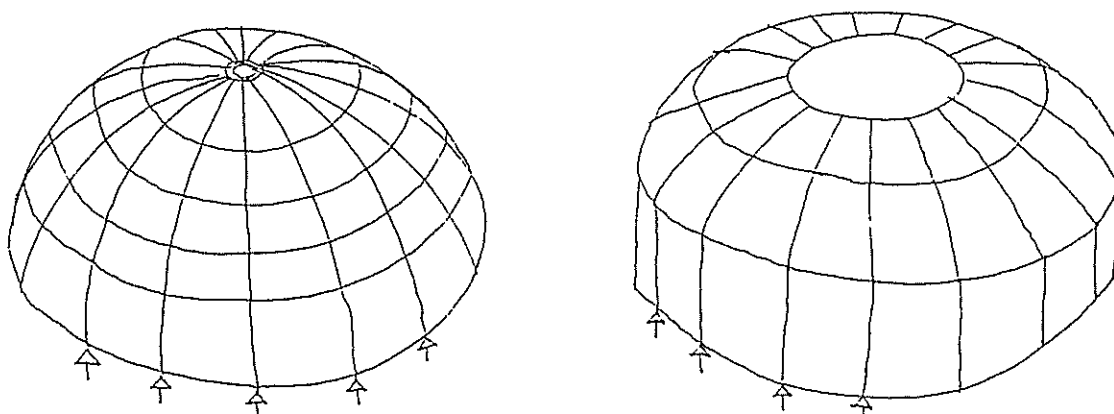


In hair tents, the system can work as separate elements.

Bending is the main characteristic of the surface, and all bending principal and compression tensions distributed over the ropes and poles. The main structure is roof. Together with poles and ropes it acts as a kind of space-frame structure.

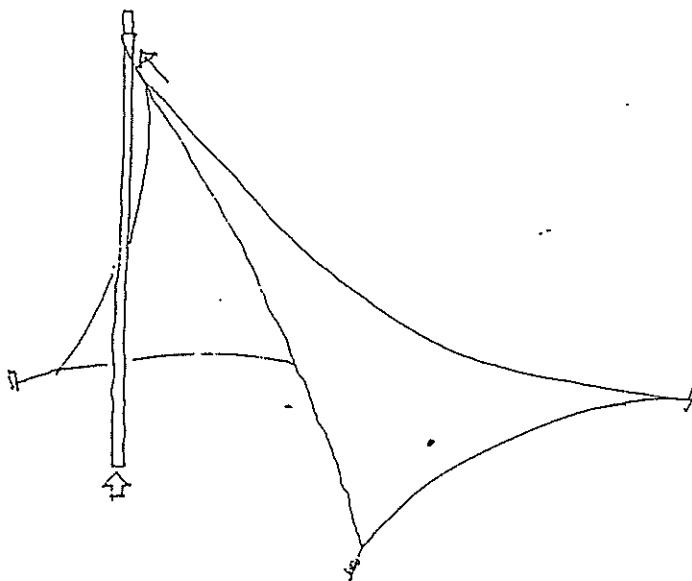


Related to their construction systems, skin and hair tents also show big differences. One is "domical shell construction" (skin tents), and the other "tension construction" (hair tents). In skin tents the system is an element in which there is no bending, and the principal tensions and compressions are distributed continuously over the wooden skeleton.

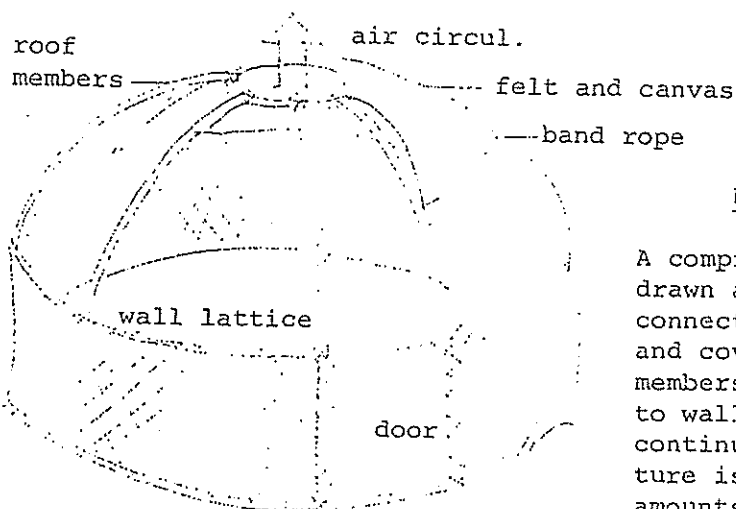


In hair tents, the system can work as separate elements.

Bending is the main characteristic of the surface, and all bending principal and compression tensions distributed over the ropes and poles. The main structure is roof. Together with poles and ropes it acts as a kind of space-frame structure.



There is a great similarity between the "Mongol Yurt" and the Turkish skin tents, which are called "alacik."

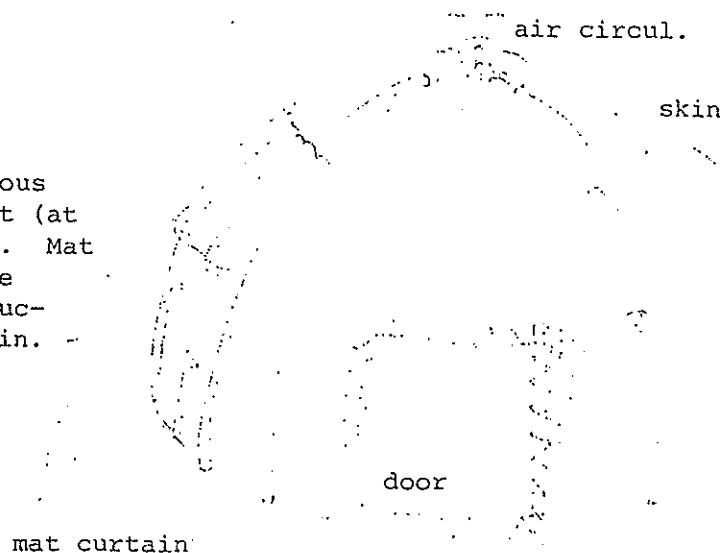


Mongol Yurt

A compressive band rope is drawn around the yurt to make connection between structure and cover materials. Roof members are tied or bolted to wall lattice and they don't continue to ground. All structure is covered with various amounts of felt and canvas depending upon the climate.

Alacik

Roof members continuous from connection point (at the top) till ground. Mat curtain tied on these members, and all structure covered with skin.



The basic elements of the Mongol yurt are the expanding wall lattice, roof structure members, felt and canvas. In the alacik, the basic elements are the mat curtain, domical shell structure members, and animal skin.

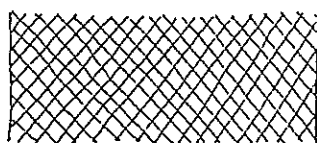
By function, the biggest difference between basic elements is the difference between expanding wall lattice and mat curtain. In expanding wall lattice, strips of wood are fastened together at intervals such that they can be expanded to form a larger wall section. Several of these sections are expanded and tied together with a door frame to form a circular wall.

Wall lattice in Mongol Yurt

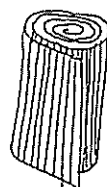
Mat curtain in Alacik



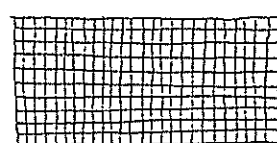
closed



open



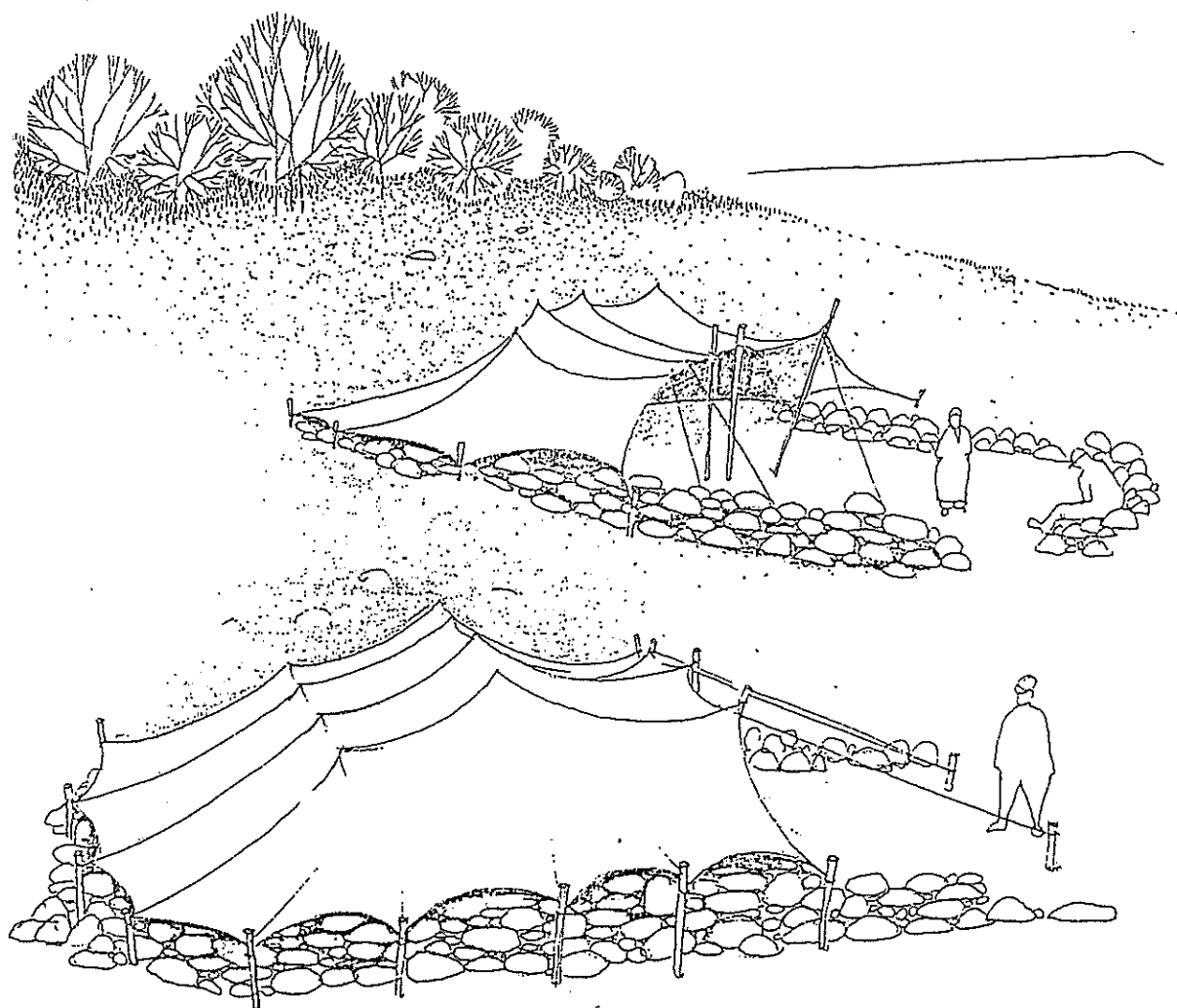
closed



open

Functions

- | | |
|------------------------------|--------------------------|
| 1. lightness and compactness | 1. same (transportation) |
| 2. Air circulation | 2. same |
| 3. Structural elements | 3. non-structural. |



Hair Tents

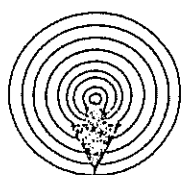
2. Dug into -- caves:

Caves, first shelters of prehistoric man, still answer the needs of many Turkish families in Cappadocia. These man-made caverns are carved from the eroded rock of the pinnacles to make houses, farms, stables or churches.

Soft rock is called "tuff." It is made of volcanic ash and mud, compacted into a sandy rock. Erosion by water and wind in the broad valley gradually carved away much of the tuff, leaving the peculiar caves. The rock is easy to carve, but when the new surfaces are exposed to air, they harden. This allows the house sculptors to work the material into durable homes that are literally a part of the landscape itself.

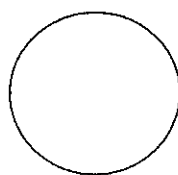
There are separate houses, villages or cities all under ground. The villages are mostly hillside rock-cut settlements or dwellings hewn into caves, with stone walls added where required. The cave dwellings are mostly communal. The construction technique used was excavation, and the process of carving into rocks and into the turf is irreversible. This type of construction has something similar to the natural growth of the cells. Natural growth is a slow development from the parent cell to its final size and form. All man-made forms remain natural forms. They show some principal differences mostly on their scale and function. Man-made forms began to take shape from final scale and its fast development. Natural growth is the opposite. It is the continuous development of an organism that is complete and individual from the start.

Construction is a discontinuous process of putting together in which, at any stage, the form is incomplete. The only man-made structural forms on the scale with which we are concerned here that are not so constructed are those cut from solid rock.



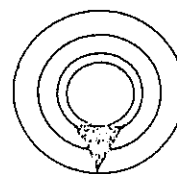
Natural Growth

Continuous development



Regular man-made Construction

Beginning from final scale



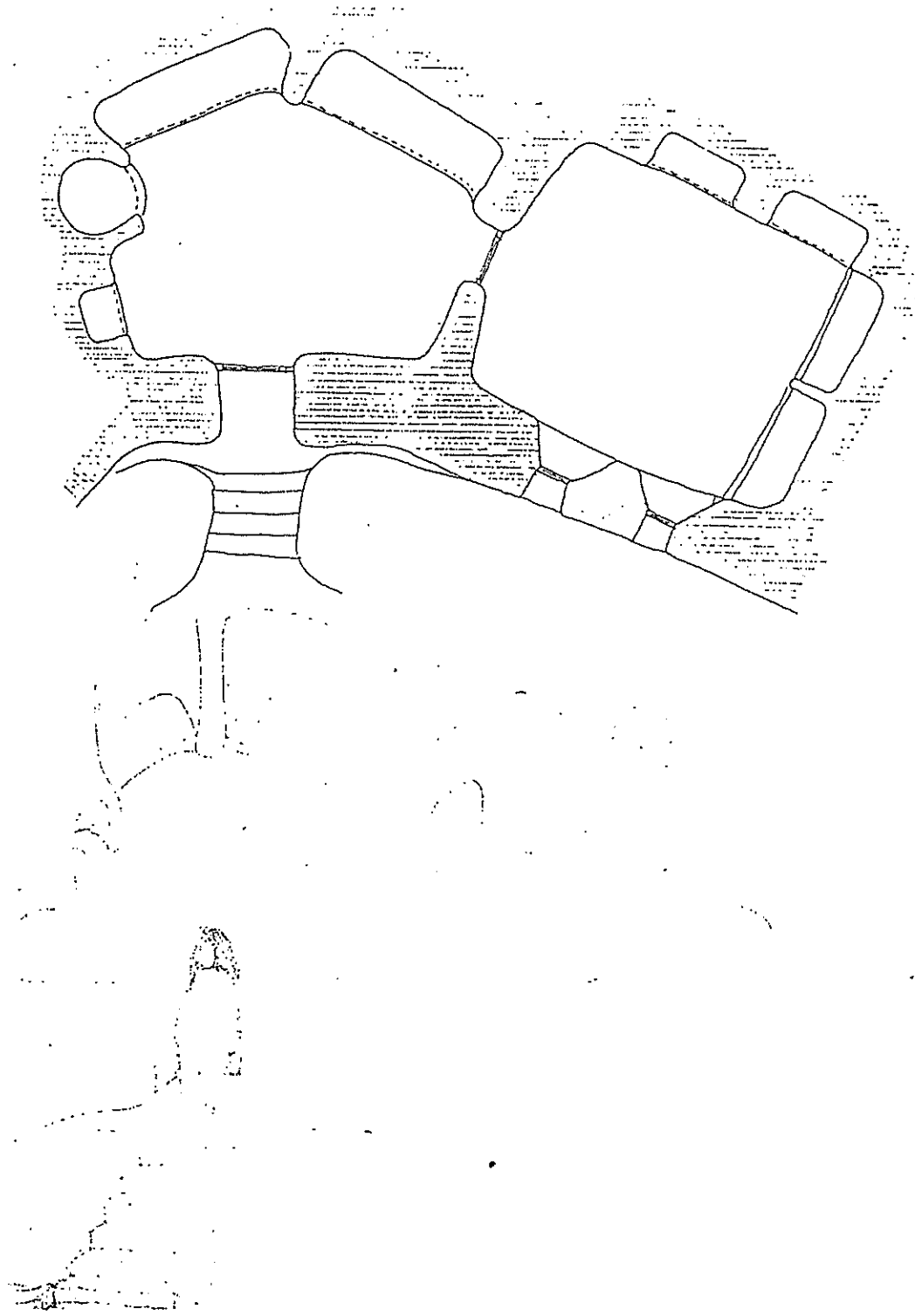
Cave Construction

Similar to natural growth

The construction process is an antithesis of the conventional building constructions by forming an outer shell which then ensures permanency and in time turns out to be the main element of constraint against flexibility and change. In the case of caves and underground structures, the nature of the constraints introduced by the construction process is different from the conventional in that digging provides complete freedom for individual expression and flexibility.

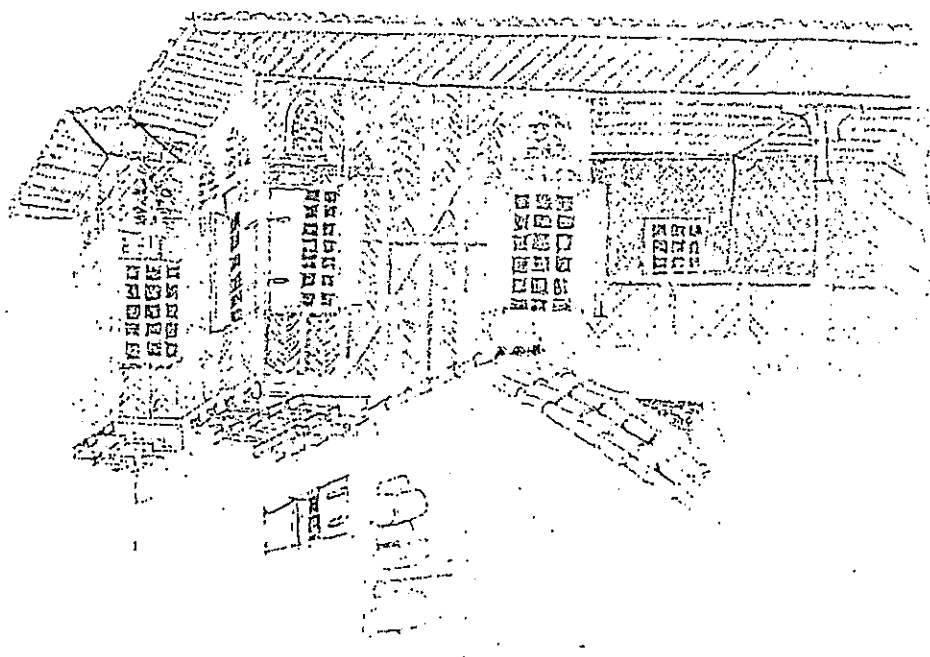
The rooms show a wide variety of shape and size. Some of these are hollowed out of the walls, niches serve as cupboards, cavities in the ground in which jars would be set. Today's village man who lives in a cave feels more comfortable in his dwelling than the one outside. Here we have again the same reason, "the micro-climate."

"The micro-climate of Cappadocia is stable throughout the year with very little variation in temperature which is an ingenious adaptation to the climatic conditions. Therefore, it is not surprising to find 41 underground cities in the same area." Urban-1973



3. Built-up:

The Turkish house originated in Anatolia, then spread to Europe, developing new characteristics and absorbing some foreign traits. It was not until the 20th century that the Turkish house began to retrogress, at first slowly and then at an ever increasing speed until it died out altogether.



The buildings that are taking their places have no relation to the former idea of a "Turkish house" today. They are direct copies of western architecture which have nothing to do with Turkish culture, Turkish technology and construction materials, Turkish social life and the climate of the country.

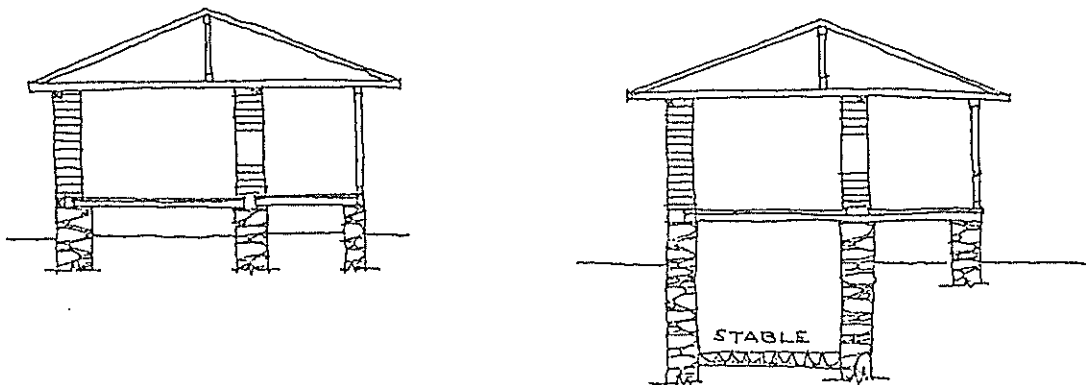
On the other hand, the Turkish house is still in existence in the rural part of the country. The reason lies in the difference between village and city man.

Village man is always conservative, but he does not know it. The old ways are familiar and safe. The new ways can be better, but they frighten him until he gets used to them. During the last century he was against the machine. Some did not like it because it was Christian-made; some did not like it because it was the enemy of apathy. It was also the enemy of household industries; encouraging daydreams. They were like all new things, disturbing their dreams. They made people ambitious, swift moving, avaricious. But these ideas changed rapidly, and today they are also turning to being slaves of fatalism.

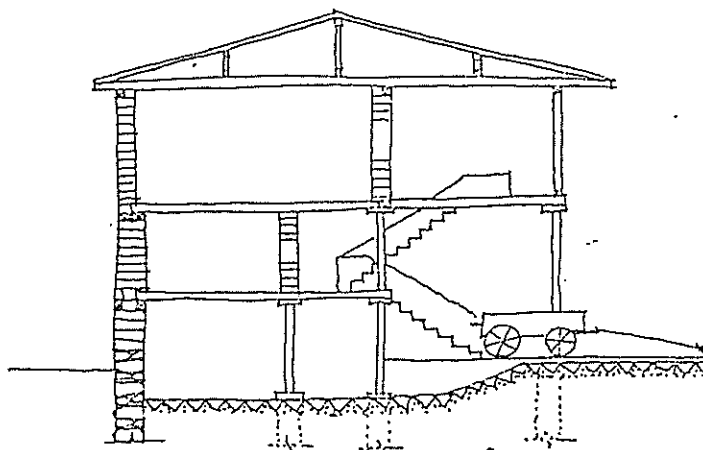
Because of his conservative ideas and the difficult life, village man kept the old Turkish house, while in cities the European influence on architecture was introduced and copied under the idea of "modernization."

The chief factor of unity and conformity in the different types of the Turkish house is their plan. It also reflects the

social and economic standing of the house. When studying the plan of a house, we must know which floor or level this plan reflects; in the case of the Turkish rural house, there is no such question. It is usually a one-story house. In the house which has more than one floor, the main living and reception floor is always on the highest level. Even when the building consists only of this one floor, it is raised above the ground to be insulated against humidity.



Sometimes there is a suspended floor placed above this court-like enclosure. This floor is generally smaller in size than the top story and does not extend above the whole of the plan. It is used as winter quarters and storage.



The ground floor is used for the accommodation of animals, ranging from cattle and beasts to sheep and goats. The first level is for storage of grain and fruit and also the winter room. The second (top) level is the main living floor.

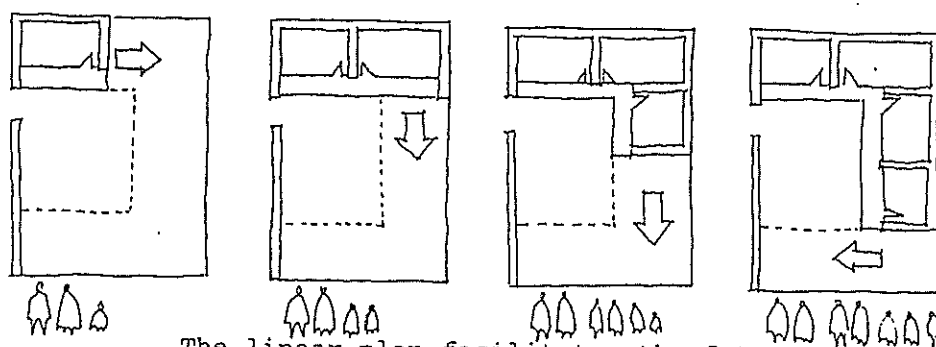
Before we examine the different types of plans and their subsequent development, we have to consider how the separate parts of the house determine the shape of its plan. The rooms and the halls are the most important of these parts. Other parts of the house such as staircases and spaces which are connected with domestic purposes need not be mentioned here, as they have little importance upon the plan of village house.

→ The Rooms (Oda)

Due to their number and shapes, the rooms are the most important of the factors influencing the plan. As a matter of fact, the Turkish room in itself is the equivalent of a house. It is used to sit, to eat and to sleep; and in some examples, to cook and to take a bath. For each of these various activities, the room is provided with cupboards, closets, built-in wardrobes, side boards and built-in bathrooms.

In Turkish houses there are no doors between the rooms, while every room has only one door. In this way rooms enjoy a privacy of their own as separate units in the plan. This characteristic of Turkish rooms, which prevents them from being used as passages, distinguishes them more than any other factor from the type of rooms of western Europe.

Since a few people could be lodged in one room, the addition of more rooms only meant at first that the members of the household had increased. Sooner or later, however, in houses of any importance, a room came into use which was intended as a reception room only. It is known under the various names of the reception or the guest room.



The linear plan facilitates the future expansion that will take place in the house.

The rooms were assigned certain definite places on the plan which never varied. Some rooms were valued more highly than others on account of their situation. Corner rooms, for instance, are more appreciated than rooms in a row, and they show their importance with their furniture as well as decoration.

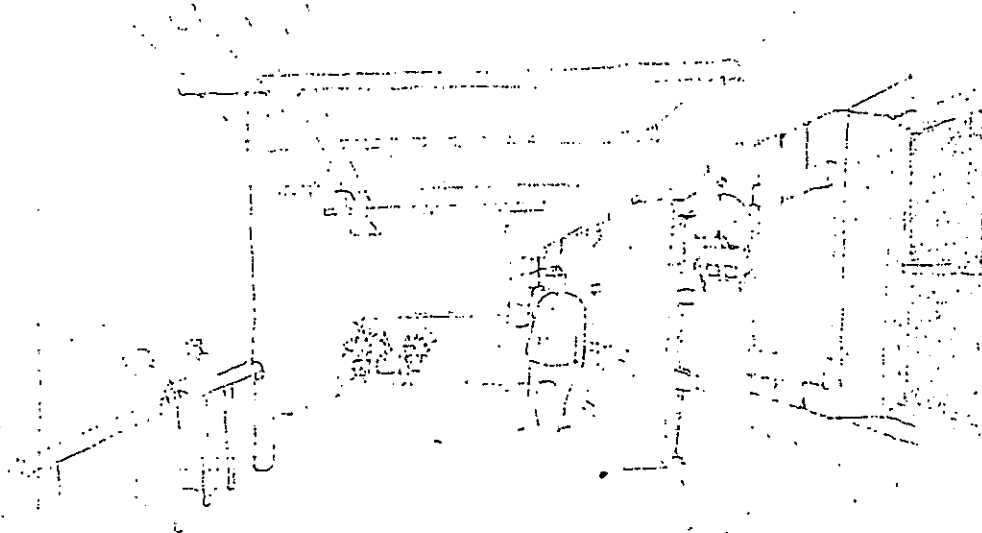
The Halls

Turkish houses differ most greatly from their western European counterparts by the fact that every room opens into the hall, and the hall is the means of access to the whole house. This difference is of great advantage to the Turkish house in that it makes it far more convenient to use.

In view of the space it occupies and the important part it plays in the plan, the hall is the most influential factor in the composition of this plan. The type of house is determined directly by the shape and location of the hall.

In village architecture, originally the hall was an open passage, a pavement, connecting the rooms with one another through their doors. As well as being a passage, the hall is also the place where the whole household assembles and where weddings and feasts are held. The secluded parts of the hall, which are free from circulation, are used for sitting.

These parts were separated from the hall either in the form of a recess ("eyvan") or in the form of a projection or divan, added to the front of the hall. The eyvan is a more protected place for sitting, and some halls are provided with more than one of them. The divans or raised platforms (Sekilik, Taht) on the other hand are open on two or three sides and are usually built to face a view. They are a few steps higher in level than the hall and are sometimes supported on consoles.



Basic Plans of the Turkish House

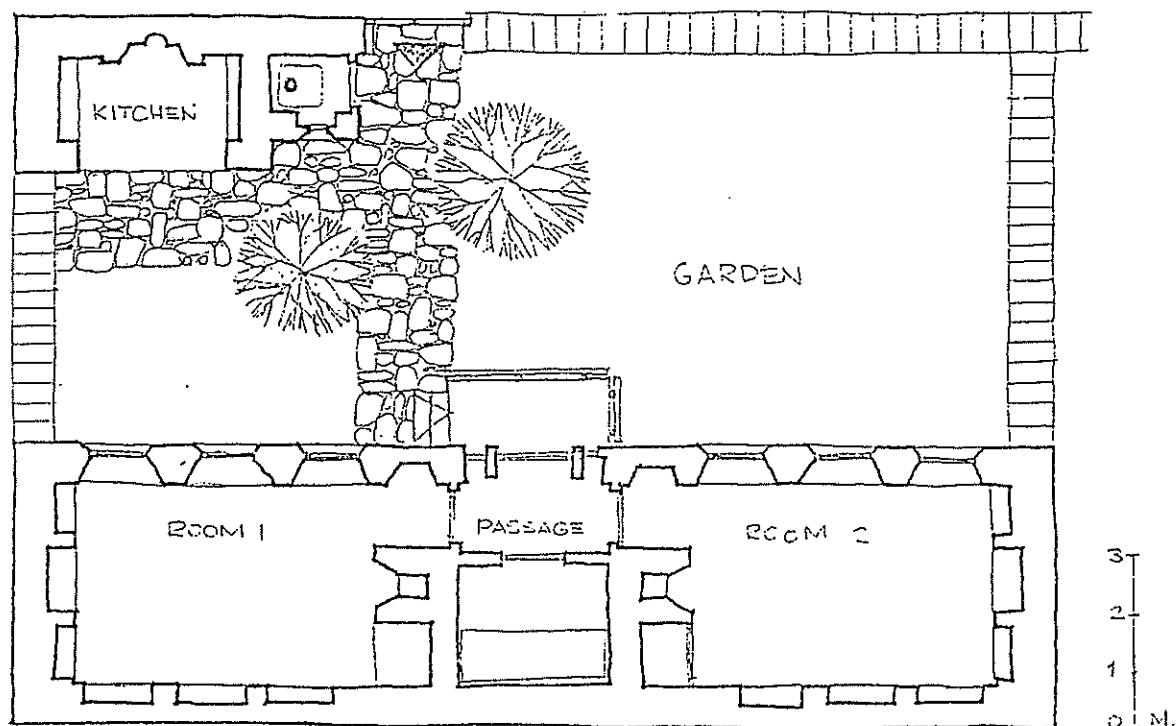
In the Turkish house, hall and rooms determine the plan. By their stage and position, the hall and the rooms are mutually related to each other. As the type of the plan is best expressed by the position of the hall, it is in reference to that position that we shall make our classification. This gives us four basic types of houses:

1. Without a hall
2. With an outer hall
3. With an inner hall
4. With a central hall

This classification includes most of the types of village houses. The four standard types have not in the course of time always been reproduced with exact fidelity. The position of land, the inappropriateness of the design to the terrain, and the individual character of the execution are all among the reasons why the original model was not closely followed and why composite plans arose instead.

1. House plan without a hall: This is the most primitive state of house plan and consists merely of one room or more placed in a row. There is a passage of communication in front of the rooms in the shape of a pavement or courtyard. When the rooms are above ground level, this passage takes the form of a balcony. This type of house was better adapted to the southern provinces where

the climate is hot. In colder regions, this open passage presented too many disadvantages and had to be covered.

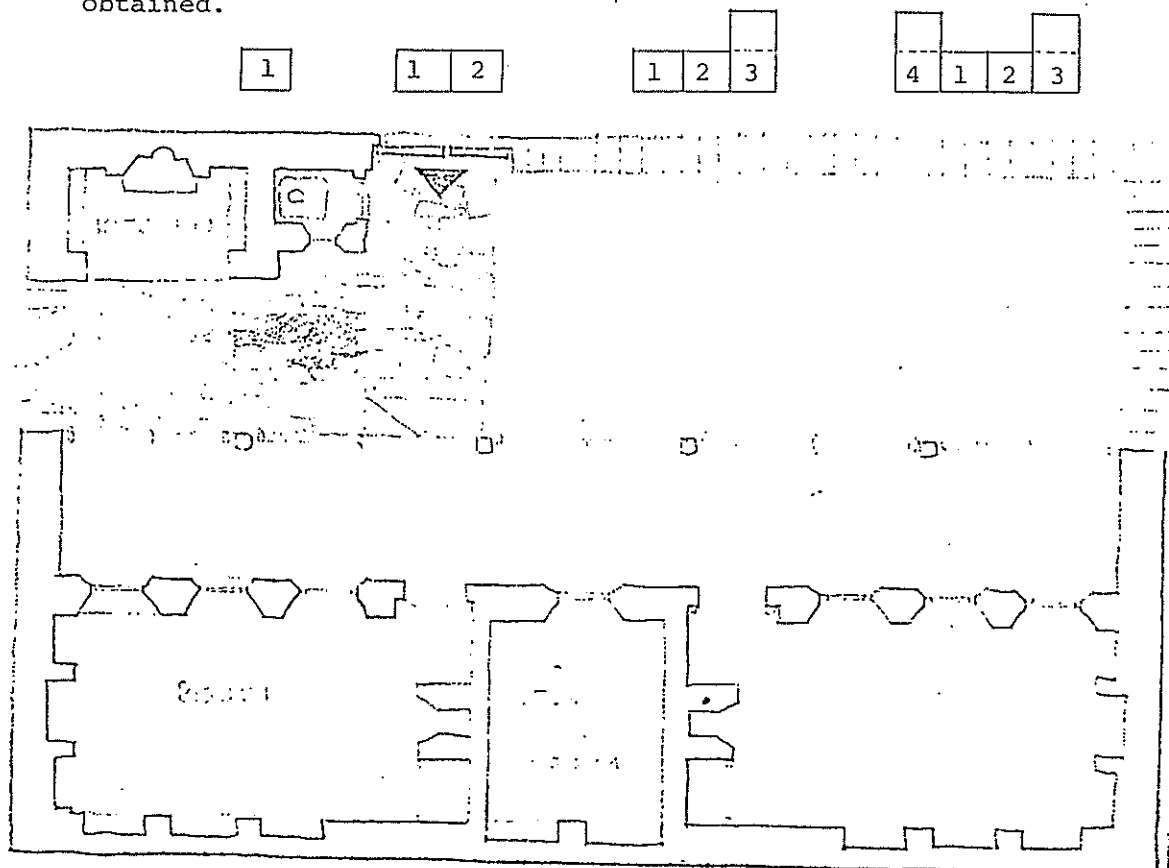


2. House plan with an outer hall: This type constitutes the first stage in the development of the plan. A covered hall connects the suite of rooms with one another. This form of plan was used in Anatolia before the arrival of the Turks. The Turks developed this plan in accordance with their own needs.

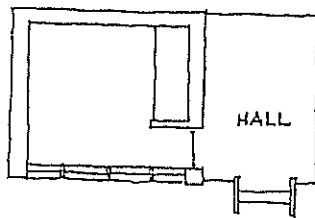
The hall at first was an open place with pillars instead of walls, only the top of which was covered. This open hall is still in use today. It is used as a covered gallery ("hayat") in places where the climate is sufficiently warm. With the improvement of standards of living, the need for more comfort in the

house made itself felt. The open hall, which was inconvenient for colder climates, was enclosed by means of glass panels placed between the pillars. After the 19th century, the glass panels of the hall were replaced by regular windows which were only of a bigger size than those of room windows.

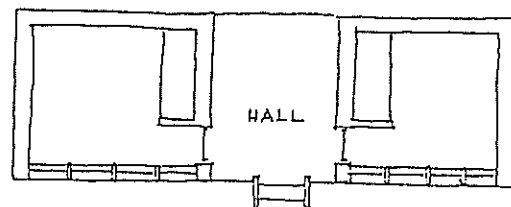
The plan of these houses consists of a hall and a suite of rooms opening into the hall. The growing dimensions of the plan brought about the addition of wings. At the beginning, these wings consisted of projecting pavilions used as rooms; then side halls were added in front of these rooms; and as rows of rooms developed along these halls, the sections so formed became wings in the accepted sense. According to whether the plan was made with one or two wings, it was  or  shaped, and the maximum size and width possible to this type of plan had been obtained.



3. House plan with an inner hall: This type, which represents the next stage in the development of the village house plan, is the one which is most widespread in Turkey. This plan was developed by the addition of another row of rooms onto the other side of the hall.

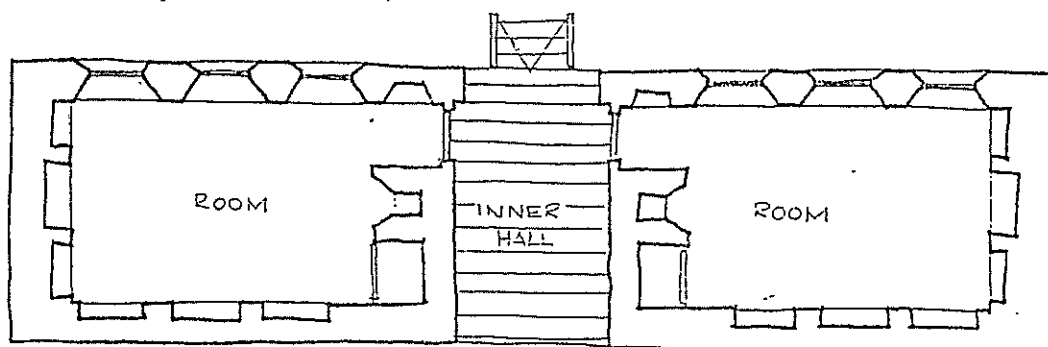


(1)



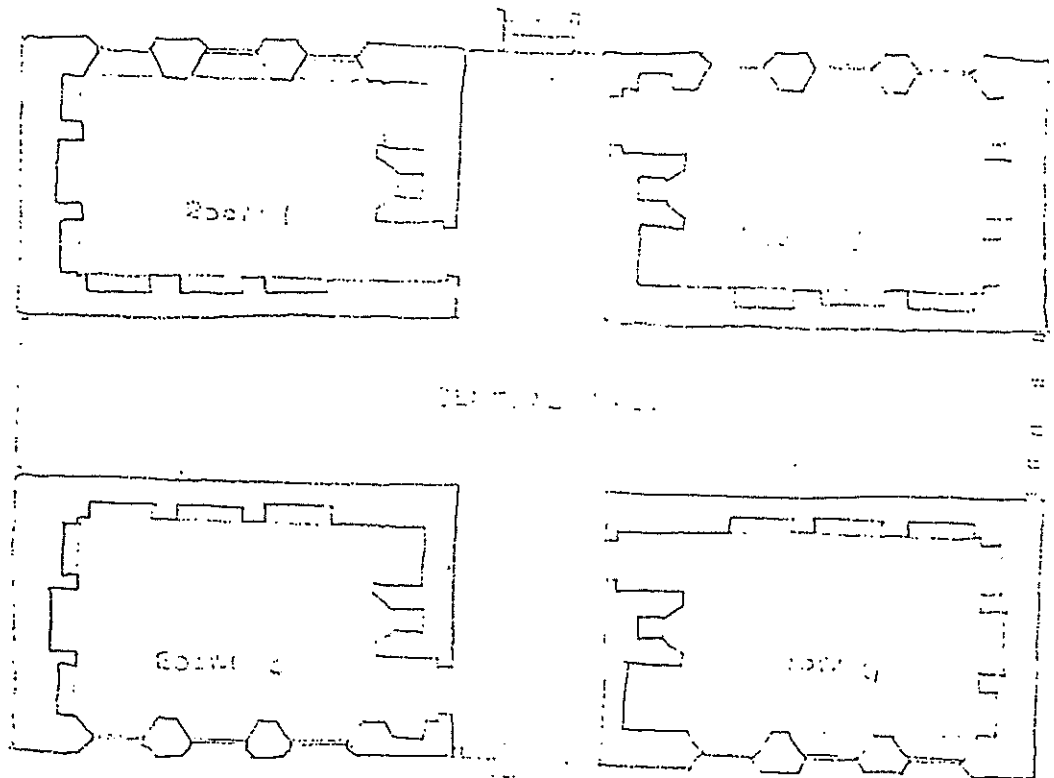
(2)

The reasons for the preference of the inner hall type are mostly of an economic and hygienic order. The fact is that there is a gain in hall space as well as economy of outer walls when the rooms are placed on both sides of the hall. In addition, the hall becomes more sheltered and communication between the rooms is easier and in complete privacy.



3
2
1
0 M

4. House plan with a central hall: The hall in this plan is situated in the middle of the house and is surrounded on four sides by rows of rooms. The fact that in this type of plan the hall was least exposed to the influence of weather and that the design was concentrated and rooms closer to one another, made it very popular in towns more than in villages.



TURKISH VERNACULAR ARCHITECTURE
AND ENVIRONMENTAL INFLUENCES

Introduction

Insufficiency and expensiveness of energy appears to be one of the common problems of the world aside from poverty, peace, housing shortages, etc. Since it is the most recent issue which every individual faces, this shortage has urged nations to handle it cooperatively. Besides that, every country is trying to develop new forms of energy and related policies in order to overcome this long-range difficulty. From developed to less developed countries, the flow of information and technology related to this problem will be accelerated to handle the issue on a global scale. With the thrust of urgency on it, researchers are trying to increase the body of knowledge in the field of new forms of energy.

However, due to some specific economic, technological and cultural differences, the very same issue will be handled in different ways within the limits of available knowledge. Developed countries tend to use every possible advanced technology and money resource, whereas less developed countries will go back to domestic resources and try to adapt new techniques as low-cost as possible. For example, nuclear power stations are more likely to be used in the United States than in Turkey, since nuclear power plant technology is most developed in the U. S. By

following the same reasoning, it is possible to give many examples displaying the specific energy problems of each country in the world. Nevertheless, the energy scene will be roughly the same when it emerges from the exponential increase in change in almost every aspect of man's life today.

Among all countries, the less developed have faced the problem from a different point of view. The energy crisis caught these countries in the middle or beginning of the process of industrialization. The beginners and precursors will try to develop new policies and programs for the use of new types of energy while they are trying to use fossil base fuels only where it is badly needed, and will gradually drive it out from newly developing sectors.

Turkey is one of the countries which was caught in the middle of industrialization. Her energy sources have limited capacities, and most of the available source is consumed in production, i.e. industry. Following are some figures from Turkey's last five-year plan:

Energy source type	Production	Imports	Exports
Petroleum	3,500,000	7,000,000	--
Coal	11,306,000	--	--
Electricity	3,397	--	--
Wood	12,800,000 T.	--	--
Dry dung	14,826,000 T.	--	--

In the preceding table, the import, production rate of several fuels are given as a reference in order to display the energy situation in Turkey. The industry, which is concentrated around the main transportation lines, settled mainly in metropolitan areas and became more dependent on petroleum; coal will be the primary consideration for fuel consumption. In other words, today's and tomorrow's industry of Turkey will be the attraction points for imported fuel, i.e. petroleum. Coal, with its serious setbacks in the quality of the environment, is likely to be the main fuel for the urban, domestic and industrial sector. Today, however, the use of coal is facing serious criticism, partly because of its negative qualities on the environment, and partly because it is and will be badly needed by industry. So far, coal is and will be produced for cities and industry in spite of the fact that a considerable amount of increase is planned in the production.

The two possible fuels for rural areas for today's and the near future's Turkey are wood, which is available for forest villages, and dry dung. The dry dung is the main fuel for most rural regions. It is domestically used for heating and cooking in village houses. However, this matter has a very low heating quality and is far from meeting the energy requirements of a Turkish village house. Besides that, its high quality as a fertilizer causes the authorities to consider it from an

agricultural point of view because the production rate of fertilizers is far from meeting the domestic demand.

Rapid industrialization began affecting life both in cities as well as in villages. New households and energy-consuming appliances are becoming the likely elements of everyday life. We can say that in the near future, a more energy demanding population will emerge for their basic needs from rural areas. It is also an inevitable fact that a considerable part of fossil base fuels is consumed by agriculture, i.e. villagers. For domestic needs, the possibility of implementing new forms of energy is strongly needed.

Among the candidates for energy conservation, solar energy with its passive applications seems to be the best suitable type. Not only does it not take highly sophisticated technology and skill, but it also helps to improve the thermal qualities of a building.

I believe that a large scale implementation of such a program will result in new environment-conscious approaches and many other solutions to the problems of Turkey.

Environment and Man

Environment affects man at every level of his existence, metabolically and perceptually. Cultures of the past (and even at present in some rural societies) are much more aware of the environmental influences, and therefore, they try to live with them

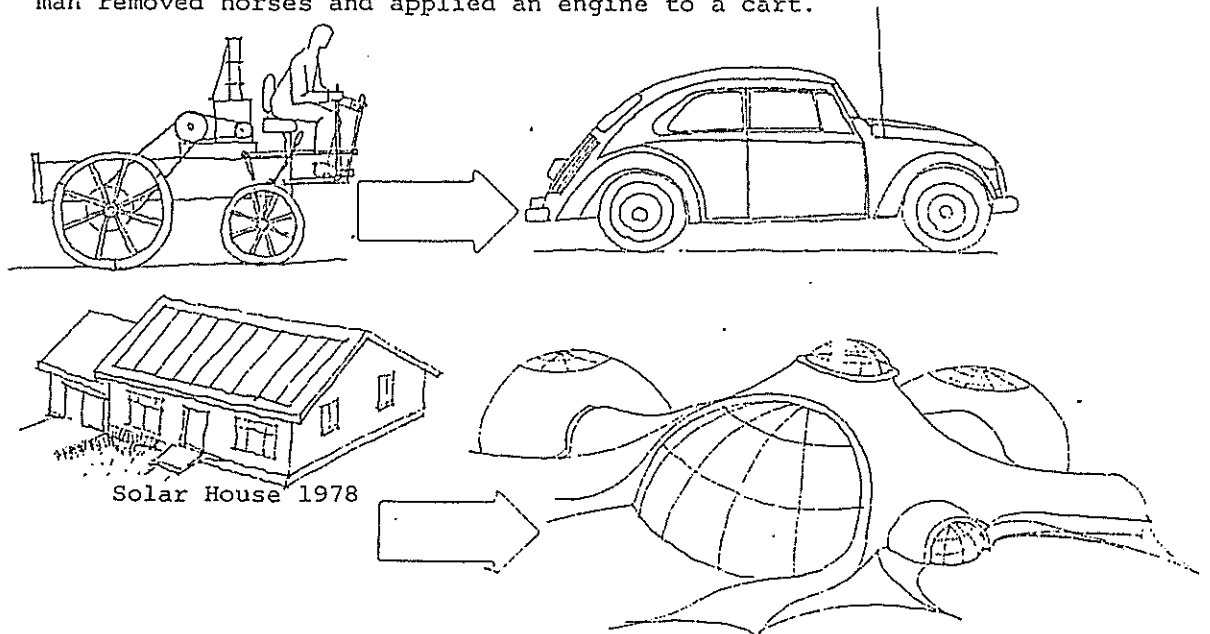
in closer harmony. Despite all the technological means of environmental control, modern age man has often built habitats that are inferior (in response to environmental influences) to the so-called primitive state. Machine age is the turning point of man and environmental relations. The value of machinery is time and movement in time. In the 19th century, to be out of date was to lack value. The machine was destroying every other source of value, partly because it was by its nature the most progressive element in the new economy. Architects were free to use their imaginations within the limits of utility of machinery. From machines themselves, architects have learned the value of simplicity, the concept of beauty, in natural qualities of materials. Modern industrial technology produced a revolution in architecture. The machine made opportunities allow architects:

- to make openings of any size;
- to use lighter materials;
- to connect interior with exterior space;
- new flexibility in planning;
- flat roofs;
- transparency in buildings.

An individual who has some knowledge of our energy problems in building today will recognize that these machine-made opportunities are our main problems which we are trying to solve by being less dependent on machinery.

From past experience, we learned that it does not matter how simple the architectural design of building is. It is always a complex task that must combine many diverse elements. What is becoming more apparent is the fact that (in terms of relevant future design) our buildings should change. Architects should be aware that each environmental force will influence our buildings. Rural parts of the world where transportation of energy is difficult will use largely solar applications.

Today's early examples of solar buildings are only the application of solar collectors to the contemporary buildings. Architects are not aware that, in addition to the basic ingredients of light and heat, building form, envelope, orientation, radiation control, mechanical systems and landscape should be changed. Development of cars has great similarity to our problem. In man's mind car shape was very similar to a cart. Because of that, man removed horses and applied an engine to a cart.



Environmental Forces

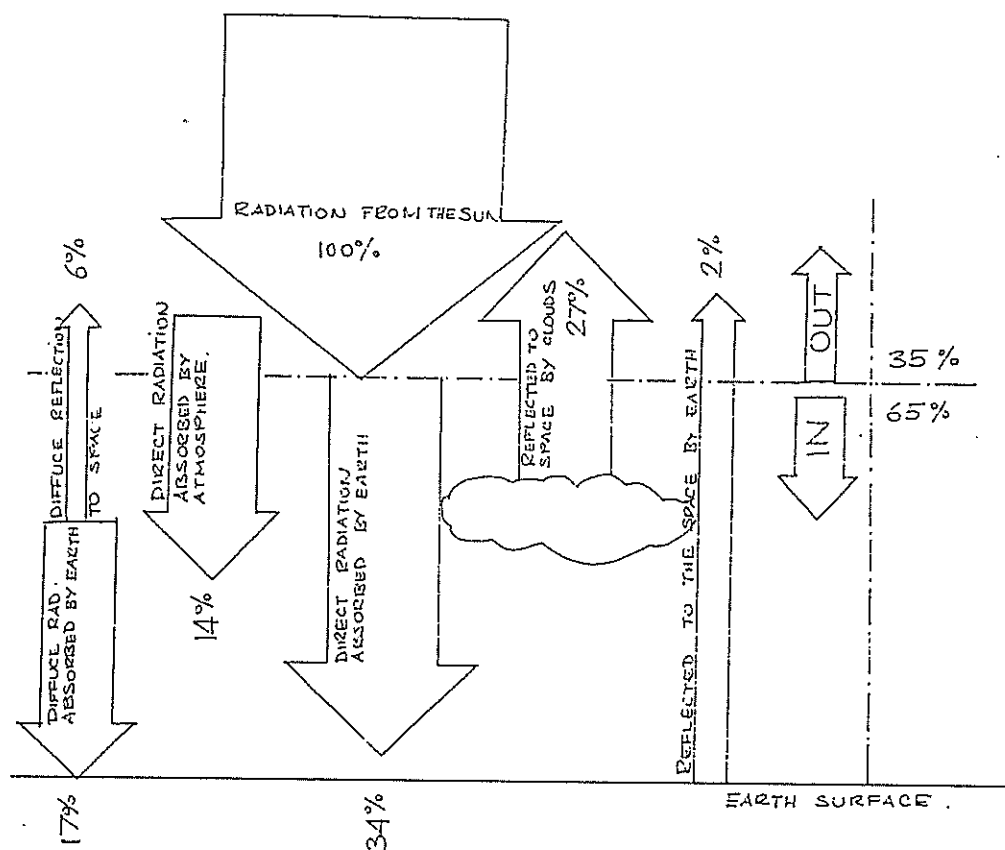
Many forces are responsible for environmental forces on the surface of earth and its atmosphere. Before studying environmental influences in relation to buildings, these necessary points should be known to those interested in energy conservation and solar house design.

Solar Energy

Directly or indirectly, all the heat energy contained within the atmosphere is derived from the sun. This energy (solar) moves through space in the form of "radiant energy." The solar energy that is received at the surface of the earth is termed "insolation." Measurements of solar radiation are made in terms of an arbitrary unit termed the "solar constant."

The whole scheme of the action of the atmosphere is simple. Incident radiation is partially reflected, diffused and absorbed by the atmosphere. The proportions of these phenomena vary according to the length of the ray considered, to the climate, and to the distance made in the atmosphere. This distance varies according to the height of the sun. The transparency of the atmosphere in comparison to the direct radiation is very much influenced by water (vapor or clouds and other various particles).

We can say that the proportion of radiation diffused grows very rapidly with the amount of particles until radiation on the ground is diffused when the sky is uniformly covered.



The radiation that is lost in outer space by direct reflection or scattering is known as the "albedo" of the earth. Its value varies from about 30 to 40 percent of the incoming solar radiation, depending on the amount and type of cloud cover and the quantity of dust and other particles (plant pollen, oil, sea salt) in the air.

Atmosphere is heated in two ways: through the absorption of radiant energy, and direct transfer of heat. The atmosphere

absorbs mainly the long wavelengths. But incoming solar radiation is made up mainly of short-wave radiation. For this reason, the atmosphere absorbs only 14 percent of incoming radiation. Most of this absorption occurs $1\frac{1}{2}$ miles in the lower atmosphere, where the air is dense and contains appreciable quantities of water, vapor, and carbon dioxide.

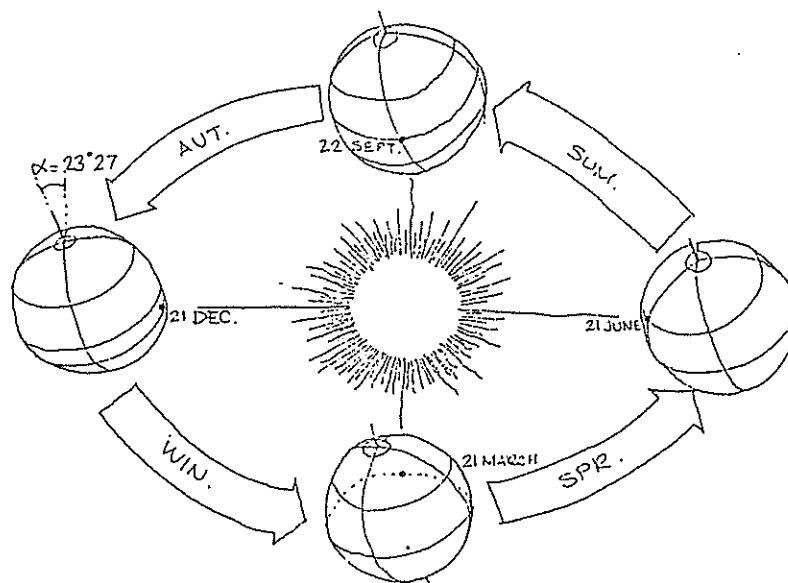
Once the earth is heated by radiation, it becomes a radiating body. Since the atmosphere can absorb a maximum of about 90 percent of the terrestrial radiation, it derives more heat through radiation from the earth than directly from the sun. This has been known as the "greenhouse effect." In the greenhouse effect, atmospheric differences play an important role in the absorption of terrestrial radiation as well as solar radiation.

Since the surface of the earth can heat to a higher temperature than the atmosphere, air in contact with these surfaces will be heated by conduction. The influence of conduction heat transfer would be restricted to a very thin layer of atmosphere next to the surface of the earth. In general, conduction adds heat to the atmosphere during the daylight hours and summer, and it subtracts heat from the atmosphere during nights and winter.

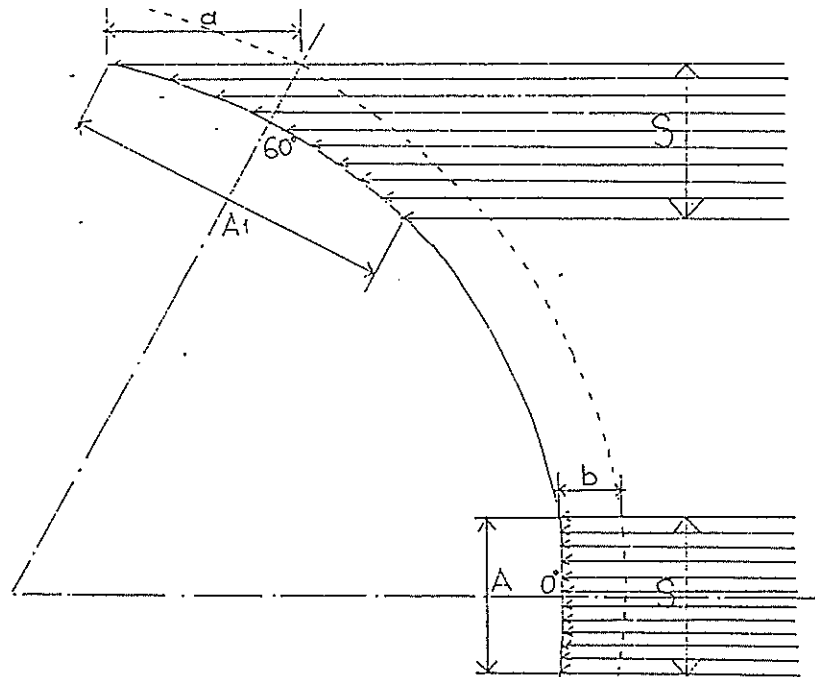
Distance of the Earth from the Sun and Directness of Solar Radiation

Earth in its orbit around the sun shows differences in distance from the sun. The maximum difference in distance

amounts to about three million miles. Many of us still believe that the time when we are closer to the sun is summer, and when we are farther away from the sun it is winter. It must be made clear here that the earth is nearest the sun in January and farthest from it in July. The reason is because we do not receive convective heat from the sun, but rather, radiation. Summers and winters are more related to the angle of radiation received from the sun.



Directness of the sun's radiation is the most important reason for seasonal temperature changes. It relates to the tilting of the earth's axis and its parallelism within the earth's orbit. Direct radiation is concentrated over a smaller surface area than oblique radiation and is therefore more intense per unit of area. (See following diagram, A and A_1 .)



An accompanying factor is the lesser thickness of the atmosphere through which the sun's radiation passes when it is more direct; this makes it possible for a greater amount to be transmitted through to the earth's surface. (See diagram, a and b.)

Sun Path Diagrams

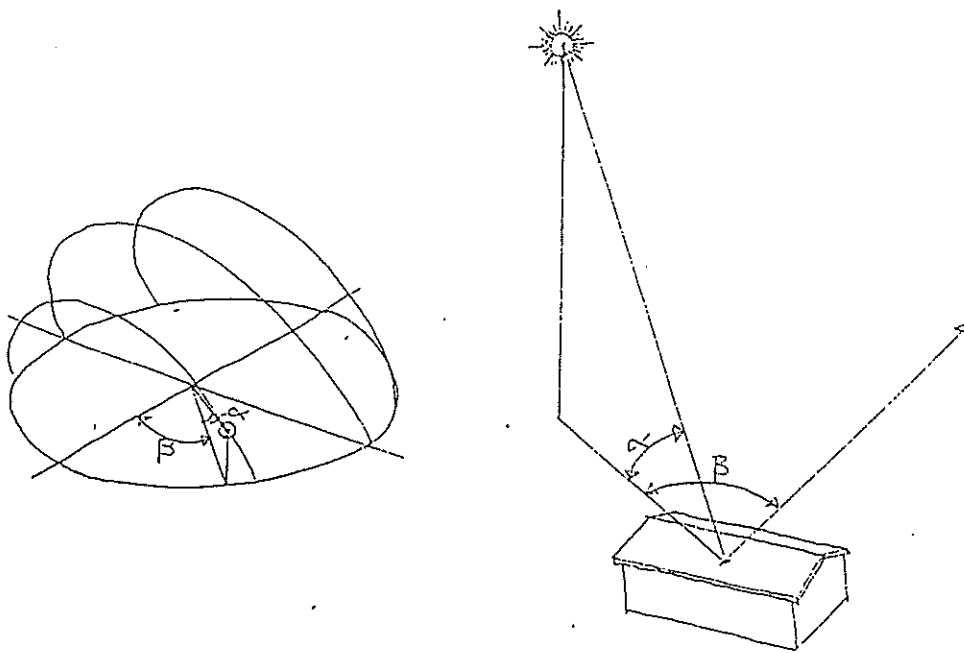
Today's modern architecture is not correctly answering the need of 20th century people. Relation between building and natural environment is decreasing. Since the sun is the coordinator of nature, our future buildings, which are part of the natural environment, should be greatly influenced by the sun. The sun's position should affect architects' decisions. These positions showing the greatest differences throughout the year can be determined by various methods. The most common

methods are "calculative methods" and "graphic projection."

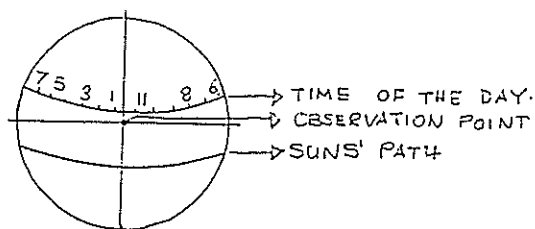
The graphic projection method will be demonstrated because it is easier to understand.

Sun path diagrams are the graphic projection of the sun at different times of the year from different latitudes. The position of the sun should be expressed using the values of two angles:

1. Solar altitude (α): Measured up from the horizon to the sun.
2. Solar azimuth (β): Angular deviation from the south.

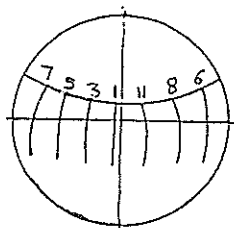


How to read sun path diagrams: The center of the circle is the observation point. The elliptical curves in the diagram show the horizontal projections of the sun's path across the sky.

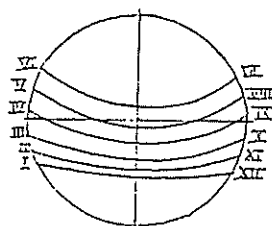


Numbers at the top of the elliptical curve give the time of day.

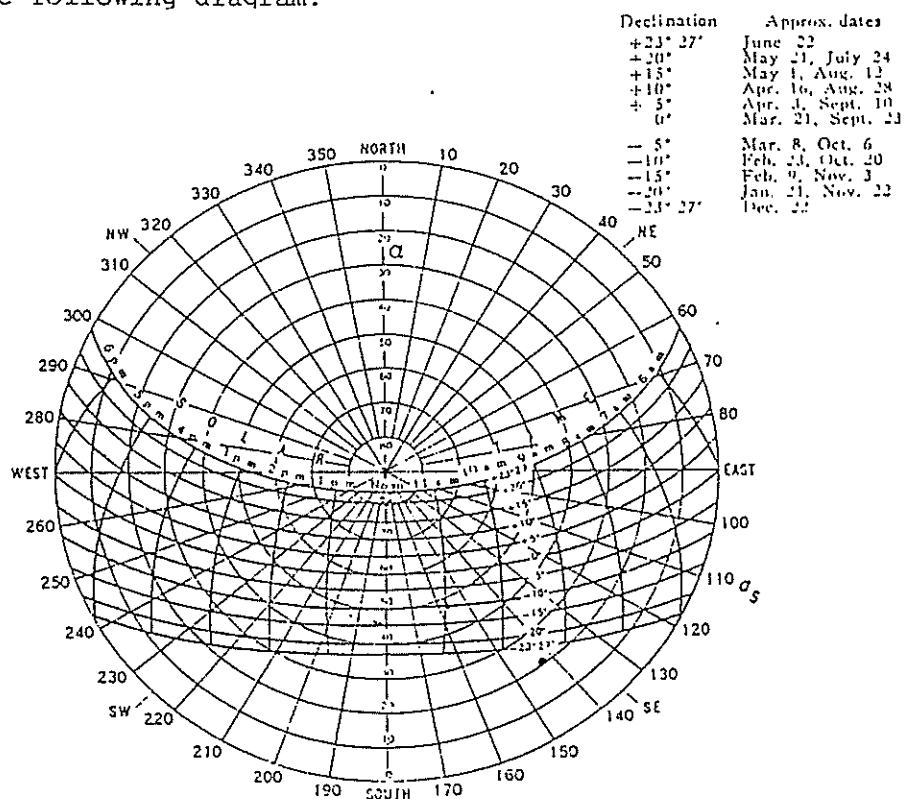
The lines connecting to those numbers present the same thing in different months.



Each elliptical curve belongs to a different month. It presents in Roman letters which can be read at the right and left ends of the diagram.



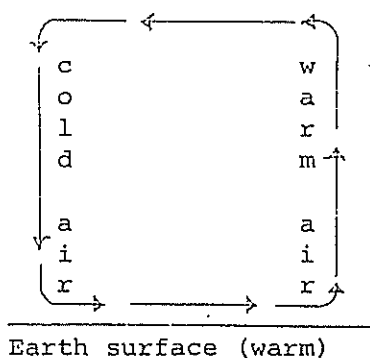
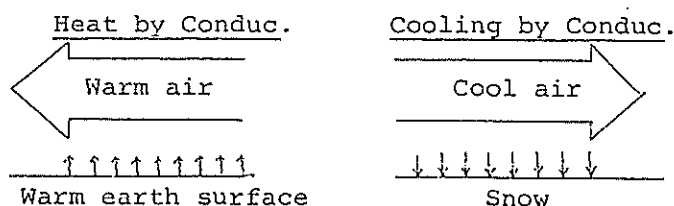
If we put all this information together, we should be able to read the following diagram.



Wind

The other factors affecting the distributional pattern of temperatures on the earth's surface are horizontal and vertical air movements (wind), with contained heat energy.

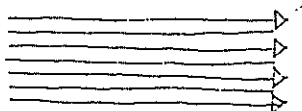
Heating or cooling the air by contact (conduction) creates horizontal air movements.



When the earth's surface is warmer than the atmospheric temperature, the air temperature rises by the absorption of terrestrial radiation and by conduction. Air expands and becomes less dense, and is displaced upwards by cooler and denser adjacent air. This is known as convective heat distribution by air movement.

In every season, large volumes of air are moved above the surface of the earth at varying speeds, intensities, and temperatures. Closer to the earth's surface, there are three types of wind flow that are known today:

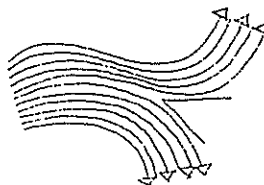
1. Laminar air flow: Layers of air flowing one on top of the other.



2. Turbulent air flow: Air masses moving in the same direction but in a random pattern.



3. Separated air flow: Layers of air flow varying in momentum.



Surfaces of buildings always produce turbulent air flow, and separation occurs when air flows around sharp corners.

Humidity and Precipitation

Humidity is the state of the atmosphere with respect to water vapor. It is a significant element of weather and climate for several reasons:

- It is the source of all precipitation;
- It affects air temperature (by absorbing solar and terrestrial radiation);
- It influences sensible temperatures which the human body feels.

The distribution of precipitation regulates the accumulation and transfer of heat from place to place on or near the earth's surface. This is due to its role in heat transfer and its vital heat contributions to organic life. Precipitation

ranks highest in importance among the world's physical patterns.

The other factors

The heating of the atmosphere is influenced by different characteristics of the atmosphere as well as by different surface conditions on the earth below.

Major global differences in surface materials and in their capacity for heating and cooling are well illustrated by the contrast between air temperatures over land and water. Land surfaces are experiencing a greater and more rapid rise in temperature following the receipt of solar energy than water surfaces. Heat loss on earth is always faster and greater on land than in water. Some reasons are:

- Because of transparency of water, solar radiation can penetrate far below the surface. The warming process is always slower than the earth is. But on the other hand, the cooling process is slower.
- Water can distribute, by waves and currents, heat energy to a larger and deeper mass.

Snow and ice have a strong cooling influence on the air temperature. The air immediately above them loses heat energy by both radiation and conduction. Horizontal air flow replaces cool air with warmer air which in turn becomes cooler.

Differences in vegetation cover also influences air temperatures. Because of their different reflection and absorption

capacities, a field, grassy park, or forest will always have different temperatures under the same conditions. This is caused by the absorption or insulation capacity of vegetation.

Environment and Building

One of the primary functions of a building is the control of indoor environment to make it suitable for healthy and comfortable living. The degree and nature of this control are of particular importance when artificial means such as air conditioning, heating, and forced ventilation are not used. The desired indoor temperatures for occupation are usually different from those occurring outdoors due to climate. This is so for most of the seasons of the year and hours of the day. This causes substantial differences in temperature between the indoor and outdoor environments. To be successful in the control of indoor environment, the house must meet the following requirements:

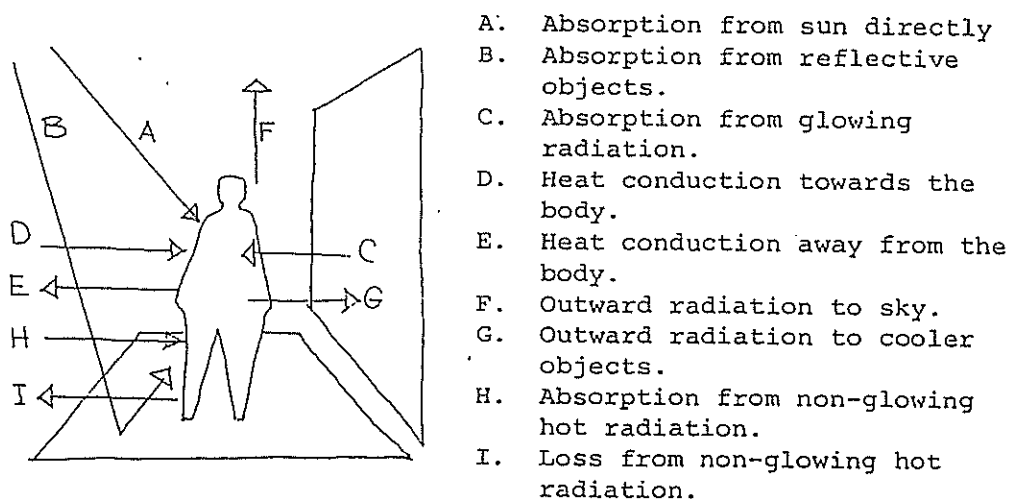
1. The house should meet human comfort indexes.
2. The house should do the work of a passive solar collector:
 - a) house orientation
 - b) house form
3. The house should meet adequate construction material selection:
 - a) color and reflectivity of materials
 - b) thermal conductivity-heat storage capacity of materials

c) shading

4. The house should be integrated with surrounding nature.

1. The house should meet human comfort indexes

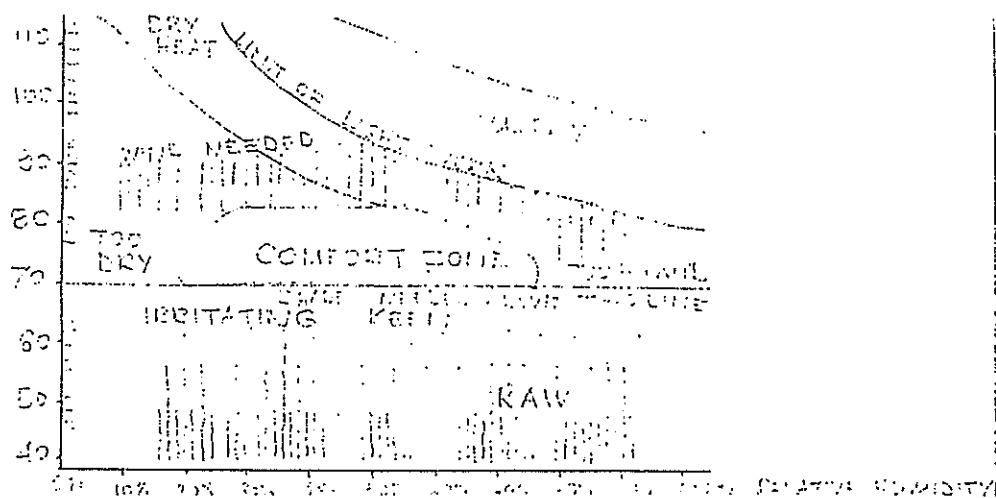
Man's physical and mental functions vary best within a given range of climatic conditions. Only within this range can he be comfortable and function efficiently. The four major elements of climate which affect human comfort are: (1) air temperature, (2) solar radiation, (3) air movement, and (4) humidity and precipitation. Similar to other features in nature, man receives and gives off heat.



When there is a balance between heat gain and heat loss, man feels comfortable. However, when there is an imbalance, he feels cold or hot.

Comfort zones for human requirements show the differences between researchers and writers. For example, Dr. H. M. Vernon and T. Bedford (British Department of Scientific and Industrial

Research) believe that the comfort zone is from 66.1° - 72.1° F. S. F. Markham (Climate and the Energy of Nations, London 1947, p. 143) believes that the range of temperature from 60° - 76° F. is ideal for man. C. E. P. Brooks (Climate in Everyday Life) believes in a range from 58° - 70° F., and others from 69° - 80° F. These differences are based on man, varying within people, depending upon their age, health, sex, activity in various areas of the world, and inherited or cultural characteristics.



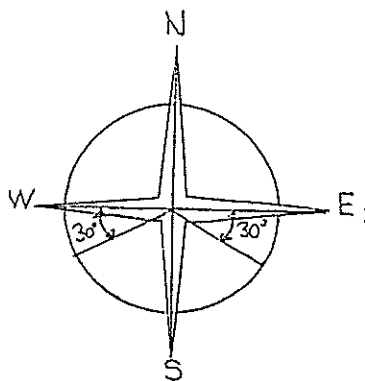
2. The house should do the work of a passive solar collector

Like the passive solar air collector, the house should capture and let in sunlight where radiation changes its shape to another energy form called "heat." As we know from solar collector design, the glaze surface on the side of the sun accomplishes this. The other insulated sides of the collector do not allow the captured heat to escape through the surface of the collector

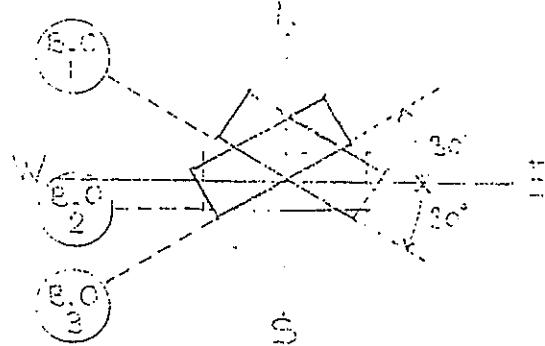
by convection, conduction or radiation. There are times when additional heat gain is needed. At some time more than at others or during the hot periods, heat loss becomes more important. Constructive design of architects can answer those needs which are working in opposite ways. To be able to complete a successful design, an architect should concentrate on:

- a. house orientation
- b.. house shape

House orientation: As Bruce Anderson explains in his work The Solar Home Book, a number of researchers have arrived at the same conclusion: The principle facade of a house (where most living quarters take priority) should face within 30° due south. Of course, this is a very basic explanation. We should



try to find optimum orientation to different latitudes. This 60° angle giving different orientation implies different results in heat gain. Victor Olgyay, in his book Design with Climate, is against generalization. He explains that solar radiation and outdoor temperatures act together to influence the overall heat gain through the surfaces of a building.



B.O 3 Building orientation 3
(orientation 30° SE):
Building will be warmer
than building 2 and 1 in
early winter mornings.

B.O 1 Building orientation 1
(orientation 30° SW)

Early morning radiation will reach the house a few hours later than building 3. For this reason, during the early morning hours, the house will be colder than building 3 (and building 2). In the late afternoon, it will receive more radiation than both orientation 2 and 3. This can be an advantage for night usage (only in winter).

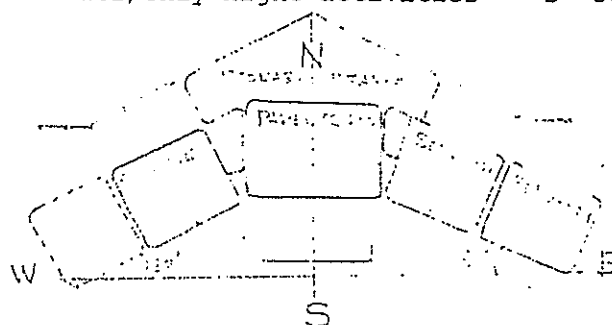
Like sunflowers, it is impossible to move a village house parallel to sun path diagrams every hour of the day in order to receive maximum amounts of energy. Why, within this 60° angle, should the house be oriented in only one direction? The effect of solar radiation varies in rooms with different orientations. Rooms with different orientation should, of necessity, have separate regulation devices for heat supply if all rooms are to have the same temperature and if the solar heat gain is to be best utilized. Considering that rooms are strongly separated from each other in Turkish village houses, a constant and equal distribution of heat is not possible. Here architects should do their own program according to their client's needs, the usage of different spaces of the house, and sun path diagrams.

In general, Turkish village house space orientations are as follows:

Food preparation and breakfast -- $S \sim 30^\circ$ SE

Rooms which take daily activities -- S

Rooms for, only night activities -- $S \sim 30^\circ$ SW



House shape: In vernacular architecture, a form is built in direct response to material capabilities and to the climate, and then the internal activities are filled into the external shell. The thermal effectiveness varies according to the geometry of the building, ratios of surface area, and to the ground area, and surface area to volume varies from shape to shape. Correct shape can reduce the energy required to provide a suitable room climate. In Turkish villages, when technical means are not available, a correct choice of shape for a building will make a difference.

From an energy point of view, the ideal house shape is a geometric volume which has minimum heat loss and maximum heat gain in the winter and does just the reverse in the summer. Since insolation is the only energy source, the south face of the house has a lot to do with optimum shape, and this varies from region to region.

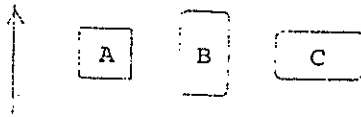
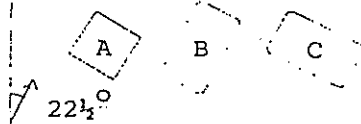
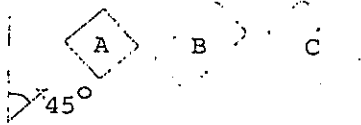
Cool regions: An increase on south face length means more heat gain.

An increase in height and width means more volume to heat. This can make space less efficient.

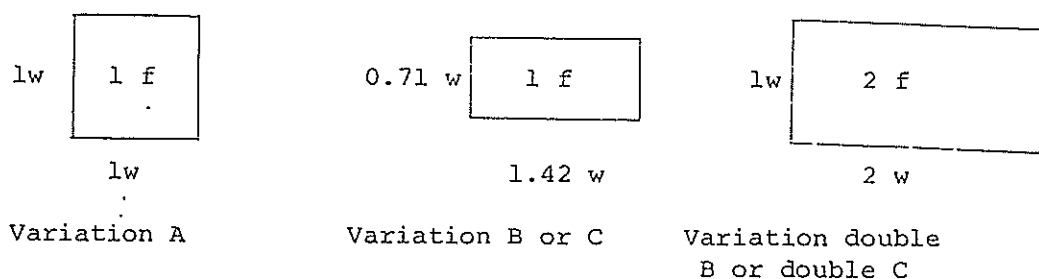
Hot regions: A decrease on the south face length of the house is needed for less heat gain.

An increase in height and width is needed for larger volume.

In Ashrae Handbook of Fundamentals we can see relative insolation values in houses of different shapes and orientation for different latitudes. Example: "January 21, 40° N latitude (Northern part of Turkey)":

Facade Orientations		Insolation on Wall (BTU/Day)				
		a	b	c	d	Total
	A	118	508	1630	508	2764
	B	84	722	1160	722	2668
	C	168	361	2320	361	3210
	Double B	118	1016	1630	1016	3780
	Double C	234	508	3260	508	4216
 22½°	A	123	828	1490	265	2406
	B	87	1180	1060	376	2703
	C	174	590	2120	188	3072
	Double B	123	1655	1490	630	3709
	Double C	246	828	2980	265	4319
 45°	A	127	1124	1174	127	2602
	B	90	1670	835	180	2775
	C	130	835	1670	90	2775
	Double B	127	2348	1174	254	3903
	Double C	254	1174	2348	127	3903
 67½°	A	265	1490	828	123	2406
	B	138	2120	590	174	3072
	C	378	1060	1180	87	2703
	Double B	265	2980	828	246	4319
	Double C	530	1490	1656	123	3799

Building Sizes & Relative Wall and Floor Areas



(Illustrations from Bruce Anderson - The Solar Home Book, p. 81.

The study carries three different sizes of buildings - A (square house), B (rectangular house), and C (double-sized rectangular house). Facade orientations vary according to four angles facing the south (90° S, $67\frac{1}{2}^\circ$ S, 45° S, $22\frac{1}{2}^\circ$ S). From the data we can observe that a rectangular house, oriented east-west, has the greatest potential for total solar heat gain.

If we can assume an optimum of heat flow in and out of the building, then we can state as a rule that a shape with the maximum heat gain and minimum heat loss in overheated and underheated periods respectively is an optimum shape with respect to energy exchange. The thermal impacts of temperature and radiation on the indoor air partly depends on the form of the building. Quantitatively, this can be computed by the heat flow method as suggested by V. Olgyay (Design with Climate, Princeton, New Jersey, 1963, p: 87). The optimum form can be expressed as:

$$\frac{C_1}{C_2} = \frac{y}{x}$$

Where C_1 and C_2 are the heat effects on side (x) and side (y) of an area respectively.

A modifying factor, which V. Olgyay calls "the criterion of elasticity," must be applied, however, depending on the intensity of summer and winter in the particular region.

3. The house should meet adequate construction material selection: Material selection has a definite effect on how a building gains or loses the heat received from solar radiation. Here we will be concerned with two types of materials:

- a) opaque
- b) transparent

Heat from solar radiation enters a building by conduction through opaque walls and roofs, or by direct radiation through transparent materials such as windows. Opaque materials such as mud-brick, stone, and wood prevent the passage of light; their thermal characteristics vary considerably because of different degrees of mass, color and surface reflectivity.

--Color and reflectivity of materials: Two major properties of opaque walls that help determine their thermal performance are color and reflectivity.

Most rural houses near the Mediterranean (south of Turkey) are painted in white, but in the north and eastern parts of the country, houses are not painted. All have kept the natural colors

of mud bricks or stones. White painted Mediterranean rural buildings are good examples of protection from direct exposure by using reflective surfaces. Through their experiences, villagers have found out that dark earth colored houses are warmer during the winter, and white colored Mediterranean village houses are cooler in summer. The reason is the properties of surface materials, their absorptance (measure of their tendency to absorb sunlight),

$$\alpha = \frac{F_a}{I} \quad \begin{array}{l} \text{(absorbed solar energy)} \\ \text{(incident solar energy)} \end{array}$$

$$E = \frac{R}{R_b} \quad \begin{array}{l} \text{(radiation from material)} \\ \text{(radiation from black body "p=0")} \end{array}$$

and emittance (their propensity to emit thermal radiation).

The reflectance of a surface is $p = \frac{I_r}{I}$ where I_r = reflected solar radiation.

Bigger values of α mean better absorbers of sunlight.

Bigger values of E mean better emitters of thermal radiation.

Small values of α/E mean good surfaces for hot summer sun.

Large values of α/E mean good surfaces for winter sun.

	α	p	E	α/E
White paint	0.20	0.80	0.91	0.22
Green paint	0.50	0.50	0.90	0.56
Gray paint	0.75	0.25	0.95	0.79
Red paint	0.74	0.26	0.90	0.82
Black paint	0.96	0.04	0.88	1.09
White plaster	0.07	0.93	0.91	0.08
Brick	0.55	0.45	0.92	0.60
Concrete	0.60	0.40	0.88	0.68
Stone	0.55	0.45	0.44	1.25

--Thermal conductivity - heat storing capacity of materials:

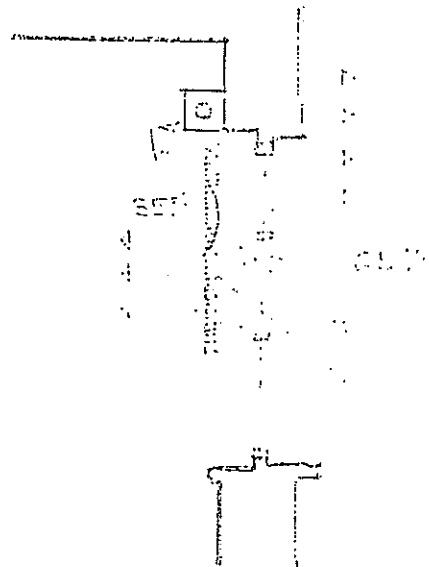
The quantity of heat stored in the building component depends largely on the density of the material. Internal temperature will be directly influenced by this factor and also by the thermophysical properties of the materials. The combined effect of these are expressed as the product of the thermal conductivity (λ) and the heat storing capacity (c) of the component. The pattern of internal temperatures will be determined by the value of (λc) components, while lower values of (λc) will be warmed quicker than those with higher values of (λc). They will also tend to cool faster when the heating system is turned off.

Materials	Material Properties				
	Density (p)	Sp. Heat (c)	Conduct. (λ)	Diffus. (α)	(λc)
Mud brick	1540	.18	.61	22	170
Wood	500	.45	.17	7.6	38
Stone	1800	.20	1.18	33	425

Materials	Component Properties				
	Width (d)	Thermal Resistance (R)	Thermal Conductance (K)	Time Constant (RC)	Time Lag (ϕ)
Mud brick	50	1.046	.95	114.0	14.5
Wood	20	1.406	.71	52.5	9.9
Stone	40	564	1.77	48.5	10.0

--Shading: One of the most effective methods of reducing heat gain through transparent materials is shading. But today there are very few appropriate uses of shading devices surrounding us. The reason for this is a lack of understanding of the sun's movement. A good shading device should keep sunlight in during the winter, and out during the summer. We can put shading devices into two groups: internal and external.

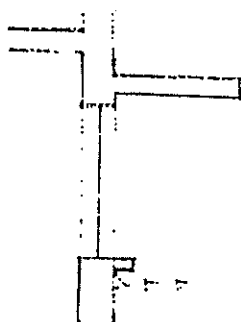
Internal shading devices can reduce the amount of heat dispersed within a space. It may be easy to use, but not as effective as external shading. It may stop radiation in front of the window, but it is still in the interior. We lose some radiation there by reflection. But some amounts turn into heat which is undesirable during the hot summer days. The most common internal shading devices are venetian blinds, vertical blinds, shades, and draperies. These devices can reject up to 65 percent of the solar radiation that strikes the glass directly.



External shading is the most effective against overall heat gain. Fixed overhangs and vegetation are the most common types of external shading. With enough knowledge about sun path diagrams, we can block out up to 95 percent of the solar radiation by using either fixed overhangs or trees.

Vegetation can provide better shading than fixed overhangs. The reason is that it follows the climatic seasons. The time when we need sunshine is when sunlight passes through the trees. But the time when we do not need radiation, sunlight stops at the leaves of the vegetation. The aim of the architect is, therefore, to accommodate an equitable area for special vegetation, i.e. trees.

Exterior movable shading devices are the most efficient devices when compared to fixed overhangs and vegetation. However, the cost and maintenance make it undesirable to use in rural buildings.



Fixed Overhang



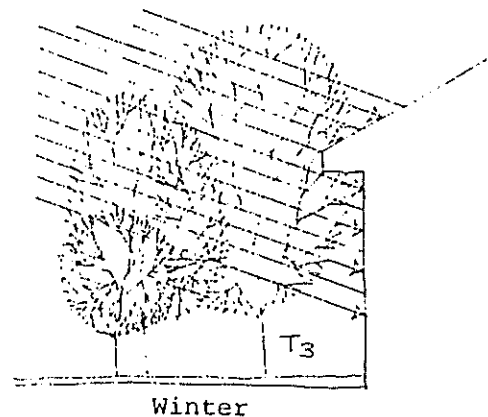
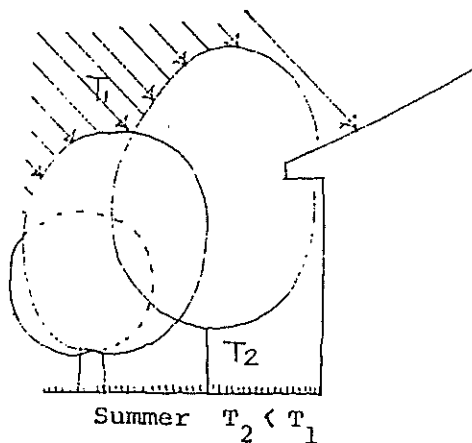
Vegetation

4. The house should be integrated in surrounding nature.

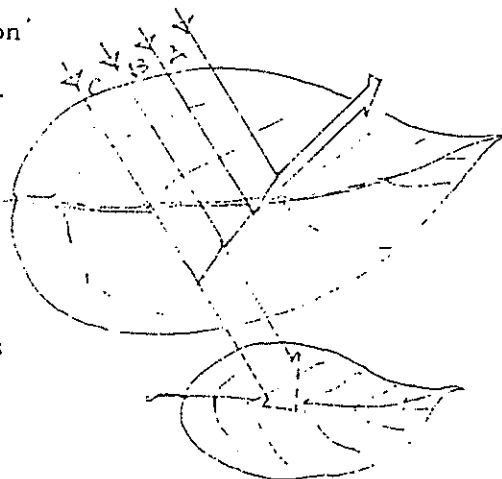
Using plants for climate control: Each individual, through his experience, knows that plants make the environment more pleasant and livable for man. Today's architects are more familiar with the architectural usage of plants (to create privacy, to screen, to reveal progressively a view, or to articulate space)

than with climate control by plants. Because of new energy requirements in building, architects should learn how to use them.

Solar radiation control by plants: Trees, shrubs, ground covers, and turf are among the best exterior solar radiation control devices. Plants may be used to direct solar radiation by shading the sun or by intercepting reflected radiation from the surroundings.



Part of the sun's radiation is absorbed, reflected and transmitted through the leaves. Each leaf reduces the value of transmitted radiation. Obstruction occurs mostly on deciduous plants in full leaf.



Temperature control is linked directly to solar radiation control, wind control and precipitation control. Plants and grassy covers reduce temperatures by scattering of light and radiation and absorption of solar radiation, and also by the evapo-transpiration process.

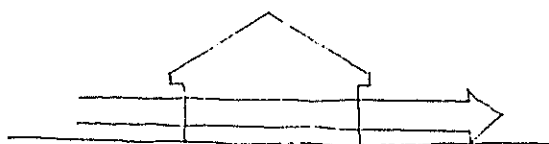
Reflection reduction: Architects in their man-made environments predominately use light and smooth surfaces, which increase reflection. Plants generally have a rougher and darker surface than what we are doing next to them. Because of this darker color and leaf surface, there is a great decrease in the amount of radiation.

Plants provide insulation for buildings, not only from the intense heat of solar radiation, but also from abrupt temperature changes. Creation of dead-air spaces is one of the most important insulation characteristics of nature. This acts much the same as the dead-air space in the wall of a house.

Victor and A. Olgyay, in their book Design with Climate, Princeton, 1963, p. 34, estimate that with good natural protection on three sides of a building, the fuel savings might be as high as 30 percent.

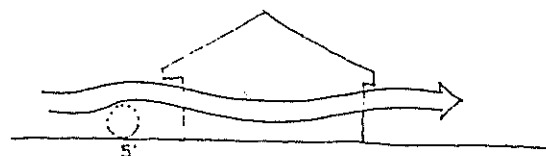
Wind control by plants: This can be in different ways -- obstruction, guidance, deflection and filtration. The degree of effectiveness of plants and the placing techniques of plants makes different possibilities for control.

- Correct use of planting affects the air movement in the interior and exterior of a building.
- Correct use of planting may either augment or reduce the natural airflow through the building.
- By the use of planting, the direction of airflow within the building can be changed to desirable directions.

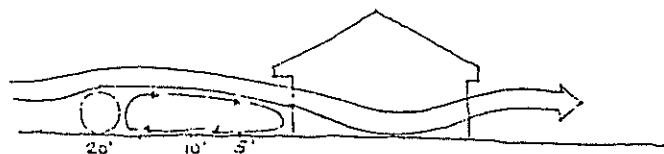


Air flow without vegetation.

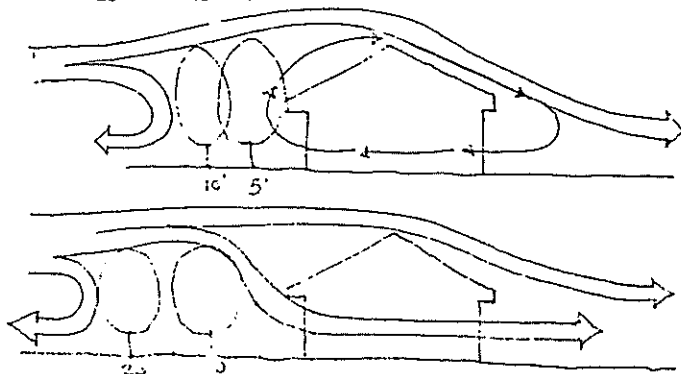
Air flow - low hedge:
Hedge at building face or 20 feet from building wall does not change air-flow within the house. But hedge 5 feet from building is maximum dead air space as insulation.



Air flow - high hedge:
Hedge 5 and 10 feet from building makes airflow pass building without entering interior.



Hedge 20 feet from building separates airflow in two ways - interior and exterior airflow.



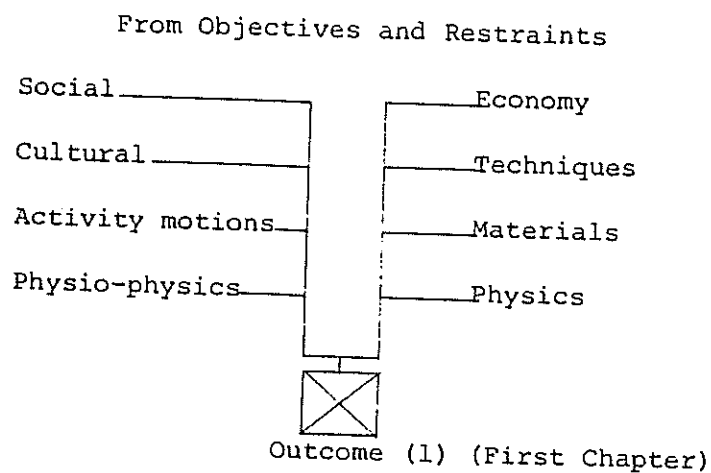
Airflow - high and medium shrubs.



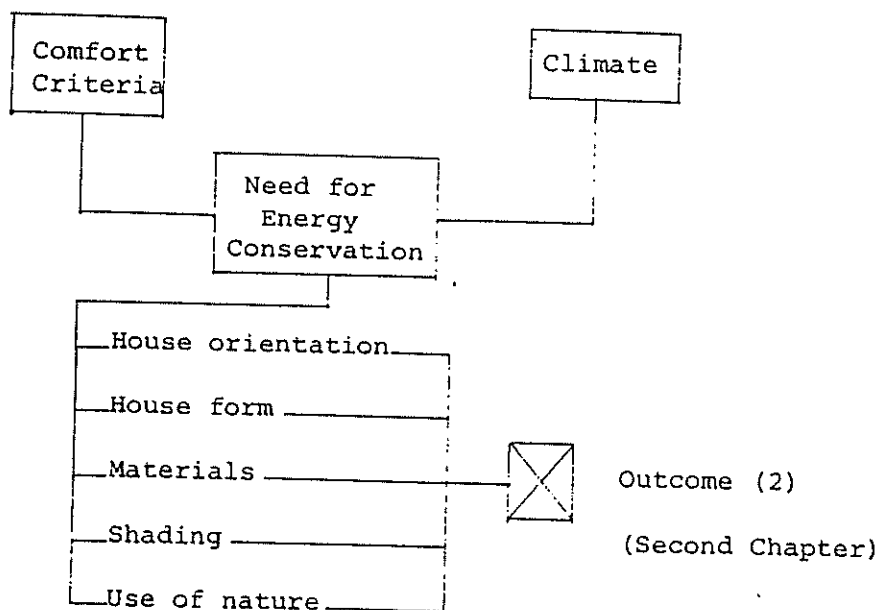
Conclusion

As we see in the first part of this work, culture, traditions, economy, building materials and techniques have great influence on house form. Also, it should not be overlooked that environmental factors are among the important determining issues in house form. Since man is part of a social system, which is in itself an interaction with the environmental systems, we can not isolate one from the other. The relationship between culture, habitat and environment can be analyzed in the hierarchical order of direct and indirect relations. Rather than determining the shape and other characteristics of a house, each factor in its own capacity and intensity, using A. Rapoport's term, modifies it. In his book House Form and Culture, A. Rapoport presents his basic hypothesis that "the house form is not merely the outcome of physical environmental forces, but is the result of a wide range of socio-cultural forces acting in their broadest terms, and socio-cultural forces are defined as the primary forces."

The first part of this work deals with Turkish village house design and influences of social, economic, cultural and technological factors on building, which I will call "comprehensive design pattern."

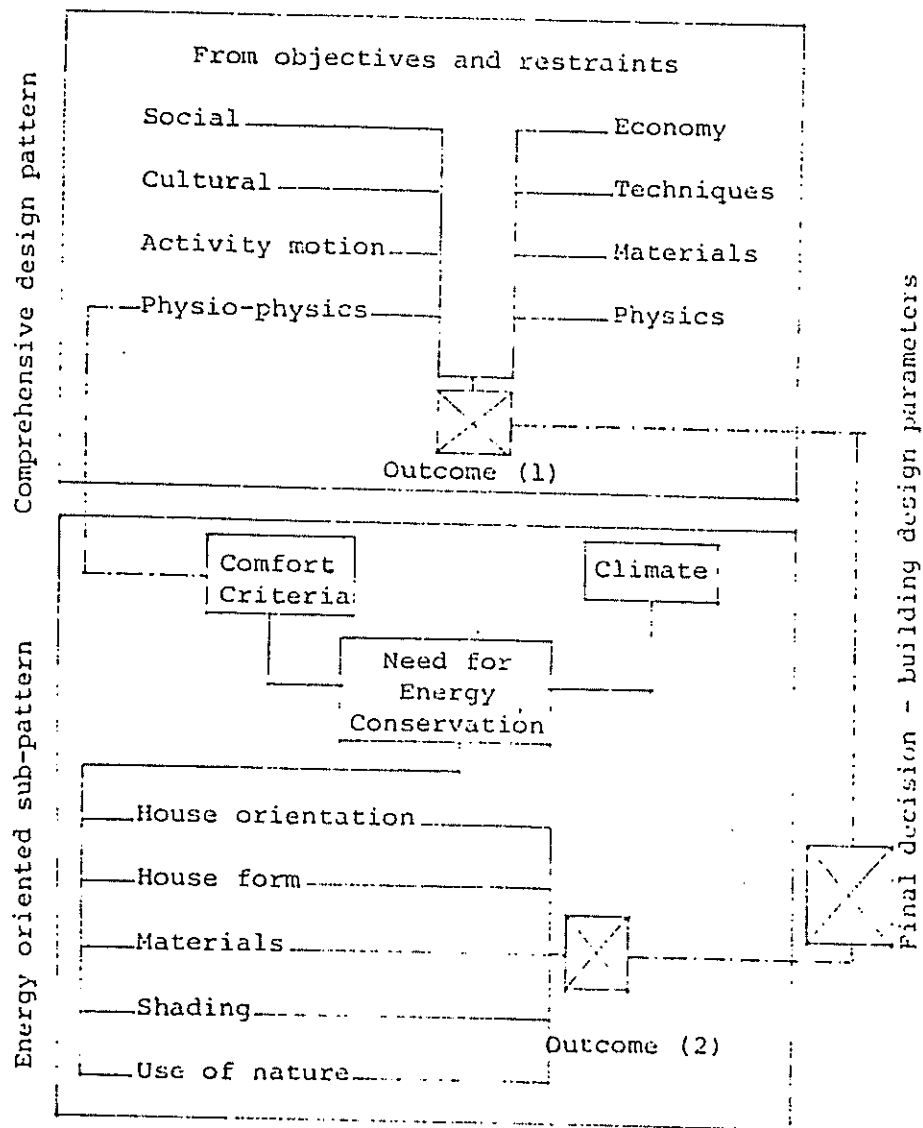


The second part of this work analyzes the house from an energy point of view, which I will call "energy oriented sub-pattern of comprehensive design pattern."



In the house design stage, the influences of "comprehensive design pattern" and "energy oriented sub-pattern" will not be separated. The outcomes of each pattern will influence each

other and those mixtures of outcomes will become new building design parameters.



CLIMATE IN TURKEY AND CLIMATIC DATA IN DIFFERENT REGIONS

The weather affects everyone in numerous ways, and occasionally with deep economic consequences. In Turkish society people who are the most influenced by the weather are the people who are subjects of my dissertation, "villagers." In every aspect of their social, economical and cultural life, it is possible to see this great influence. Since my interest lies with the influence of climate on buildings, I will concentrate on the climatic data in different regions of Turkey related to rural building construction.

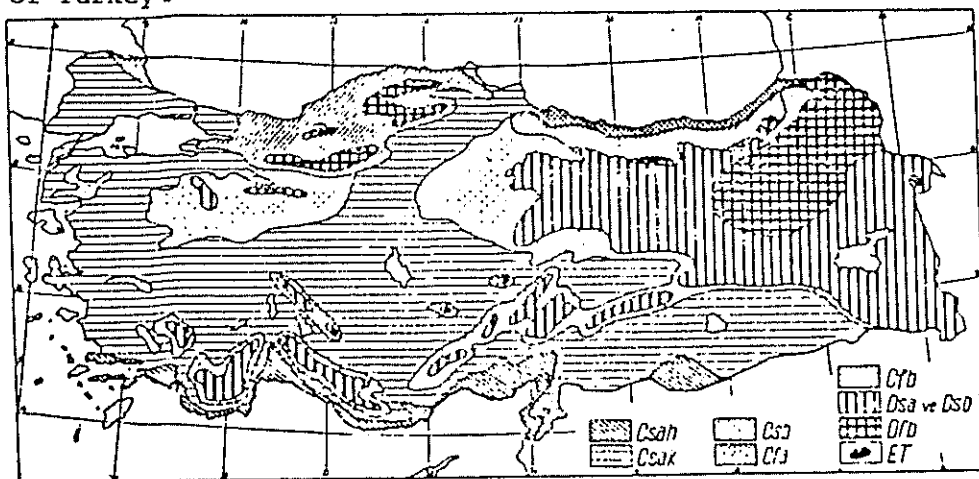
Climate -- the aggregate of the weather as revealed by past experiences -- includes temperature, winds, atmospheric moisture, cloudiness, precipitation, and air pressures that have prevailed during any considerable period. It comprises the average annual temperature, the temperatures of each season, the usual temperature during the hottest time of the day, and the normal frequency of temperatures above or below certain limits.

In Turkey the climate at any two places is not quite the same, because invariably at least one of the several factors influencing climate differs. These factors include:

- distance from the Equator
- elevation
- land, sea relations

- relations to lakes and other bodies of water
- relation to mountain ranges, hills, and valleys
- color and wetness of soil
- character of the vegetation

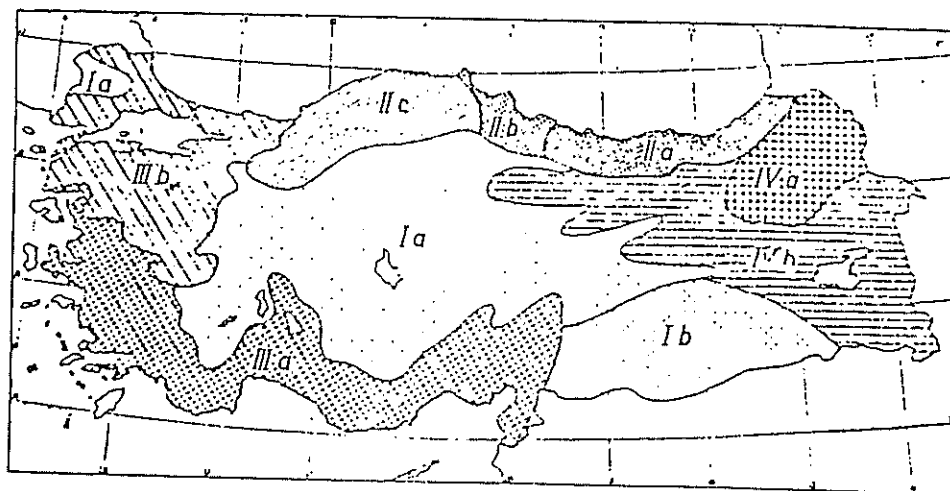
One of the first studies about "macro climate types of Turkey" was done by F. Christiansen-Weniger. In his book Turkiye Ziraatinin Temelleri, Ankara 1953, by using "Koppen Formulas,"¹ he finds out eighteen different climate types. But as we see from the following drawing, this system will not be helpful to us for the specific regional climatic characteristics of Turkey.



According to Dr. Sirri Erinc,² Turkey has four different types of climate. Regions and climates are strongly related. I believe Dr. Erinc's classification can be easily used for our purpose, for the classification of design data on house construction for different climate and regions.

¹W. Koppen, Grundriss der Klimakunde, Berlin, 1931.

²Dr. Sirri Erinc, "Klimatoloji ve Metodiari," Tas Matraasi, Istanbul 1969.



According to Dr. Erinc's book we can classify the different climatic regions of Turkey as follows:

1. Climate of middle Anatolia and southwest Anatolia
(Hot in the summer, cold in the winter, precipitation is low.)
 - 1a. Middle Anatolia: Cooler than southwest in summer ($20-25^{\circ}\text{C}$.)
Colder than southwest in winter (0°C , -3°C)
 - 1b. Southwest Anatolia: Summers are very hot (more than 30°C)
Winters are warm (0°C , 5°C .)
2. Climate of Black Sea region
(High precipitation in every season of the year)
 - 2a. Eastern part of the Black Sea region: Maximum precipitation of the country. Hot in the summer, warm in the winter.
 - 2b. Middle part of Black Sea region.
 - 2c. Western part of Black Sea region: Lower precipitation than eastern part of the region. Warmer in summer, cooler in winter.

3. Eastern part of Anatolia: Coldest part of Turkey. Long winters and very short summers. According to precipitation, it can be separated into two parts:

3a. Northern part: More precipitation in summer.

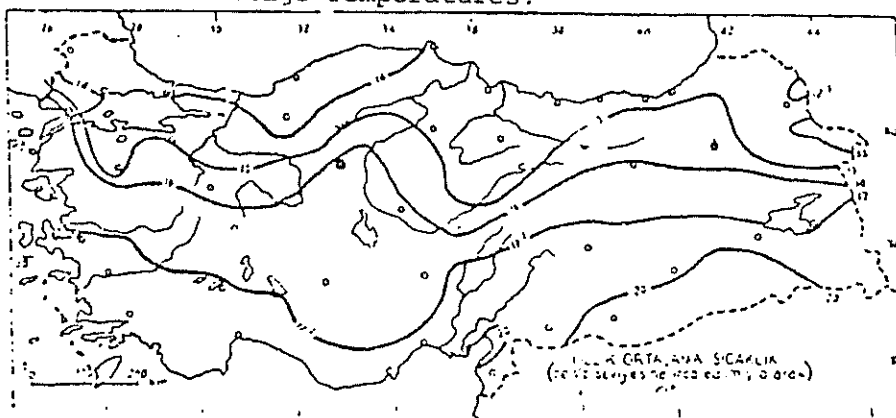
3b. Southern part: High precipitation in winter and spring.

4. Climate of Mediterranean region:

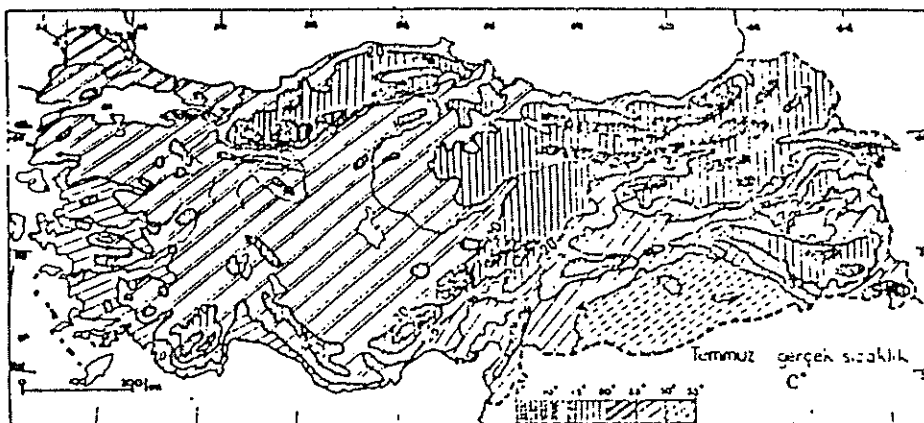
4a. Mediterranean region: Warm winters and hot summers. No precipitation during summer.

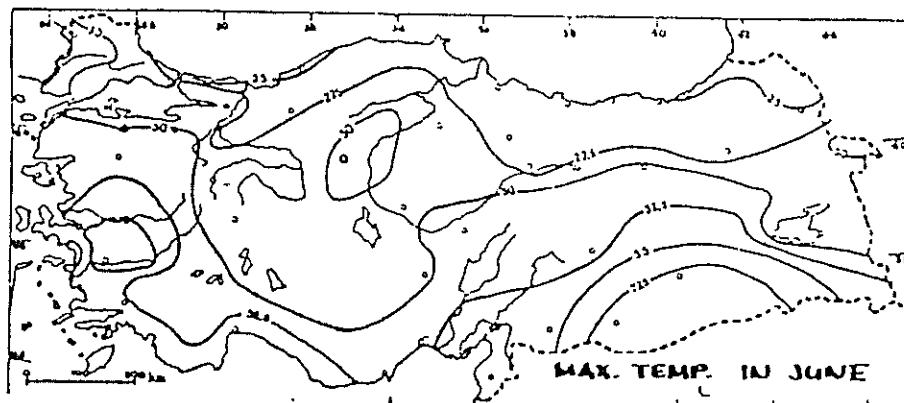
4b. Marmara region: Cold winter, hot summer. More precipitation during summer.

1. Annual Average Temperatures:

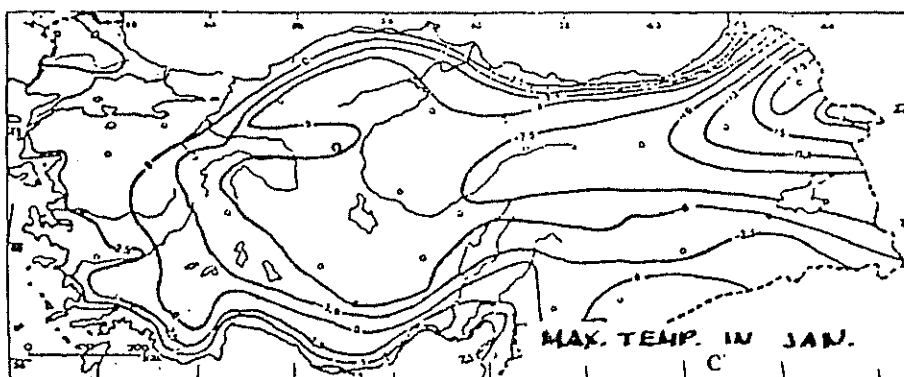
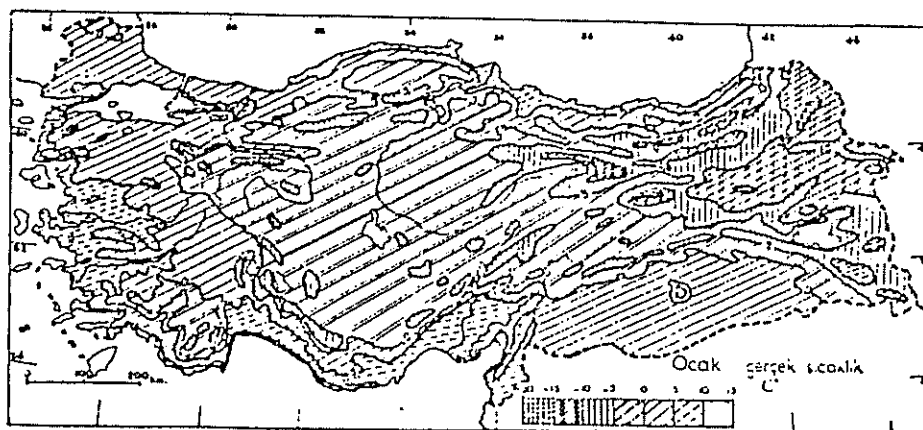


2. Average Temperatures in June:





3. Average Temperatures in January:



4. Temperature Differences in Different Parts of Turkey:

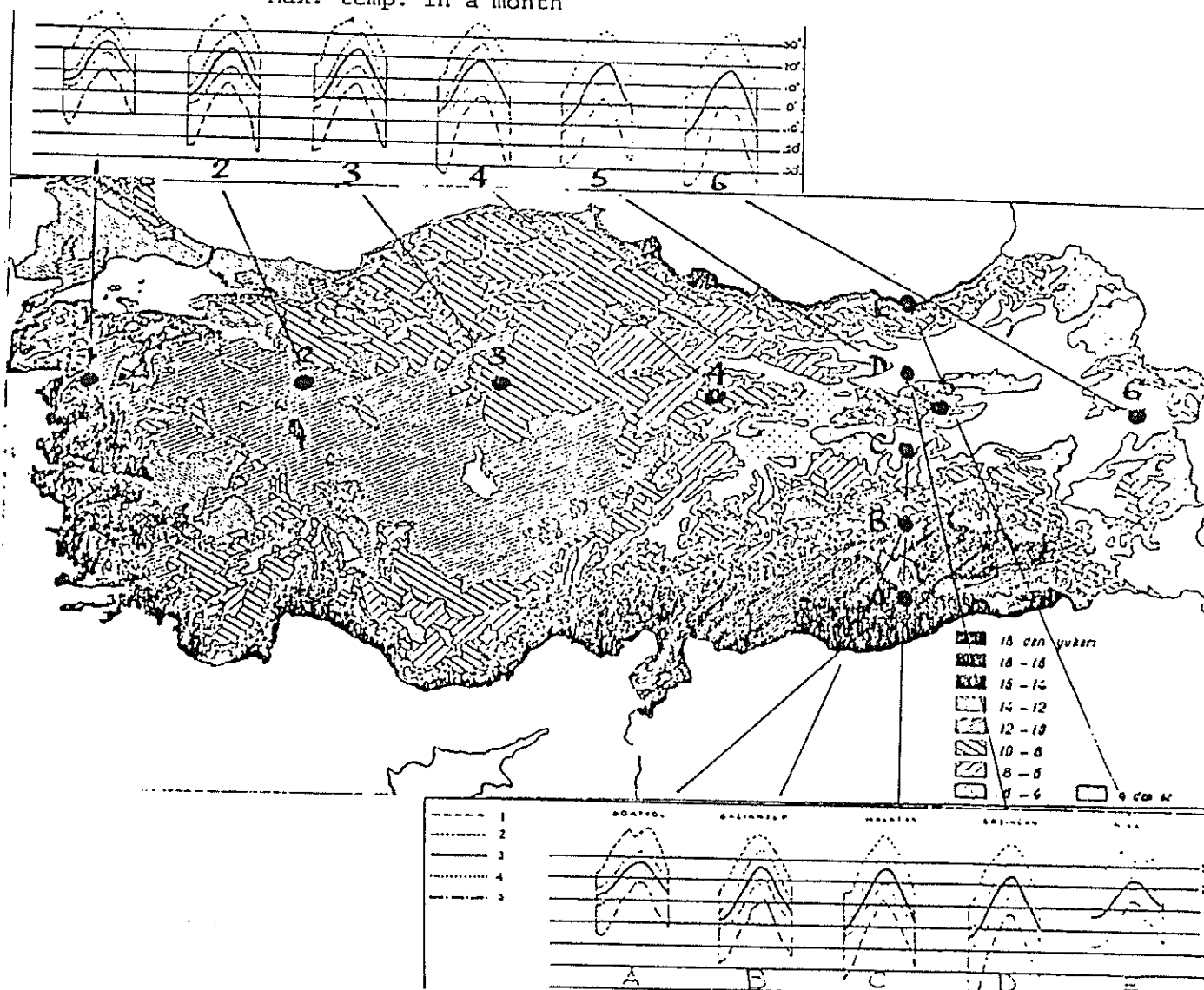
Min. temperature in a month

Min. average temp.

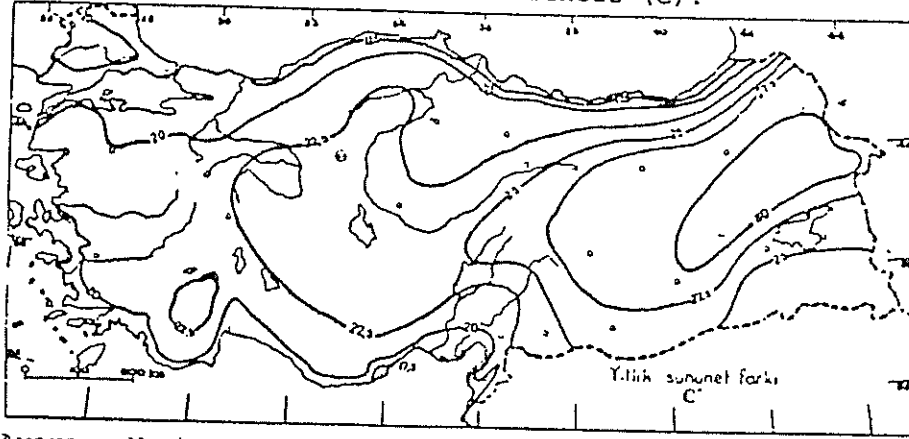
Average temperature

Average max. temperature

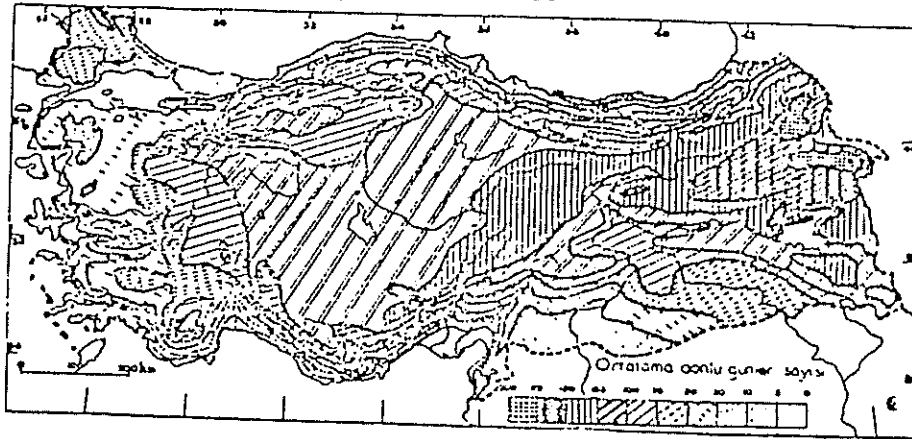
Max. temp. in a month



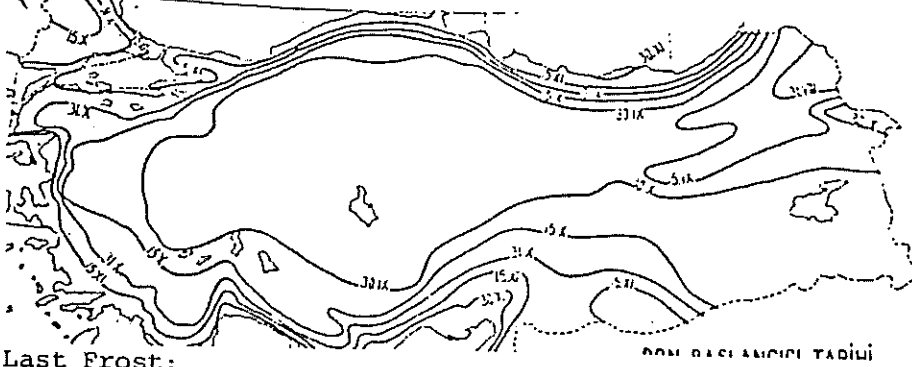
5. Annual Average Temperature Differences (C):



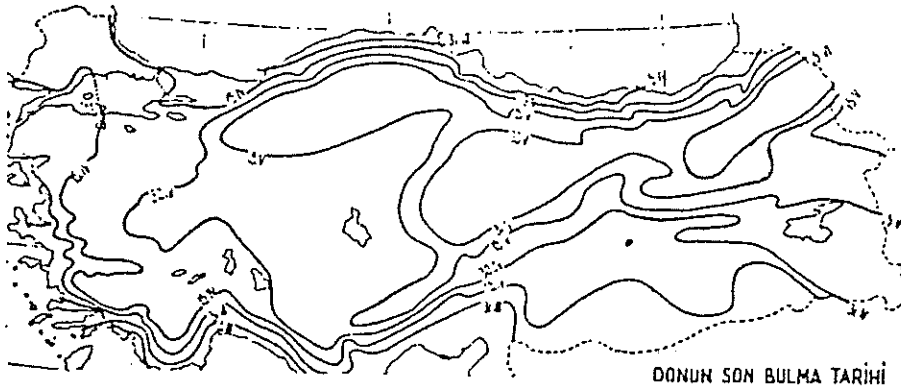
6. Average Number of Days with Frost:



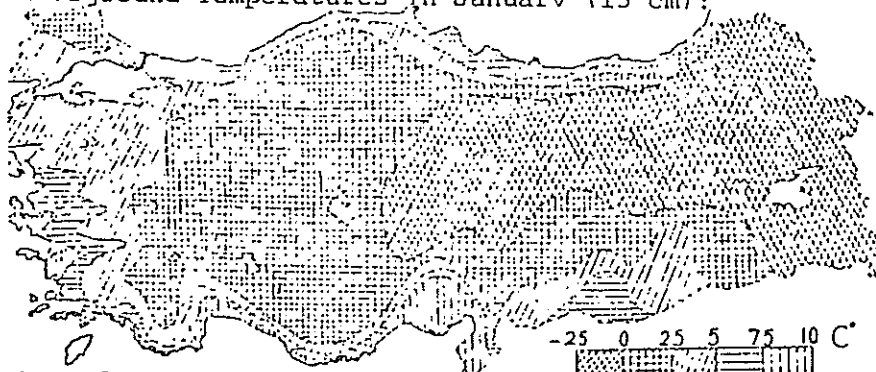
7. First Frost:



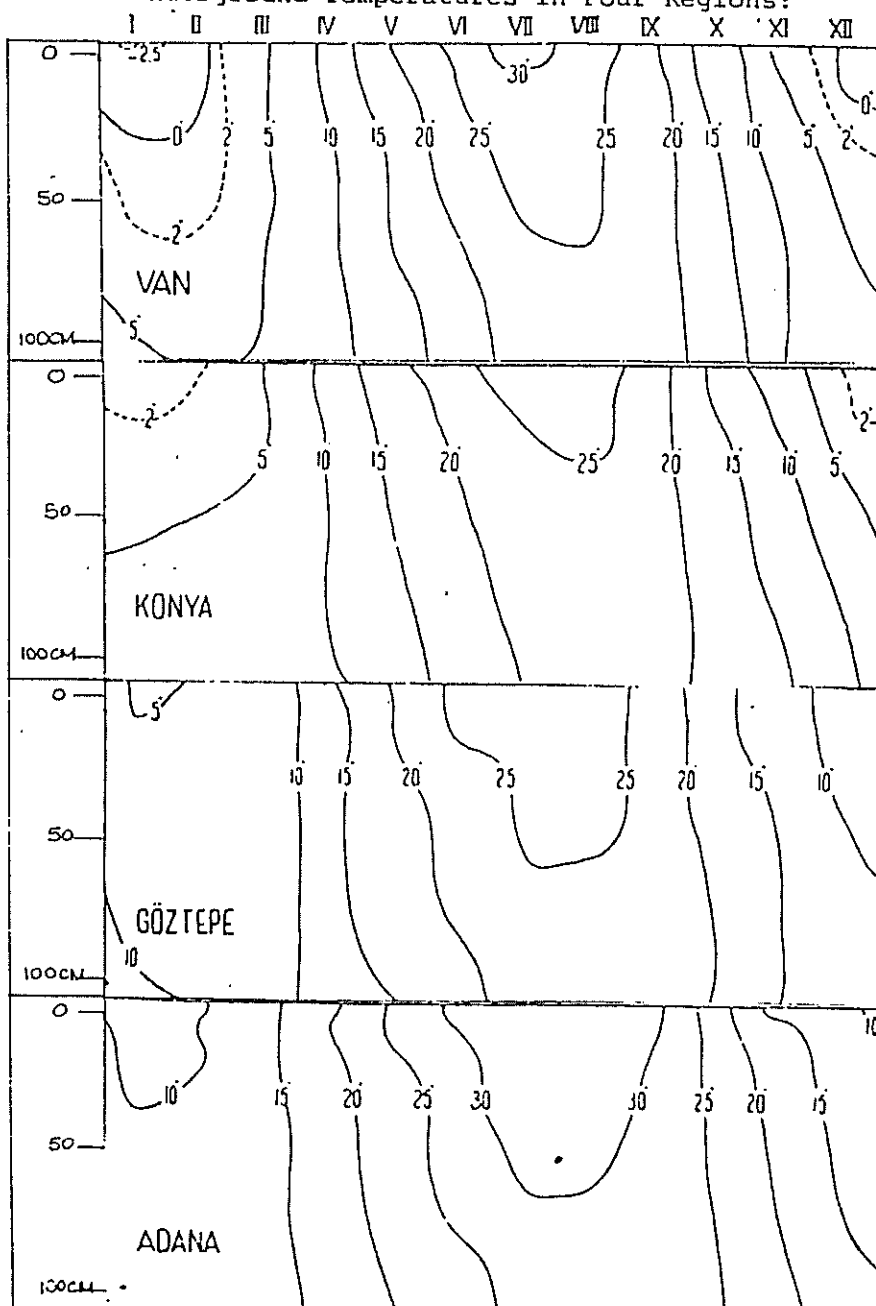
8. Last Frost:



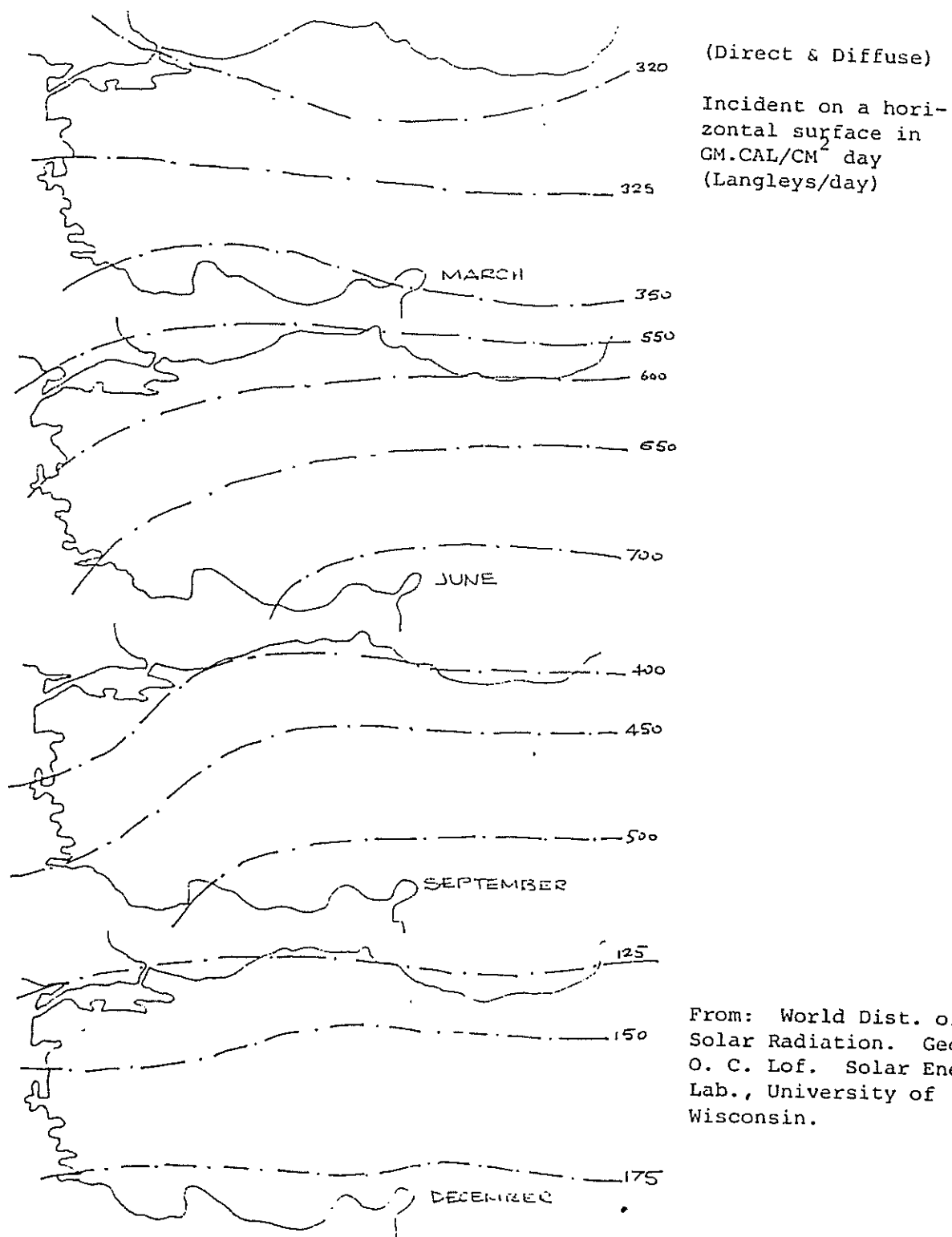
9. Underground Temperatures in January (15 cm);



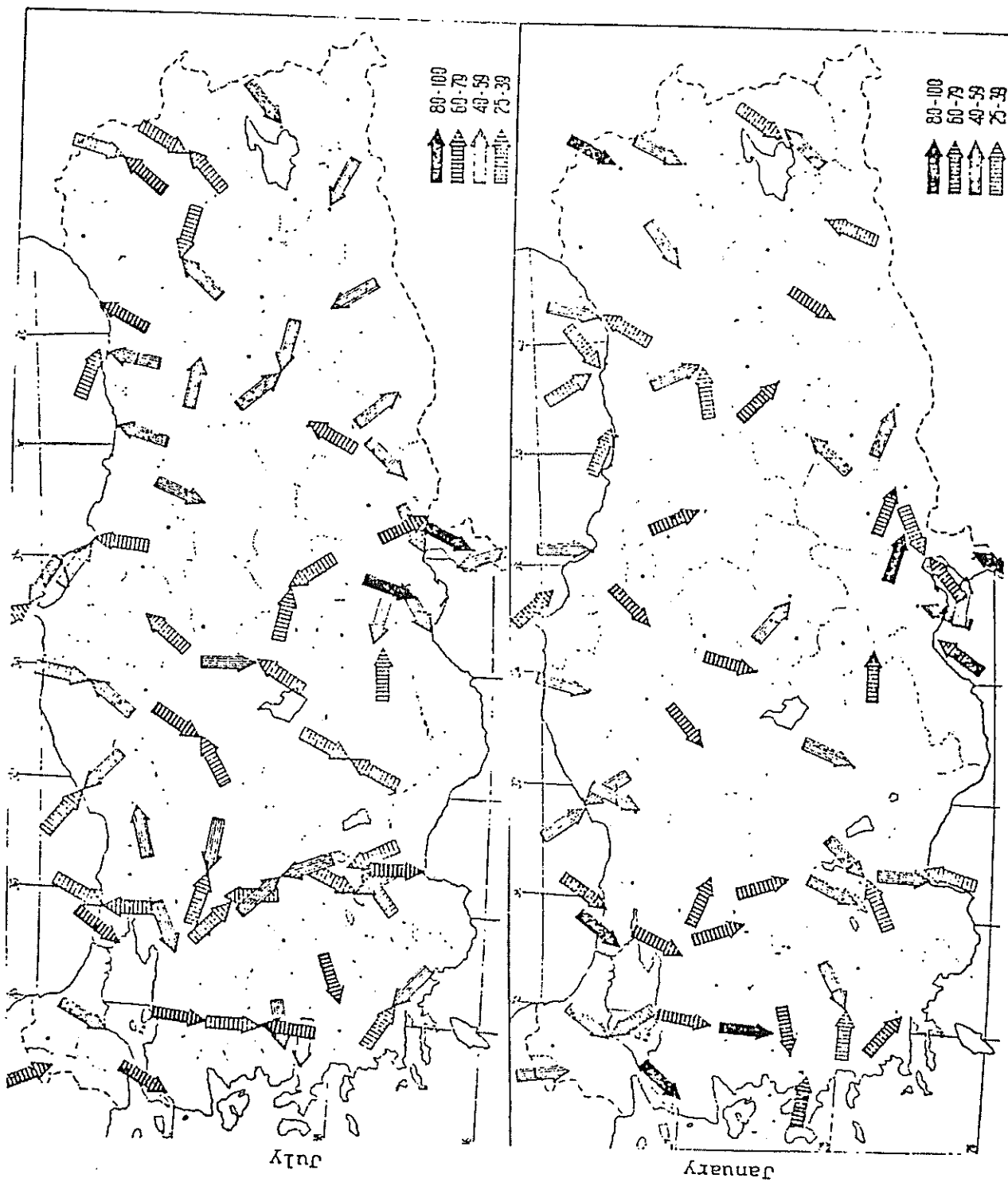
10. Annual Underground Temperatures in Four Regions:



Daily Means of Total Solar Radiation



From: World Dist. of
Solar Radiation. George
O. C. Lof. Solar Energy
Lab., University of
Wisconsin.

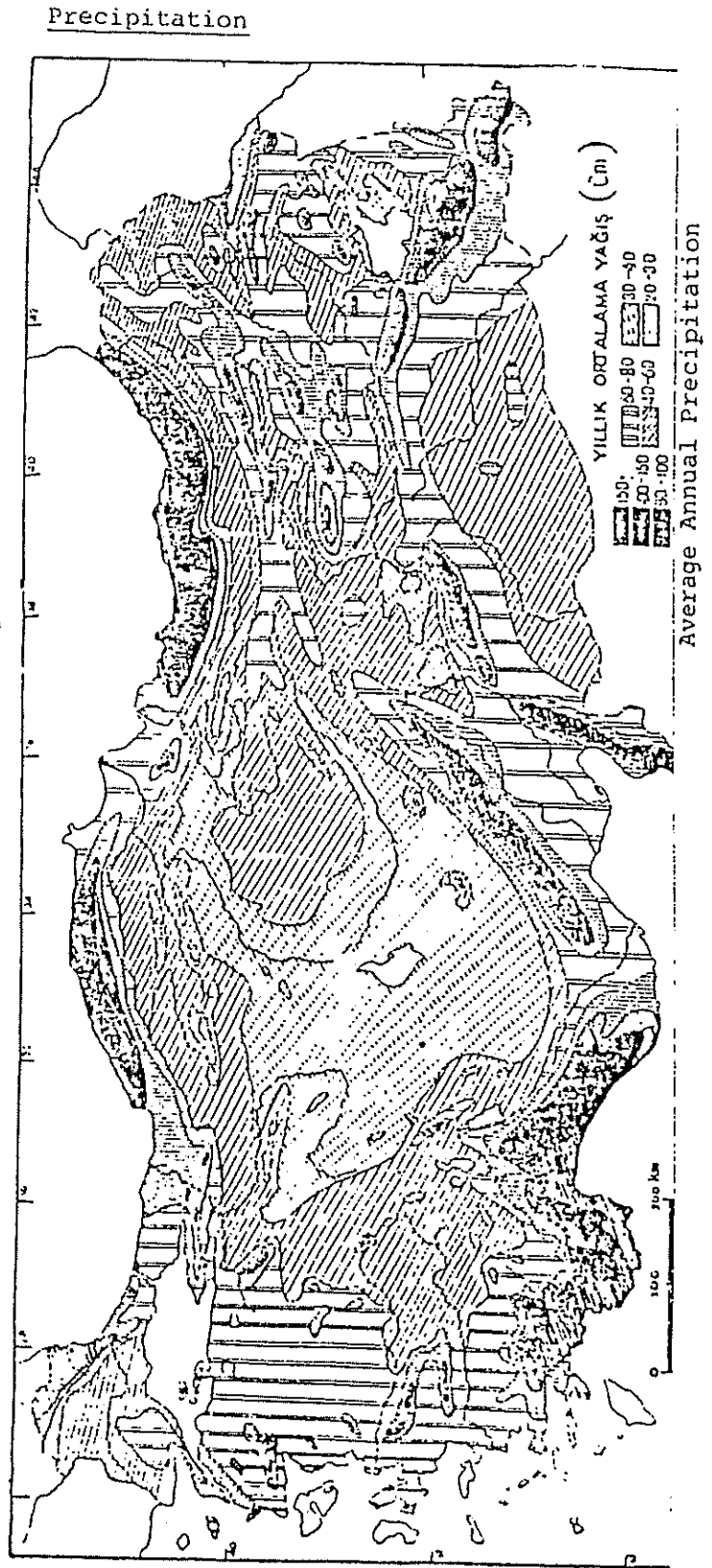
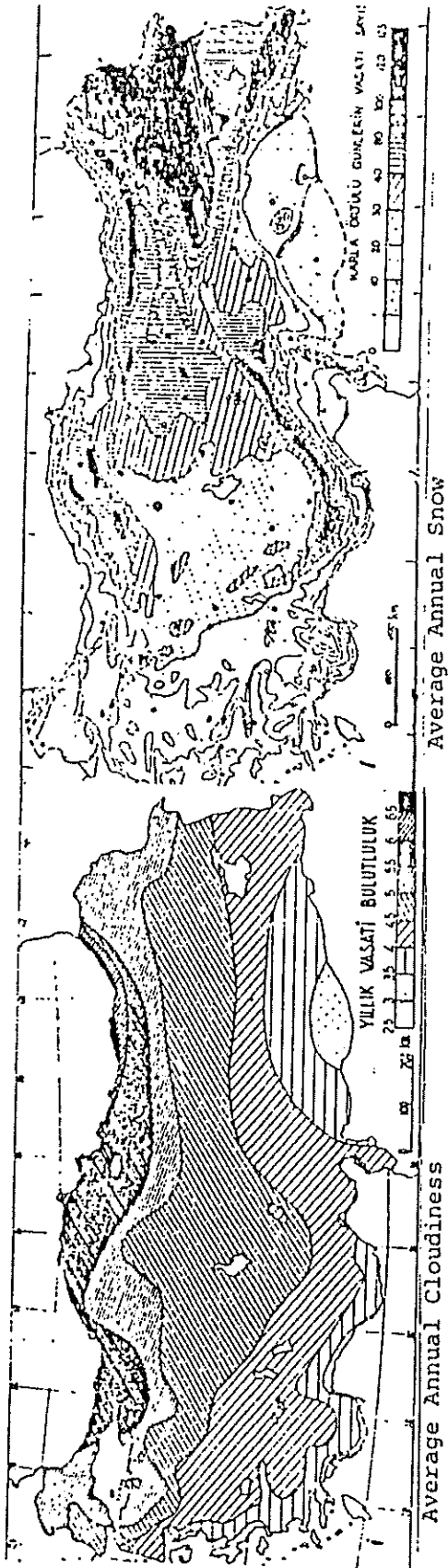


Wind
1. Surface wind directions:

2. Average surface wind directions and relative frequencies:*

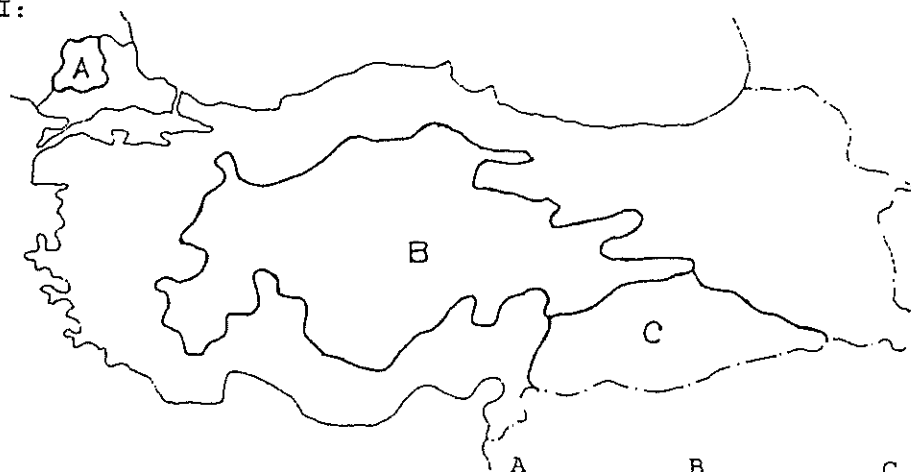
CITY	JAN.		JULY	
	Istikamet	Frekans %	Istikamet	Frekans %
Adana	N 27° E	38	S 27° W	59
A. Karahisar	S 23° E (N 44° W)	50 (41)	N 18° W	63
Akhisar	S 4° W (N 4° E)	63 (32)	N 4° E	93
Ankara	N 36° E (S 63° W)	60 (26)	N 36° E	65
Antakya	N 27° E	80	S 22° W	95
Antalya	N	60	N 4° E (S 13° W)	42 (30)
Balıkesir	N 9° E (S 27° W)	60 (22)	N 13° E	57
Bolu	S 81° W	52	N 27° E	50
Burdur	S 32° E (N 31° E)	52 (32)	N 27° E	50
Bursa	N 76° E	55	N 27° E	65
Çanakkale	N 40° E	72	N 45° E	92
Çorum	S 40° W	30	N 49° E	77
Diyarbakır	S 32° E	55	N 36° E	64
Dört Yol	N 67° E	51	S 55° W (N 72° E)	59 (27)
Edirne	N 14° W	67	N 5° W	45
Elâzığ	S 81° E (N 50° W)	47 (43)	N 50° W	76
Erzincan	N 77° W	43	N 23° W (S 55° W)	44 (20)
Erzurum	S 54° W (S 68° E)	47 (27)	N 55° E	49
Eskişehir	S 81° E (N 72° W)	51 (31)	N 65° W	62
Gaziantep	N 49° E	54	N 72° W	78
Giresun	S 27° W	53	N 63° W	37
Göztepe	N 36° E	61	N 40° W	84
İskenderun	S 18° E	54	N 81° W	59
İslâhiye	N 27° W	60	N 72° W	51
Isparta	S 32° E (S 58° W)	37 (29)	N 36° E (S 76° W)	42 (25)
Izmir	S 86° E	55	N 81° W	60
Karaköşe	S 48° W (N 27° E)	39 (28)	N 27° E	57
Kars	S 40° W (N 18° E)	62 (31)	N 36° W	63
Kastamonu	S 36° W (N 13° E)	51 (29)	N 13° E	52
Kayseri	N 81° W (S 27° E)	36 (25)	N 49° W	53
Kırşehir	N 3° E (S 31° W)	43 (36)	N 15° E	78
Konya	S 27° W (N 27° E)	34 (30)	N 27° E	56
Kütahya	S 18° E (N 41° W)	36 (25)	N 9° W	61
Malatya	S 27° W	37	S 48° W	46
Manisa	N 81° E	56	N 31° E	66
Mersin	N 63° E	56	S 40° W	73
Muğla	S 50° E (N 54° W)	42 (39)	N 54° W	59
Nazilli	N 27° E	66	N 67° E (N 86° W)	43 (37)
Rize	S 36° W	61	N 13° E (S 27° W)	40 (31)
Samsun	N 54° W (S 9° W)	44 (32)	N 50° W	57
Silirt	S 54° E	56	S 22° W	36
Sinop	N 32° W (S 50° E)	40 (39)	N 41° W	62
Sivas	N 22° E	42	N 27° W	64
Şile	N 27° E (S 4° W)	31 (30)	N 49° E	60
Tekirdağ	N 31° E	44	N 36° E (S 36° E)	50 (30)
Trabzon	S 4° W (N 72° W)	45 (25)	N 32° W (N 54° E)	34 (30)
Ulukışla	S 64° E (W)	50 (35)	N 56° W	61
Urfa	N 43° W	40	N 65° W	53
Van	N 58° E	52	S 51° W (N 40° E)	43 (29)
Zonguldak	S 41° E (N 50° W)	57 (30)	SE (N 32° W)	46 (35)

* From "Hamdiye Bercis."



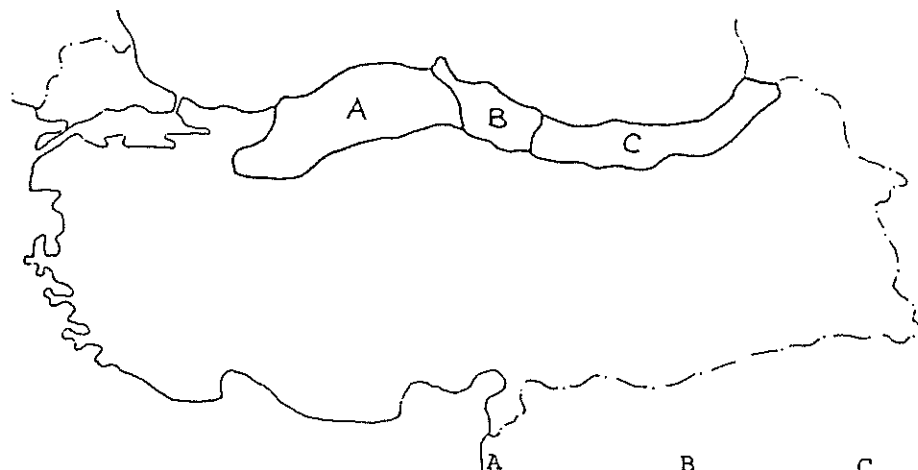
Climatic Data for Building Construction

Region I:



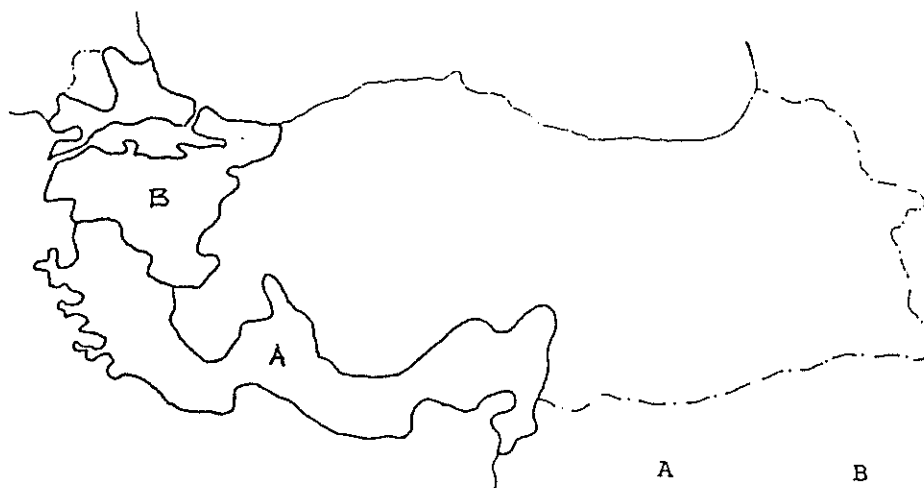
	A	B	C
Annual average days with frost	50 - 75	100 - 125	10 - 50
Annual average precipitation (cm)	40 - 60	30 - 40	40 - 60
Precipitation seasons:			
winter	37	30	58
spring	21	37	28
summer	20	13	0
autumn	27	20	14
Example city:	Edirne	Kayseri	Urfa
Annual ave. days w/precipitation	100	75	60
Annual ave. days w/snow	20	30	20
Average date for first snow	Dec. 15	Dec. 15	Dec. 30
Average date for last snow	Mar. 15	Mar. 15	Mar. 15
Annual average cloudiness	5.5	4.5	4
Annual average foggy days	25	20	10
Annual average evaporation (mm)	1000-1250	1250-1500	1500-2250
Radiation-Cal.cm ² /min.			
Jan.	0.24-1.15	0.27-1.26	0.29-1.29
July	0.64-1.71	0.59-1.50	0.65-1.85
Average temp. in July	25	25	35
Average temp. in January	0	-5	0
Average first frost date	Oct. 15	Sep. 30	Nov. 15
Average last frost date	Apr. 15	May 15	Apr. 15

Region 2:



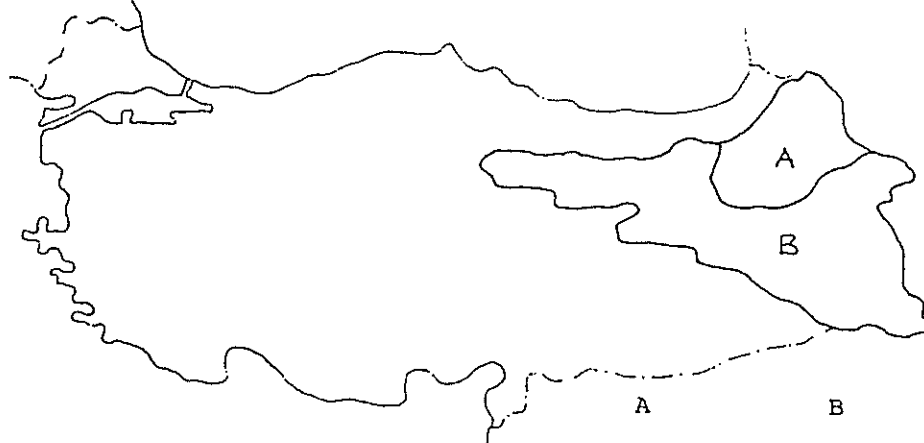
	A	B	C
Annual ave. days w/frost	10 - 30	10 - 30	10 - 30
Annual ave. precipitation (cm)	100 - 150	60 - 80	>150
Precipitation seasons:			
winter	24	30	29
spring	16	22	19
summer	21	20	20
autumn	34	28	30
Example city:	Zonguldak	Sinop	Trabzon
Annual ave. days w/precipitation	125-150	100-125	150-175
Annual ave. days w/snow	30	40	80
Ave. date for first snow	Dec. 30	Dec. 15	Dec. 30
Ave. date for last snow	Mar. 30	Mar. 30	Mar. 30
Annual average cloudiness	5.5-6	5.5-6	6-7
Annual average foggy days	15-20	10-15	5-10
Annual average evaporation (mm)	500-600	800-1000	800-1250
Radiation Cal.cm ² /min. Jan.	0.16-0.96	0.20-1.00	0.15-0.90
July	0.50-1.40	0.55-1.55	0.45-1.45
Average temperature in July	25 C	25 C	25 C
Average temperature in January	5 C	5 C	5 C
Average first frost date	Nov. 15	Nov. 15	Nov. 30
Average last frost date	Mar. 30	Apr. 15	Apr. 30

Region 3:



	A	B
Annual average days with frost	10 - 15	10 - 25
Annual Average precipitation (cm)	80 - 100	40 - 80
Precipitation seasons:		
winter	43	36
spring	28	21
summer	6	16
autumn	25	27
Example city:	Antalya	Istanbul
Annual ave. days w/precipitation	65	85
Annual ave. days w/snow	5	15
Average date for first snow	Dec. 30	Dec. 20
Average date for last snow	Mar. 1	Mar. 30
Annual average cloudiness	3.5	5
Annual average foggy days	2	7
Annual average evaporation (mm)	1250	1000
Radiation Cal.cm ² /min. Jan.		
July		
Average temp. in July	30 C	25 C
Average temp. in January	10 C	0 C
Average first frost date	Nov. 30	Sept. 31
Average last frost date	Mar. 15	Apr. 15

Region 4:
(Study area)



	A	B
Annual average days with frost	180	150
Annual average precipitation (cm)	60 - 80	60 - 80
Precipitation seasons:		
winter	15	27
spring	31	40
summer	36	6
autumn	18	27

Example city:

	Erzurum	Kars
Annual ave. days w/precipitation	100	125
Annual ave. days w/snow	120	120
Average date for first snow	Oct. 20	Nov. 20
Average date for last snow	Apr. 15	Apr. 15
Annual average cloudiness	6-6.5	4.5-5
Annual average foggy days	12	12
Annual average evaporation (mm)	1250	1000
Radiation Cal.cm ² /min. Jan.		
July		
Average temperature in July	25	30
Average temperature in January	-12	- 8
Average first frost date	Aug. 31	Sep. 15
Average last frost date	June 15	May 15

Building Survey

To be able to reach adequate thermal comfort, space characteristics and heat load sources should be known. In building surveys, the following physical aspects must be considered.

1. Orientation of building with respect to:
 - a. Sun and wind effects
 - b. Surrounding structures
 - c. Surrounding reflective surfaces
2. Use of space
3. Physical dimensions of space
4. Ceiling heights
5. Construction materials
6. Surrounding conditions (exterior color of walls and roof)
7. Windows
 - a. size
 - b. location
 - c. material
 - d. type
 - e. type of glass, single or multipane
 - f. shading
8. Doors
9. Internal heat-gain from people, lighting, appliances and equipment
10. Thermal storage capacity of the house.

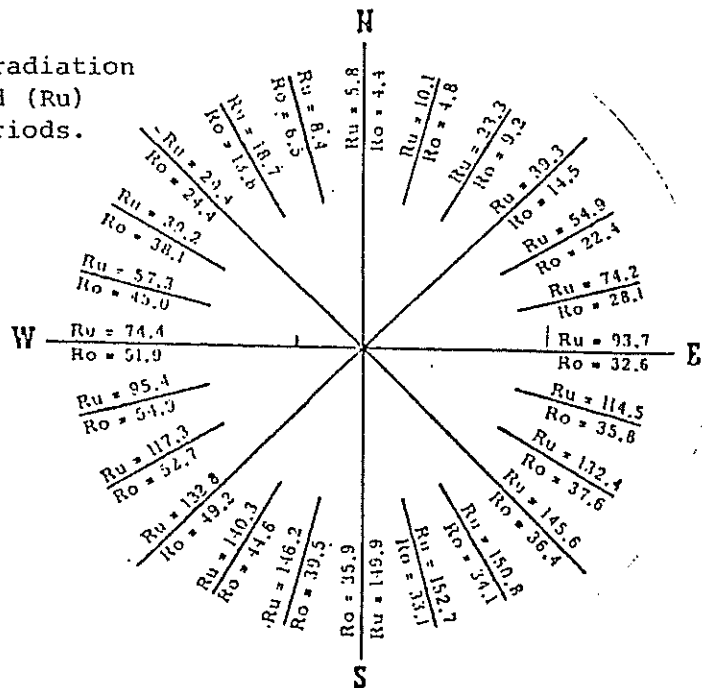
1. Orientation of building with respect to:

- a. Sun and wind effects
- b. Surrounding structures
- c. Surrounding reflective surfaces

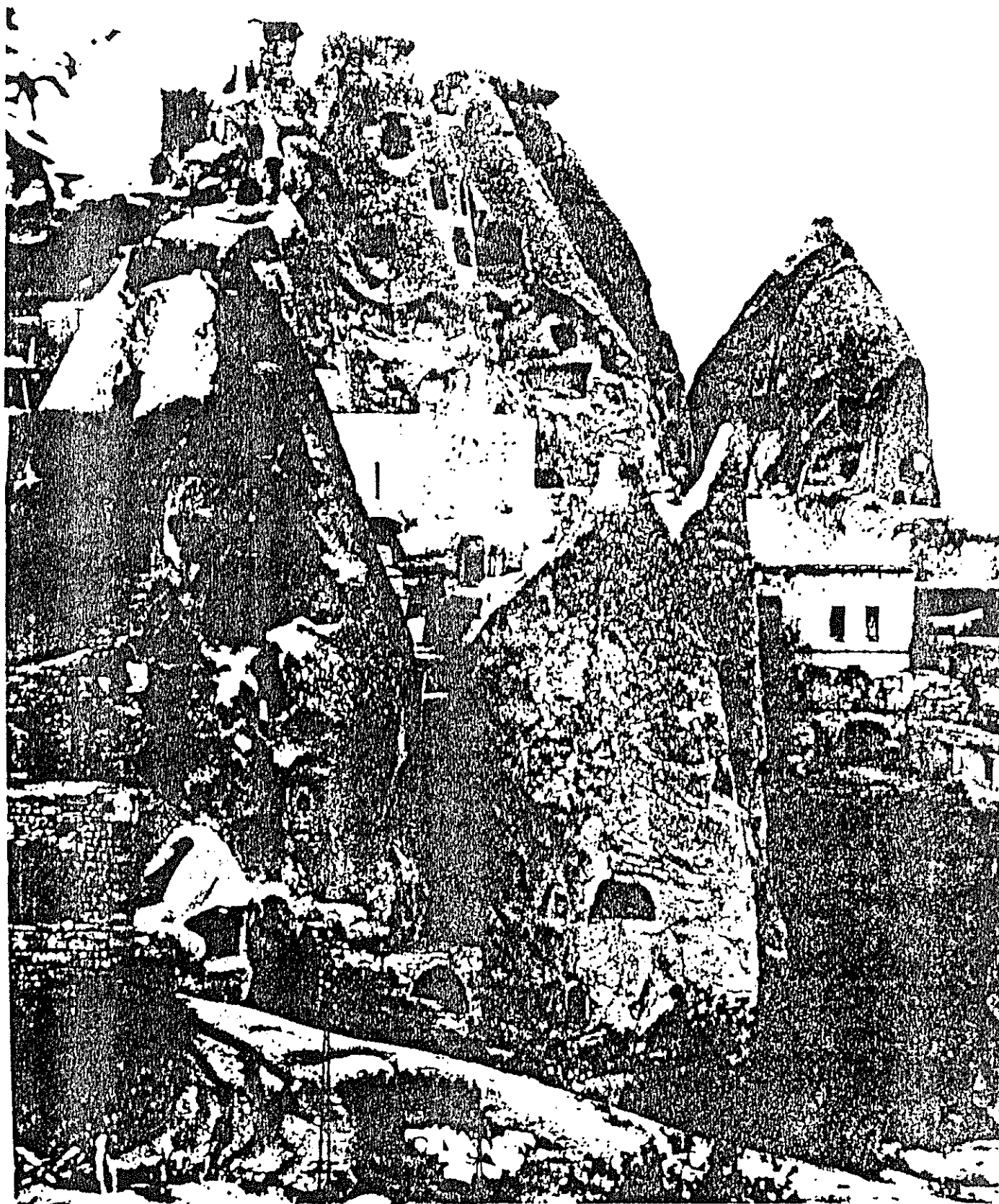
Current studies showed us that (for 40° N) for a house in which all living areas face in a single direction, the most radiation during the underheated is received when orientation is 17.5° to the east of south. This orientation also gives the lowest amount of radiation during the overheated period.

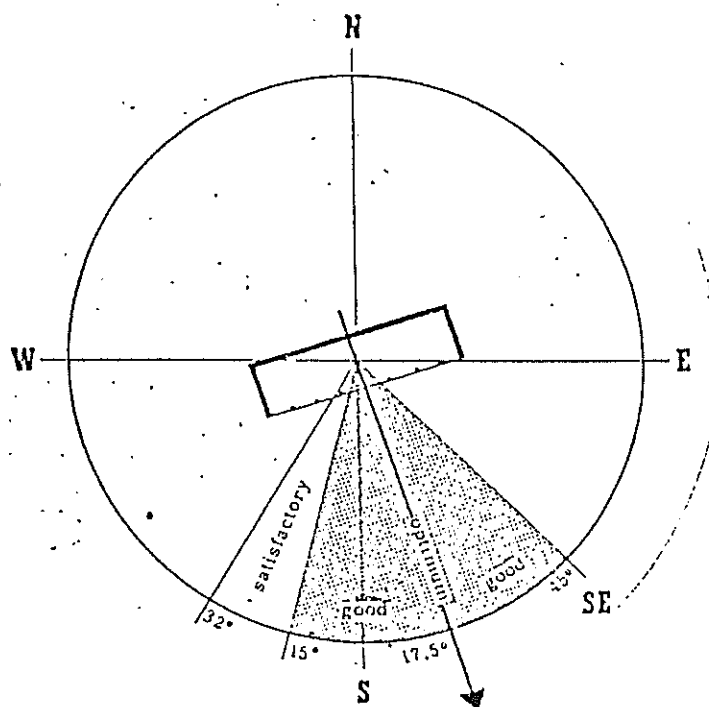
Yearly direct average radiation received at underheated (Ru) and overheated (Ro) periods.

Numbers represent
1000 Btu's per Ft²



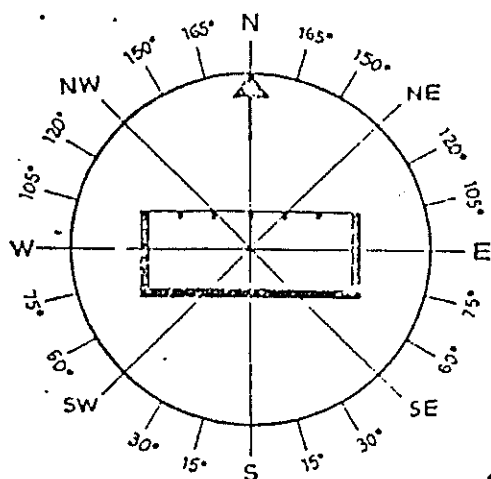
Maximum intensity during the overheated period is received when the building is oriented 17.5° to the south of west. Satisfactory orientation may be found as much as 32° to the southwest, where useful winter radiation is still obtained.





Orientation Chart for Northeastern Part of Turkey

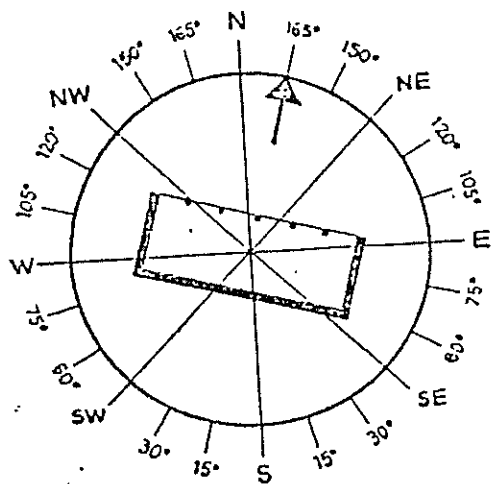
The amount of solar radiation received on vertical surfaces varies according to their orientation and the time of the year. Our goal should be to find the most advantageous orientation, considering both summer and most winter conditions in each construction site.



ORIENTATION : NORTH

R_u IN A YEAR IN THOUSAND BTU-S = 5.8

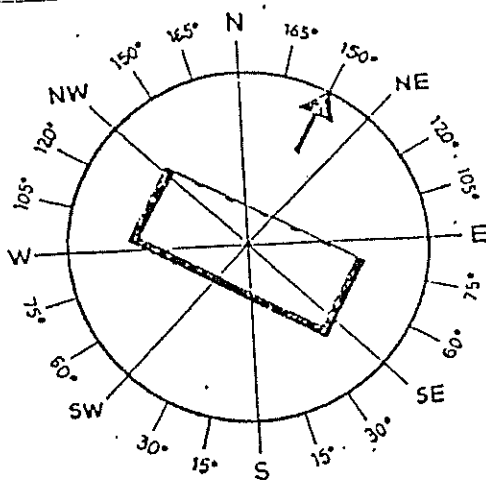
R_o IN A YEAR IN THOUSAND BTU-S = 4.4



ORIENTATION : N-NE 165°

R_u IN A YEAR IN THOUSAND BTU-S = 10.1

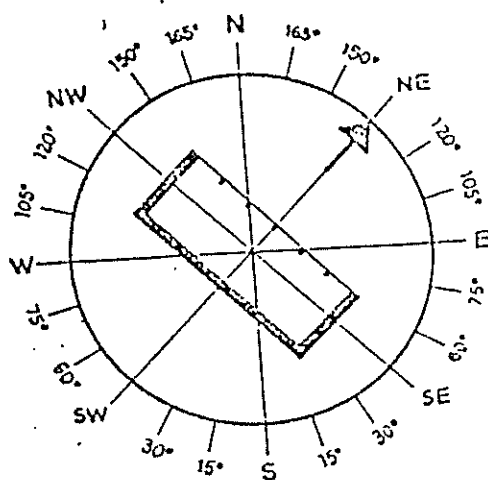
R_o IN A YEAR IN THOUSAND BTU-S = 4.8



ORIENTATION : N-NE 150°

R_u IN A YEAR IN THOUSAND BTU-S = 23.3

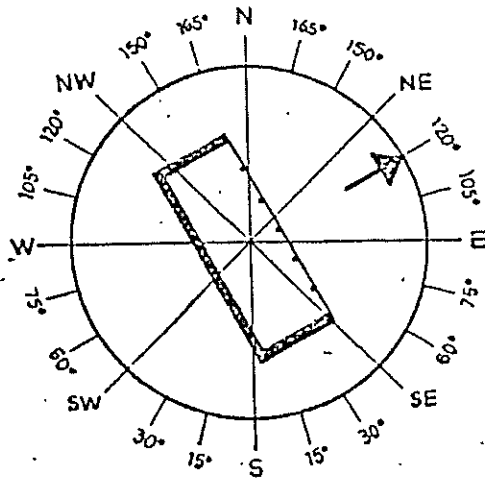
R_o IN A YEAR IN THOUSAND BTU-S = 9.2



ORIENTATION : NE

R_u IN A YEAR IN THOUSAND BTU-S = 39.3

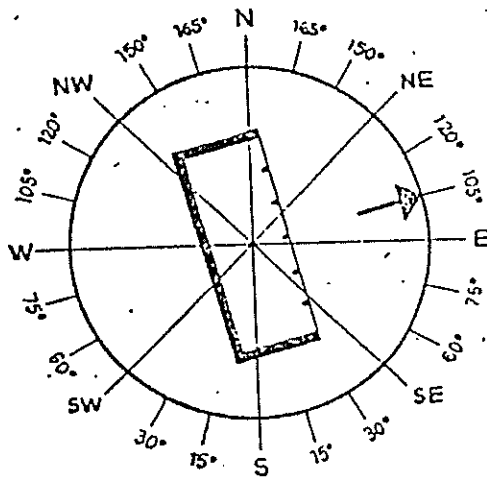
R_o IN A YEAR IN THOUSAND BTU-S = 14.5



ORIENTATION : NE-E 120°

R_U IN A YEAR IN THOUSAND BTU-S = 54.9

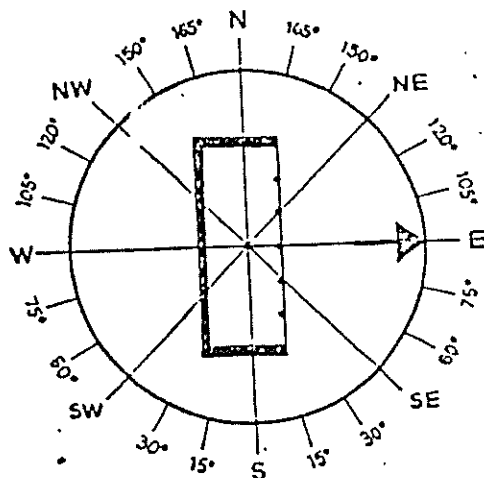
R_O IN A YEAR IN THOUSAND BTU-S = 22.4



ORIENTATION : NE-E 105°

R_U IN A YEAR IN THOUSAND BTU-S = 74.2

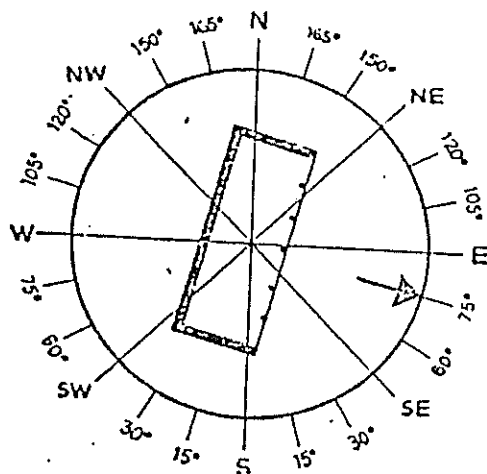
R_O IN A YEAR IN THOUSAND BTU-S = 28.1



ORIENTATION : EAST

R_U IN A YEAR IN THOUSAND BTU-S = 93.7

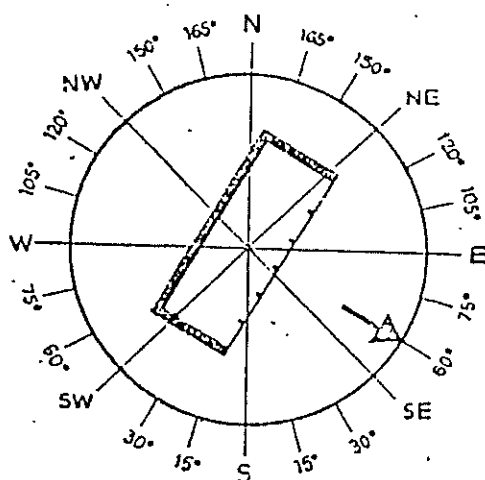
R_O IN A YEAR IN THOUSAND BTU-S = 32.6



ORIENTATION : SE-E 75°

R_u IN A YEAR IN THOUSAND BTU-S = 114.5

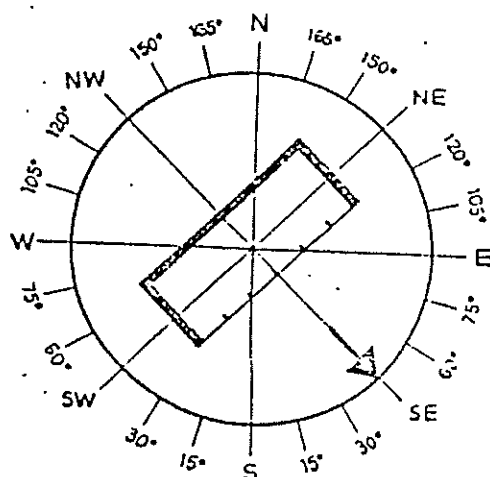
R_o IN A YEAR IN THOUSAND BTU-S = 35.8



ORIENTATION : SE-E 60°

R_u IN A YEAR IN THOUSAND BTU-S = 132.4

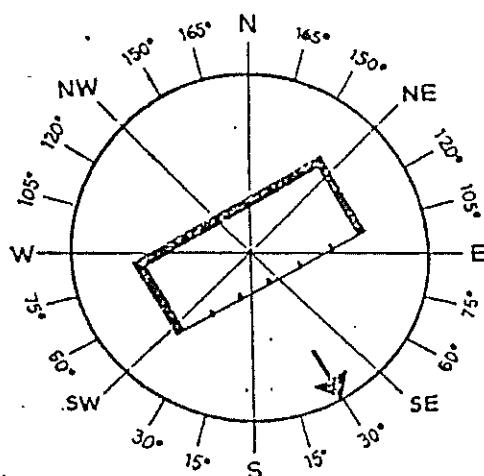
R_o IN A YEAR IN THOUSAND BTU-S = 37.6



ORIENTATION : SE

R_u IN A YEAR IN THOUSAND BTU-S = 145.6

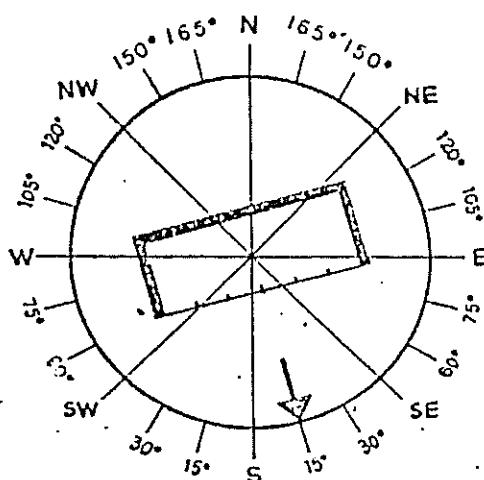
R_o IN A YEAR IN THOUSAND BTU-S = 36.4



ORIENTATION : S-SE 30°

R_u IN A YEAR IN THOUSAND BTU-S = 150.8

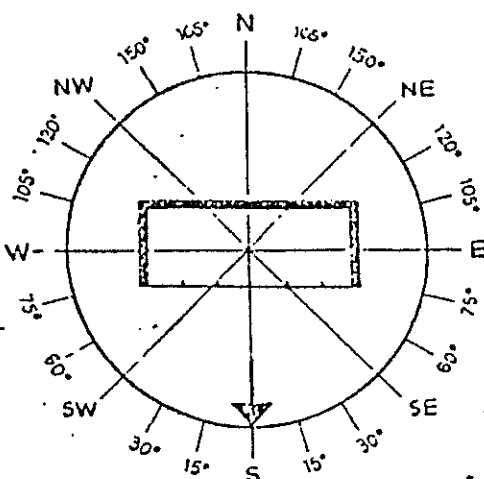
R_o IN A YEAR IN THOUSAND BTU-S = 34.1



ORIENTATION : S-SE 15°

R_u IN A YEAR IN THOUSAND BTU-S = 152.7

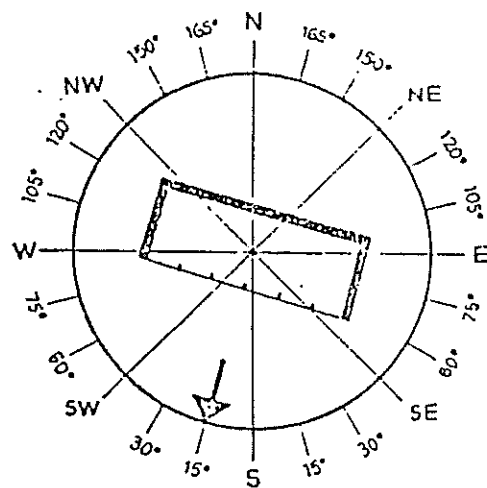
R_o IN A YEAR IN THOUSAND BTU-S = 33.1



ORIENTATION : SOUTH

R_u IN A YEAR IN THOUSAND BTU-S = 149.9

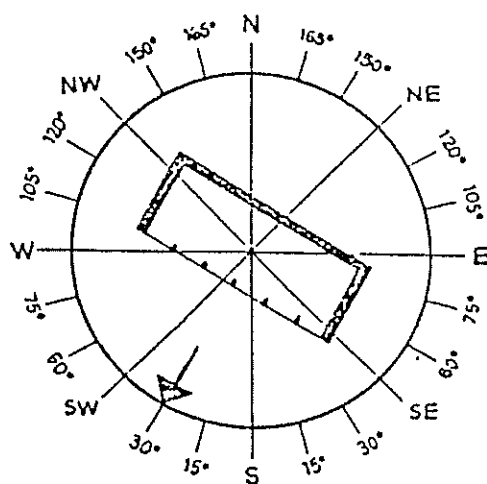
R_o IN A YEAR IN THOUSAND BTU-S = 35.9



ORIENTATION : S - SW 15°

$$R_u \text{ IN A YEAR IN THOUSAND BTU-S} = \boxed{146.2}$$

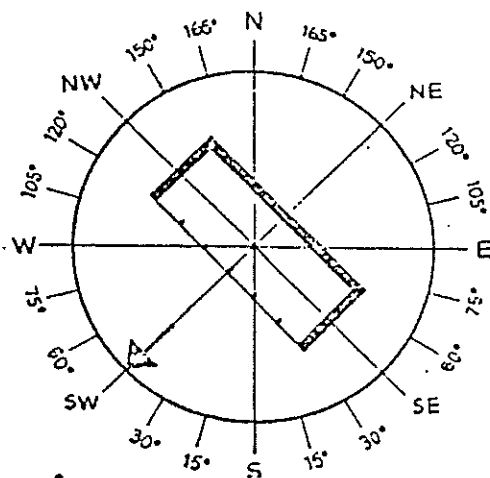
$$R_o \text{ IN A YEAR IN THOUSAND BTU-S} = \boxed{39.5}$$



ORIENTATION : S - SW 30°

$$R_u \text{ IN A YEAR IN THOUSAND BTU-S} = \boxed{140.3}$$

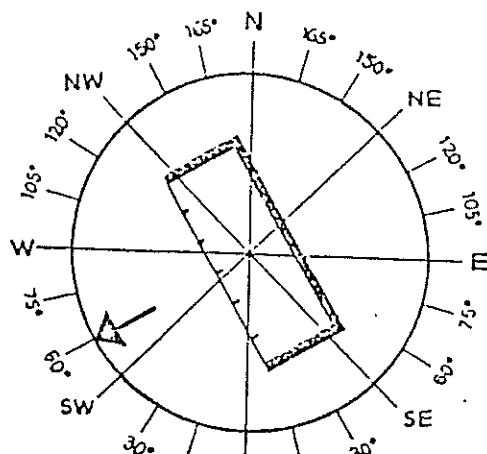
$$R_o \text{ IN A YEAR IN THOUSAND BTU-S} = \boxed{44.6}$$



ORIENTATION : SW

$$R_u \text{ IN A YEAR IN THOUSAND BTU-S} = \boxed{132.8}$$

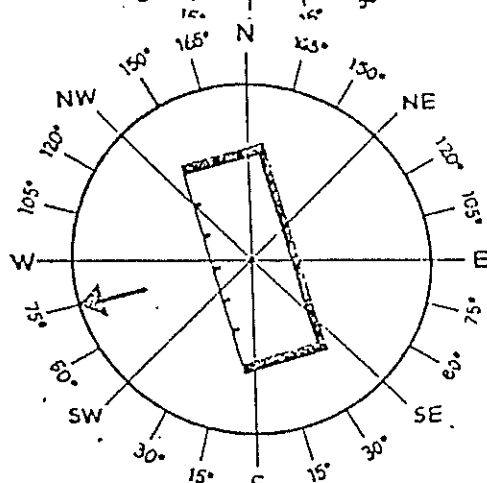
$$R_o \text{ IN A YEAR IN THOUSAND BTU-S} = \boxed{49.2}$$



96
ORIENTATION : SW-W 60°

R_u IN A YEAR IN THOUSAND BTU-S = 117.3

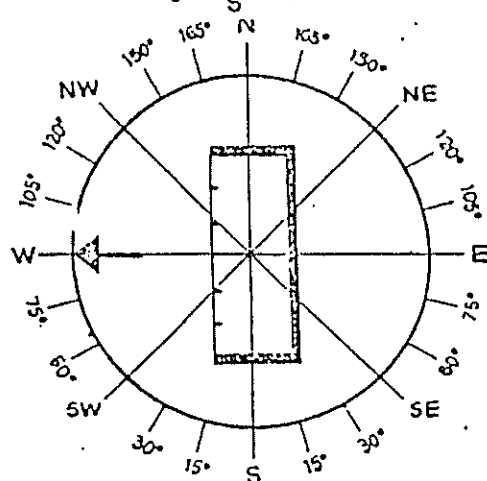
R_o IN A YEAR IN THOUSAND BTU-S = 52.7



ORIENTATION : SW-W 75°

R_u IN A YEAR IN THOUSAND BTU-S = 95.4

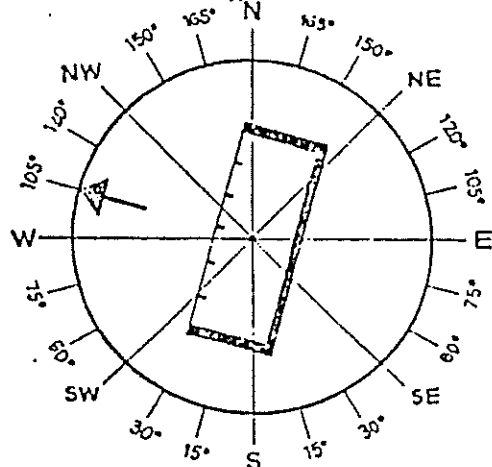
R_o IN A YEAR IN THOUSAND BTU-S = 54.9



ORIENTATION : WEST

R_u IN A YEAR IN THOUSAND BTU-S = 74.4

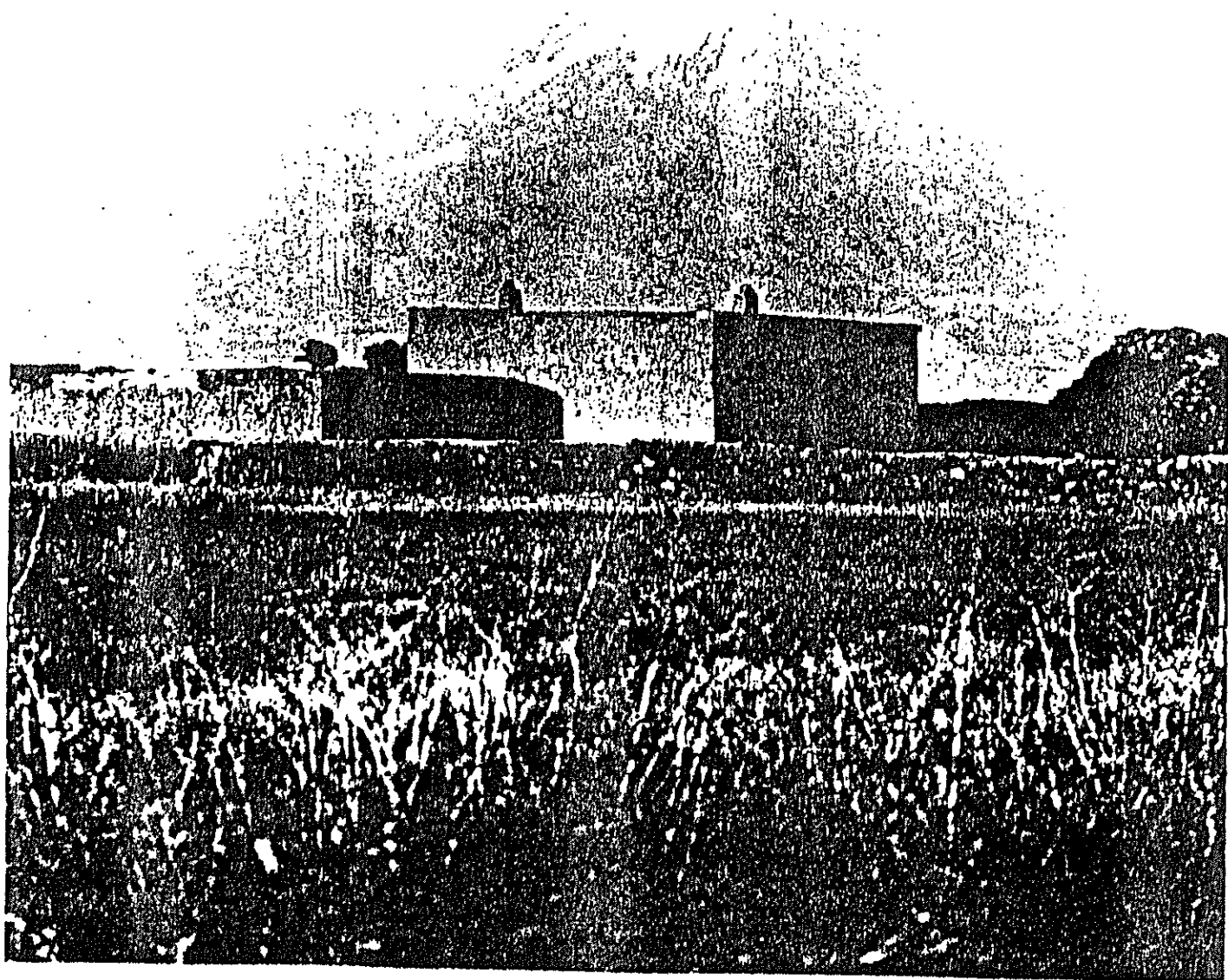
R_o IN A YEAR IN THOUSAND BTU-S = 51.9



ORIENTATION : NW-W 105°

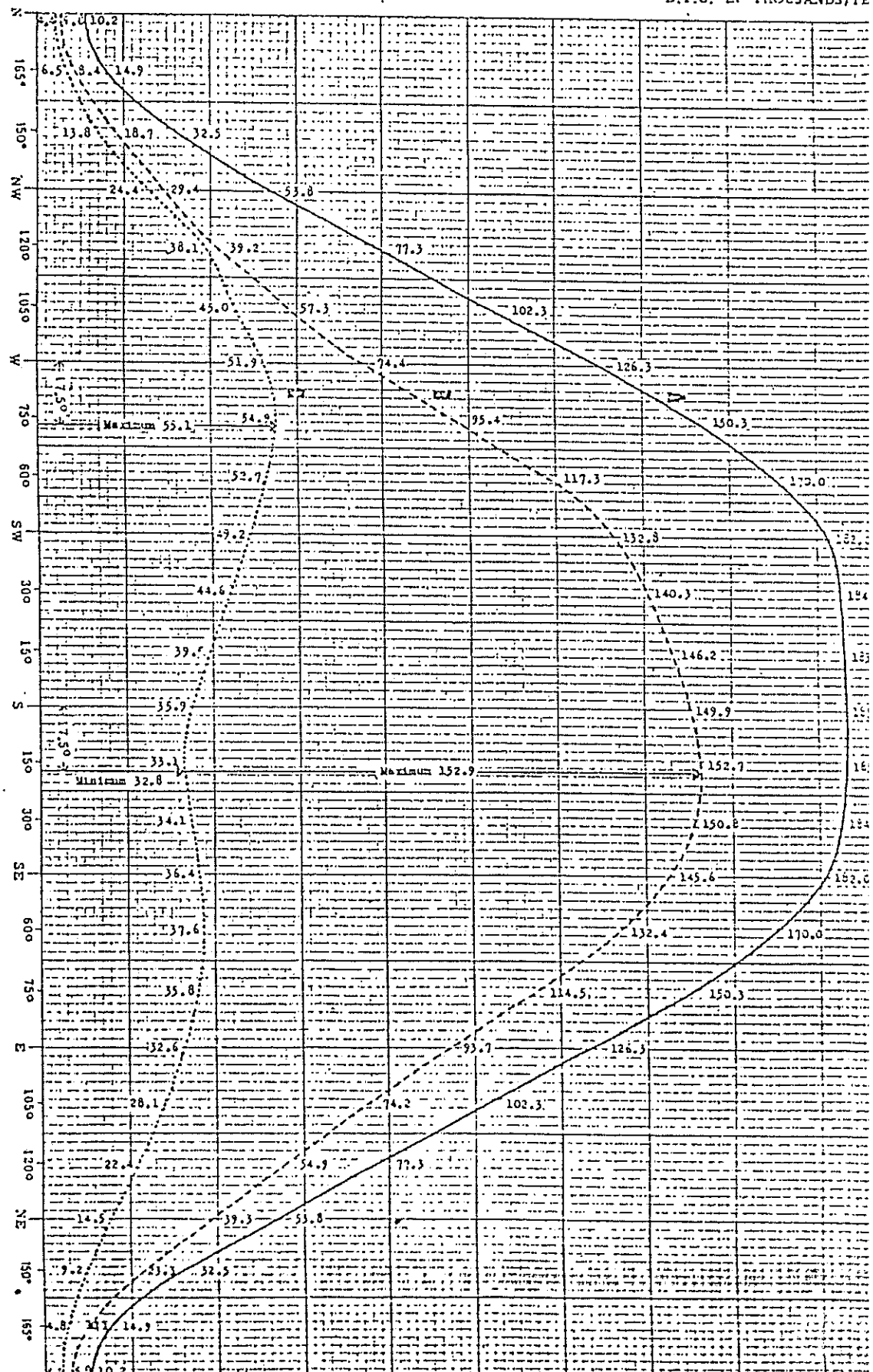
R_u IN A YEAR IN THOUSAND BTU-S = 57.3

R_o IN A YEAR IN THOUSAND BTU-S = 45.0



YEARLY RADIATION RECEIVED ON VERTICAL SURFACES OF DIFFERENT ORIENTATIONS IN NEW YORK - NEW JERSEY AREA.
 "A" CURVE INDICATES THE TOTAL, DIRECT AVERAGE RADIATION
 "B" CURVE INDICATES THE DIRECT AVERAGE RADIATION IN UNDECREENED PERIOD
 "C" CURVE INDICATES THE DIRECT AVERAGE RADIATION IN OVERHEATED PERIOD

(ASHRAE HANDBOOK OF FUNDAMENTALS)
 ORIENTATION



2. Use of space:

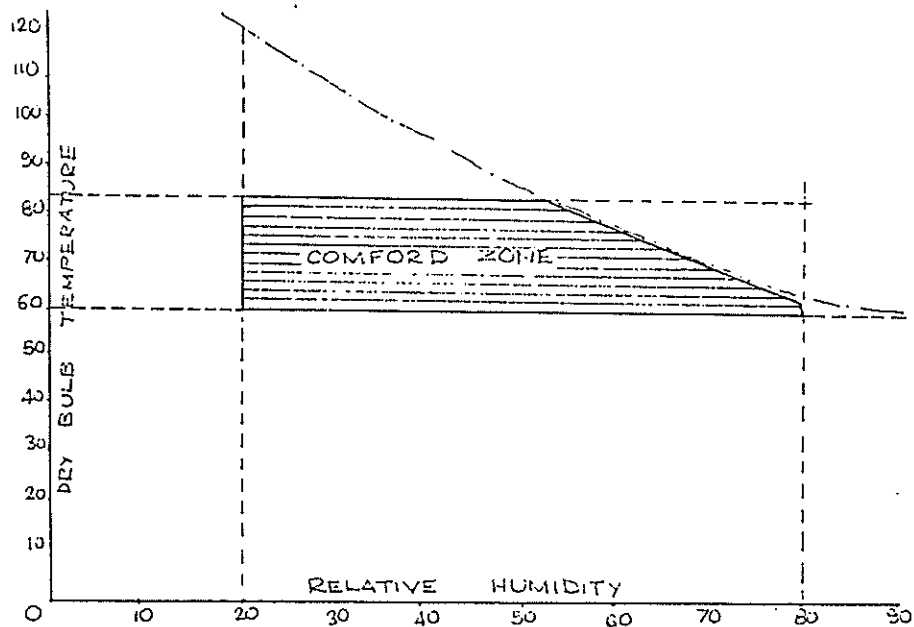
As explained in Chapter I, the Turkish room is where all daily activities take place. Villagers should have an adequate temperature for different activities to be able to reach a desirable indoor environment. For this we have to know the basic thermal processes of the body.

The body, with its activities (sleeping, walking, working, playing), produces a continuous heat. It also loses heat continuously. Heat loss is approximately 80 percent by convection and radiation, 19 percent by evaporation, and 1 percent by conduction. The total of the body's heat gain and heat loss should be zero.

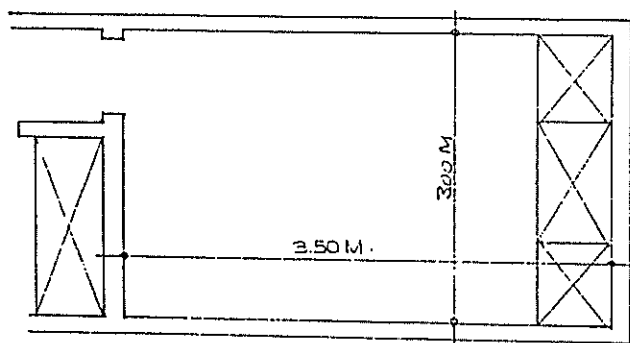
The thermal habitat of man is defined by interacting environmental forces:

1. Radiant and ambient temperatures
2. Relative humidity and air movement

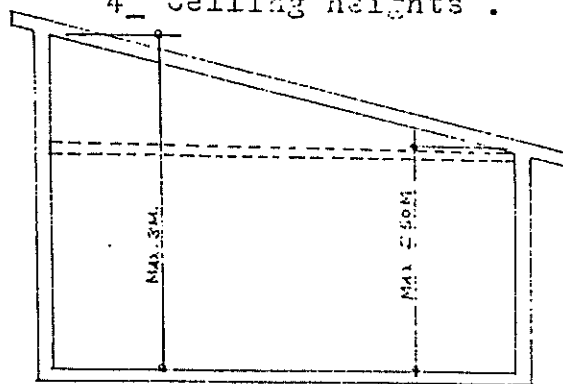
Psychrometric charts are mostly used for identifying comfort zones for male or female, in different age groups, health, activity and level from the sea in different clothing. For developed countries, the comfort zone is between 70-75° F drybulb temperature, and 20-75% relative humidity. The comfort zone is different in developing countries, mostly in rural life. The reasons are activities which are more physical in village life, and clothing.



3 Physical dimensions of space



4 Ceiling heights .



5. Construction materials:

Stone, adobe, wood, sand, lime . . .

6. Surrounding conditions:

Natural color of construction materials are always kept by village man. Since building materials are found on the site, the building very easily becomes a part of the environment. Only houses in southern villages of Turkey are painted white in order to increase reflection of the building envelope.

I am glad to see that village man has a better architectural concept to meet individual regional needs than many contemporary architects.

Reflection and Absorption of Materials

	Reflection %	Absorption %
1. White paint	70-90	10-30
2. White plaster	90-92	8-10
3. Wood:		
a. light oak	25-35	65-75
b. dark oak	10-25	85-90
c. mahogany	6-12	88-94
4. Stone:		
a. limestone	35-60	40-65
b. sandstone	20-40	60-80
5. Adobe	10-30	70-90

7. Windows:

Traditional criteria for window design are connected to daylight and ventilation requirements. Today, functions of

windows are more than just two. We can classify them under four main headings:

1. lighting
2. heating by radiation
3. ventilation
4. communicative importance between exterior and interior (view).

Today's architects should be more careful in the design of windows, because of their dominant role in determining room climate.

In the southeastern part of Turkish villages, the window seems to have developed as an opening for light and ventilation, often covered with an opaque shutter. But in the northeastern part, windows were of limited value until the arrival of glass in the villages, which admitted light while controlling ventilation.

The arrival of transparent glass and the means of assembling it into large transparent sashes opened the way for the use of windows as part of the aesthetics of the interior, bringing abundant light into a room and adding the view of outside gardens or courtyards to the interior visual scene. At the same time, the use of transparent glass broke the technical interdependence of light and ventilation, which was a product of the hole-and-wood shutter technology. But today, in villages, windows are worse than hole-and-wood shutter technology. Our target area (northeastern region), where winters take up three-fourths of the year, and during the long winter days, to reduce heat loss through

windows became an important question. Every window must be resistant to water and wind penetration, and it must have good insulation, such as double glazing.

Since the window acts as a selective energy filter, by using today's knowledge about sun and its influence on environment, we should know how to trap this energy passing through windows. To a large extent, the total heat content is determined by the flow of heat through windows. They are critical in determining the short-term response of thermal conditions in rooms to outside climatic changes and solar radiation levels, and their energy flow affects physical conditions as well as comfort.

In quantitative analysis of window design, the amount of heat and light transmittance may vary from zero to 100 percent, as in the case of a clear opening. In general, the total amount of light or heat transmitted through the glass is proportional to the size of the window. A large window gives more light and heat gain, but also more heat loss when the sun is not shining. Those uses and desirability depend on the type of control chosen.

In extremely cold climates such as the northeastern part of Turkey, humidity higher than 12-13 percent is impractical with a single glazing. Under the same conditions, with double glazing the relative humidity can be maintained in the range of 30-40 percent. The cost of double glazing can be questioned by rural people, but we should always remember that in this specific region

the most interesting aspect of window design to the building owner is the economy of daylight utilization. Window area should be properly designed and engineered to produce the most desirable effect at the lowest cost.

Coefficients of Transmission (U) of Windows

Btu per (hr) (sq. ft.) (F Deg.)

Vertical Panels

Horizontal Panels

Description	Exterior ^a		Interior	Description	Exterior ^a		Interior ^a
	Winter	Summer			Winter ^e	Summer ^f	
Flat Glass single glass	1.13	1.06	0.73	Flat Glass single glass	1.22	0.83	0.96
insulating glass—double ^b				insulating glass—double ^b —			
$\frac{1}{4}$ in. air space	0.69	0.64	0.51	$\frac{1}{4}$ in. air space	0.75	0.49	0.62
$\frac{1}{2}$ in. air space	0.65	0.61	0.49	$\frac{1}{2}$ in. air space	0.70	0.46	0.59
$\frac{3}{4}$ in. air space	0.58	0.56	0.46	$\frac{3}{4}$ in. air space	0.66	0.44	0.56
$\frac{1}{2}$ in. air space, low emissivity coating ^c				$\frac{1}{2}$ in. air space, low emissivity coating ^c			
emissivity = 0.20	0.38	0.36	0.32	emissivity = 0.20	0.46	0.31	0.39
emissivity = 0.40	0.45	0.44	0.38	emissivity = 0.40	0.53	0.36	0.45
emissivity = 0.60	0.52	0.50	0.42	emissivity = 0.60	0.60	0.40	0.50
insulating glass—triple ^b				Glass Block ^d			
$\frac{1}{4}$ in. air spaces	0.47	0.45	0.38	11 × 11 × 3 in. thick with cavity divider	0.53	0.35	0.44
$\frac{1}{2}$ in. air spaces	0.36	0.35	0.30	12 × 12 × 4 in. thick with cavity divider	0.51	0.34	0.42
storm windows				Plastic Bubbles ^g			
1 in.—4 in. air space	0.56	0.54	0.44	single walled	1.15	0.60	—
Glass Block ^d				double walled	0.70	0.46	—
6 × 6 × 4 in. thick	0.60	0.57	0.46				
8 × 8 × 4 in. thick	0.56	0.54	0.44	Description	Single Glass	Double or Triple Glass	Storm Windows
—with cavity divider	0.48	0.46	0.38	Windows			
12 × 12 × 4 in. thick	0.52	0.50	0.41	All Glass ^h	1.00	1.00	1.00
—with cavity divider	0.44	0.42	0.36	Wood Sash—80% Glass	0.90	0.95	0.90
12 × 12 × 2 in. thick	0.60	0.57	0.46	Wood Sash—60% Glass	0.80	0.85	0.80
Single Plastic Sheet	1.00	1.00	0.70	Metal Sash—80% Glass	1.00	1.20	1.20
				Sliding Patio Doors			
				Wood Frame	0.95	1.00	—

From: Ashrae Handbook of Fundamentals, Chapter 20, p. 370.

HEAT LOSSES (0° TO 70°) THROUGH WOOD CASEMENT WINDOWS

Opening, Ft. and In.		Area, Sq. Ft.	Heat Loss through Glass, Btu per Hr.	Crack, Ft.	Infiltration Loss, Btu per Hr.		Total Window Loss, Btu per Hr.	
Width	Height				Weather- stripped	Not Weather- stripped	Weather- stripped	Not Weather- stripped
0'11 1/2"	2'0"	2.40	190	6.92	208	339	398	529
	2'10"	2.72	215	7.58	227	371	442	586
	3'2"	3.04	240	8.26	248	405	488	645
	3'6"	3.36	266	8.92	268	437	534	703
	3'10"	3.68	291	9.58	287	469	578	760
	4'2"	4.00	316	10.26	308	503	624	819
	4'6"	4.32	342	10.92	328	535	670	877
	4'10"	4.64	367	11.58	347	567	714	934
	5'2"	4.96	392	12.26	368	601	760	993
1'3 1/2"	2'6"	3.23	255	7.58	227	371	482	616
	2'10"	3.65	289	8.26	247	405	536	694
	3'2"	4.09	324	8.92	268	437	592	761
	3'6"	4.52	358	9.58	287	469	645	827
	3'10"	4.94	391	10.26	308	503	699	894
	4'2"	5.38	426	10.92	328	535	754	961
	4'6"	5.81	460	11.58	347	567	807	1027
	4'10"	6.23	493	12.26	368	601	861	1094
	5'2"	6.67	528	12.92	388	633	916	1161
1'7 1/2"	2'6"	4.05	320	8.26	248	405	568	725
	2'10"	4.58	362	8.92	268	437	630	799
	3'2"	5.14	407	9.58	287	469	694	876
	3'6"	5.67	448	10.26	308	503	756	951
	3'10"	6.20	490	10.92	328	535	818	1025
	4'2"	6.76	535	11.58	347	567	882	1102
	4'6"	7.29	577	12.26	368	601	945	1178
	4'10"	7.82	619	12.92	388	633	1007	1252
	5'2"	8.38	663	13.58	407	665	1070	1328
1'11 1/2"	2'6"	4.90	388	8.92	268	437	656	825
	2'10"	5.55	439	9.58	287	469	726	908
	3'2"	6.21	491	10.26	308	503	799	994
	3'6"	6.86	543	10.92	328	535	871	1078
	3'10"	7.51	594	11.58	347	567	941	1161
	4'2"	8.17	646	12.26	368	601	1014	1247
	4'6"	8.82	698	12.92	388	633	1086	1331
	4'10"	9.47	749	13.58	407	665	1156	1414
	5'2"	10.13	801	14.26	428	699	1229	1500
2'3 1/4"	2'6"	5.73	453	9.58	287	469	740	922
	2'10"	6.48	513	10.26	308	503	821	1016
	3'2"	7.26	574	10.92	328	535	902	1109
	3'6"	8.02	634	11.58	347	567	981	1201
	3'10"	8.77	694	12.26	368	601	1062	1295
	4'2"	9.55	755	12.92	388	633	1143	1388
	4'6"	10.31	816	13.58	407	665	1223	1481
	4'10"	11.06	875	14.26	428	699	1303	1574
	5'2"	11.84	937	14.92	448	731	1385	1668

HEAT LOSSES (0° to 70°) THROUGH DOUBLE-HUNG WOOD WINDOWS

Opening, Ft. and In.		Area, Sq. Ft.	Heat Loss through Glass, Btu per Hr.	Crack, Ft.	Infiltration Loss, Btu per Hr.		Total Window Loss, Btu per Hr.	
Width	Height				Weather- stripped	Not Weather- stripped	Weather- stripped	Not Weather- stripped
1' 8"	3' 2"	5.29	418	11.34	340	556	758	974
	3' 6"	5.85	462	12.00	360	588	822	1050
	3' 10"	6.40	506	12.66	380	620	836	1126
	4' 2"	6.96	550	13.34	400	654	950	1204
	4' 6"	7.52	594	14.00	420	686	1014	1280
	4' 10"	8.07	638	14.66	440	718	1078	1356
	5' 2"	8.63	682	15.34	460	752	1142	1434
	5' 6"	9.19	726	16.00	480	784	1206	1510
	5' 10"	9.74	770	16.66	500	816	1270	1586
	6' 2"	10.30	814	17.34	520	850	1334	1664
	6' 6"	10.86	859	18.00	540	882	1399	1741
2' 0"	2' 6"	5.00	396	11.00	330	539	726	935
	2' 10"	5.66	448	11.66	350	571	798	1019
	3' 2"	6.34	501	12.34	370	605	871	1106
	3' 6"	7.00	554	13.00	390	637	944	1191
	3' 10"	7.66	606	13.66	410	669	1016	1275
	4' 2"	8.34	660	14.34	430	703	1090	1363
	4' 6"	9.00	712	15.00	450	735	1162	1447
	4' 10"	9.66	764	15.66	470	767	1234	1531
	5' 2"	10.34	818	16.34	490	801	1308	1619
	5' 6"	11.00	870	17.00	510	833	1380	1703
	5' 10"	11.66	922	17.66	530	865	1452	1787
	6' 2"	12.34	976	18.34	550	899	1526	1875
2' 4"	2' 6"	5.83	461	12.00	360	588	821	1049
	2' 10"	6.59	521	12.66	380	620	901	1141
	3' 2"	7.39	585	13.34	400	654	985	1239
	3' 6"	8.16	645	14.00	420	686	1065	1331
	3' 10"	8.92	706	14.66	440	718	1146	1424
	4' 2"	9.72	769	15.34	460	752	1229	1521
	4' 6"	10.49	830	16.00	480	784	1310	1614
	4' 10"	11.25	890	16.66	500	816	1390	1706
	5' 2"	12.05	953	17.34	520	850	1473	1803
	5' 6"	12.82	1014	18.00	540	882	1554	1896
	5' 10"	13.58	1074	18.66	560	914	1634	1988
	6' 2"	14.38	1137	19.34	580	948	1717	2085
2' 8"	2' 6"	15.15	1198	20.00	600	980	1798	2178
	2' 10"	7.56	598	13.66	410	669	1008	1267
	3' 2"	8.46	669	14.34	430	703	1099	1372
	3' 6"	9.35	740	15.00	450	735	1190	1475
	3' 10"	10.23	809	15.66	470	767	1279	1579
	4' 2"	11.13	880	16.34	490	801	1370	1681
	4' 6"	12.02	951	17.00	510	833	1461	1784
	4' 10"	12.90	1020	17.66	530	865	1550	1885
	5' 2"	13.80	1092	18.34	550	899	1642	1991
	5' 6"	14.69	1162	19.00	570	931	1732	2094
	5' 10"	15.57	1232	19.66	590	963	1822	2195
	6' 2"	16.47	1303	20.34	610	997	1913	2300
	6' 6"	17.36	1373	21.00	630	1029	2004	2404

HEAT LOSSES (0° to 70°) THROUGH DOUBLE-HUNG WOOD WINDOWS

Opening, Ft. and In.		Area, Sq. Ft.	Heat Loss through Glass, Btu per Hr.	Crack, Ft.	Infiltration Loss, Btu per Hr.		Total Window Loss, Btu per Hr.	
Width	Height				Weather- stripped	Not Weather- stripped	Weather- stripped	Not Weather- stripped
3' 0"	2' 10"	8.49	672	14.66	440	718	1112	1390
	3' 2"	9.51	752	15.34	460	752	1212	1504
	3' 6"	10.50	831	16.00	480	784	1311	1615
	3' 10"	11.49	909	16.66	500	816	1409	1725
	4' 2"	12.51	990	17.34	520	850	1510	1840
	4' 6"	13.50	1068	18.00	540	882	1608	1950
	4' 10"	14.49	1146	18.66	560	914	1706	2060
	5' 2"	15.51	1227	19.34	580	948	1807	2175
	5' 6"	16.50	1305	20.00	600	980	1905	2285
	5' 10"	17.49	1383	20.66	620	1012	2003	2395
	6' 2"	18.51	1464	21.34	640	1046	2104	2510
	6' 6"	19.50	1542	22.00	660	1078	2202	2620
3' 4"	2' 10"	9.42	745	15.66	470	767	1215	1512
	3' 2"	10.56	835	16.34	490	801	1325	1636
	3' 6"	11.66	922	17.00	510	833	1422	1755
	3' 10"	12.75	1009	17.66	530	865	1539	1874
	4' 2"	13.84	1099	18.34	550	899	1649	1998
	4' 6"	14.99	1186	19.00	570	931	1756	2117
	4' 10"	16.08	1272	19.66	590	963	1862	2235
	5' 2"	17.22	1362	20.34	610	997	1972	2359
	5' 6"	18.32	1449	21.00	630	1029	2079	2478
	5' 10"	19.41	1535	21.66	650	1061	2185	2596
	6' 2"	20.55	1626	22.34	670	1095	2296	2721
	6' 6"	21.65	1713	23.00	690	1127	2403	2840
3' 8"	3' 6"	12.85	1016	18.00	540	882	1556	1898
	3' 10"	14.06	1112	18.66	560	914	1672	2026
	4' 2"	15.30	1210	19.34	580	948	1790	2158
	4' 6"	16.52	1307	20.00	600	980	1907	2287
	4' 10"	17.73	1402	20.66	620	1012	2022	2414
	5' 2"	18.97	1501	21.34	640	1046	2141	2547
	5' 6"	20.19	1597	22.00	660	1078	2257	2675
	5' 10"	21.40	1693	22.66	680	1110	2373	2803
	6' 2"	22.64	1791	23.34	700	1144	2491	2935
	6' 6"	23.86	1887	24.00	720	1176	2607	3063
4' 0"	3' 6"	14.00	1107	19.00	570	931	1677	2038
	3' 10"	15.32	1212	19.66	590	963	1802	2175
	4' 2"	16.68	1319	20.34	610	997	1929	2316
	4' 6"	18.00	1424	21.00	630	1029	2054	2453
	4' 10"	19.32	1528	21.66	650	1061	2178	2589
	5' 2"	20.68	1636	22.34	670	1095	2306	2731
	5' 6"	22.00	1740	23.00	690	1127	2430	2867
	5' 10"	23.32	1845	23.66	710	1159	2555	3004
	6' 2"	24.68	1952	24.34	730	1193	2682	3147
	6' 6"	26.00	2057	25.00	750	1225	2807	3282
4' 4"	4' 6"	19.49	1542	22.00	660	1078	2202	2620
	5' 2"	22.39	1771	23.34	700	1144	2471	2915
	5' 10"	25.24	1966	24.66	740	1208	2736	3204
	6' 6"	28.15	2227	26.00	780	1274	3007	3501

8. Doors:

Heat Loss Through Wood Doors at 70 Deg. Differential

Size of Opening, Inches		Area, Sq. Ft.	Transmission Loss, Btu per Hour		Lin. Ft. of Crack	Infiltration Loss, Btu per Hour			
			No Storm Door	With Storm Door		Weatherstripped		Not Weatherstripped	
Width	Height					With Storm Door	No Storm Door	With Storm Door	No Storm Door
Single Doors									
24	78	13.0	385	274	17.0	595	1190	1190	2380
24	80	13.3	394	281	17.3	605	1211	1211	2422
28	78	15.2	450	321	17.7	619	1239	1239	2478
28	80	15.6	462	329	18.0	630	1260	1260	2520
30	78	16.2	480	342	18.0	630	1260	1260	2520
30	80	16.7	494	352	18.3	640	1281	1281	2562
32	80	17.8	527	376	18.8	658	1316	1316	2632
34	82	19.3	571	407	19.3	675	1351	1351	2702
36	80	20.0	592	422	19.3	675	1351	1351	2702
36	84	21.0	622	443	20.0	700	1400	1400	2800
Double (French) Doors									
48	78	26.0	770	549	27.5	962	1925	1925	3850
48	80	26.7	790	563	28.0	980	1960	1960	3920
48	84	28.0	829	591	29.0	1015	2030	2030	4060
60	78	32.5	962	686	29.5	1032	2065	2065	4130
60	80	33.0	986	703	30.0	1050	2100	2100	4200
60	84	35.0	1036	739	31.0	1085	2170	2170	4340

ASHRAE Handbook of Fundamentals

Coefficients of Transmission (U) for Slab Doors

Btu per (hr) (sq ft) (F Deg)

Thickness ^a	Winter			Summer, No Storm Door
	Solid Wood, No Storm Door	Storm Door ^b		
		Wood	Metal	
1 in.	0.64	0.30	0.39	0.61
1½ in.	0.55	0.28	0.34	0.53
1½ in.	0.49	0.27	0.33	0.47
2 in.	0.43	0.24	0.29	0.42
	Steel Door ¹¹			
1½ in.				
A ^c	0.59	—	—	0.59
B ^d	0.40	—	—	0.39
C ^e	0.47	—	—	0.46

TOTAL HEAT LOSS WITH U-VALUES FROM .06 TO .28

AREA IN SQ FT	VALUE OF U IN BTU PER HR PER DEG TEMP DIFFERENCE PER SQ FT																													
	.06	.07	.08	.09	.10	.11	.12	.13	.14	.15	.16	.17	.18	.19	.20	.21	.22	.23	.24	.25	.26	.27	.28							
	BTU HEAT LOSS AT 0-70 DEG TEMPERATURE DIFFERENCE																													
1	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28					
2	8	10	11	13	14	15	17	19	21	23	25	27	29	31	33	35	37	39	41	43	45	47	49	51	53	55	57	59		
3	13	15	17	19	21	23	25	27	29	32	34	36	38	40	42	44	46	48	50	53	55	57	59	61	63	65	67			
4	17	20	22	25	28	31	34	37	39	42	45	48	50	53	55	58	61	64	67	70	73	76	79	82	85	88	91			
5	21	25	28	32	35	39	42	46	49	53	56	60	63	67	70	74	77	81	84	88	91	95	98	102	105	109	112			
6	25	29	34	38	42	46	50	55	59	63	67	72	75	80	84	88	92	97	101	105	109	113	117	121	125	129	133			
7	29	34	39	44	49	54	59	64	69	74	78	83	88	93	98	103	108	113	118	123	128	133	138	143	147	152	156			
8	34	39	45	50	56	62	67	73	78	84	90	95	100	105	112	118	123	129	134	140	146	151	157	162	167	172	177			
9	39	44	50	57	63	69	76	82	88	95	101	107	113	120	126	132	139	145	151	158	164	170	176	182	188	194	200			
10	42	49	56	63	70	77	84	91	98	105	112	119	126	133	140	147	154	161	168	175	182	189	196	203	210	217	224			
11	46	54	62	69	77	85	92	100	108	116	123	131	139	146	154	162	169	177	185	193	200	208	215	223	231	239	247			
12	50	59	67	75	84	92	101	109	118	126	134	143	151	159	168	176	185	193	202	210	218	227	235	244	252	261	269			
13	55	64	73	82	91	100	109	118	127	137	146	155	164	173	181	191	200	209	218	228	237	246	255	264	273	282	291			
14	59	69	78	88	98	108	118	127	137	147	157	167	176	185	195	205	215	225	235	245	255	265	274	284	294	304	313			
15	53	74	84	95	105	116	126	137	147	158	168	179	189	199	209	219	229	239	249	259	269	279	289	299	309	319	329			
16	57	78	90	101	112	123	134	144	155	166	177	188	199	209	219	229	239	249	259	269	279	289	299	309	319	329	339			
17	71	83	95	107	119	131	143	155	167	179	190	202	214	225	238	250	261	274	285	298	309	321	333	345	357	369	381			
18	75	88	101	113	126	139	151	164	176	189	202	214	226	239	252	265	277	290	302	315	328	340	353	365	378	391	403			
19	80	93	106	120	133	146	160	173	186	200	213	226	239	253	266	279	292	305	319	333	346	359	372	385	398	411	424			
20	84	98	112	125	140	154	168	182	196	210	224	238	252	266	280	294	308	322	336	350	364	378	392	406	420	434	448			
21	83	103	118	132	147	162	176	191	206	221	235	250	265	279	294	309	323	338	353	368	382	397	412	427	441	456	470			
22	92	103	123	139	154	169	185	200	215	231	245	262	277	293	308	323	339	354	370	385	400	415	431	446	461	476	491			
23	97	113	129	145	161	177	193	209	225	242	258	274	290	306	322	337	354	370	386	402	418	434	450	466	482	498	513			
24	101	118	134	151	168	185	202	218	235	252	269	285	302	319	336	352	370	385	403	420	437	454	471	488	505	522	539			
25	105	123	140	158	175	193	210	228	245	263	280	298	315	333	350	367	385	403	420	438	455	473	491	509	526	544	561			
26	109	127	146	164	182	200	218	237	255	273	291	310	327	346	364	382	400	419	437	455	473	491	510	528	546	564	582			
27	113	132	151	170	189	208	227	246	265	284	302	321	340	359	378	397	415	435	454	473	491	510	529	548	567	586	604			
28	119	137	157	176	195	215	235	255	274	294	314	333	352	372	392	412	431	451	470	490	510	529	549	568	588	607	627			
29	122	142	162	183	203	223	244	264	284	305	325	345	365	385	405	425	445	465	485	505	525	545	565	585	605	625	645			
30	125	147	168	189	210	231	252	273	294	315	336	357	378	399	420	441	462	483	504	525	545	566	586	607	627	648	668			
31	130	152	174	195	217	239	260	282	304	326	347	369	391	412	434	455	477	499	521	543	564	586	607	629	650	672	693			
32	134	157	179	202	224	247	269	291	314	336	358	381	403	425	447	469	491	513	535	557	579	601	623	645	667	689	711			
33	139	162	185	208	231	254	277	300	324	347	370	393	415	439	462	485	508	531	554	577	600	623	646	669	692	715	738			
34	143	167	190	214	238	262	285	309	334	357	381	405	428	452	475	500	524	547	571	595	619	643	667	691	715	739	763			
35	147	171	195	221	245	270	294	319	344	368	392	417	441	466	490	515	539	564	588	613	637	661	686	710	734	758	782			
36	151	175	202	227	252	277	302	327	352	377	402	427	452	477	502	527	552	577	602	627	652	677	702	727	752	777	802			
37	155	181	207	233	259	285	311	337	363	389	414	440	465	492	518	544	570	596	622	648	673	699	725	751	776	802	827			
38	159	185	213	239	265	293	319	346	373	399	426	452	479	505	532	559	585	612	639	665	692	718	745	771	798	824	851			
39	164	191	218	245	273	300	328	355	383	410	437	464	491	519	546	573	601	628	655	683	710	737	764	791	818	845	872			
40	168	195	224	252	280	308	336	364	392	420	448	476	504	532	560	588	615	644	672	700	728	756	784	812	840	868	896			
41	172	201	230	258	287	316	344	373	402	431	459	488	517	545	574	603	631	659	688	717	746	775	804	833	862	891	920			
42	175	205	235	265	294	324	353	382	412	441	470	500	529	559	588	617	647	676	706	735	764	794	823	853	882	911	941			
43	181	211	241	271	301	331	361	391	422	452	482	512	542	572	602	632	662	692	722	753	783	813	843	873	903	933	963			
44	185	215	245	277	307	337	367	397	428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878	908	938	968			
45	189	220	252	284	315	347	378	410	442	473	504	536	567	599	630	662	693	725	756	787	818	849	880	911	942	973	1004			
46	193	225	258	290	322	354	386	419	452	483	515	547	580	612	644	676	708	740	772	804	836	868	900	932	964	996	1028			
47	197	230	263	296	329	362	395	428	462	494	526	559	592	625	658	691	724	757	790	823	856	889	922	955	988	1021	1054			
48	202	235	269	302	335	369	403	437	471	504	538	571	605	638	672	706	739	773	806	840	874	907	941	974	1008	1041	1075			
49	205	240	274	309	343	376	412	446	481	515	549	583	617	652	685	720	755	789	823	858	892	926	960	994	1028	1062	1096			
50	210	245	280	31																										

AREA IN SQ FT	VALUE OF U IN BTU PER HR PER DEG TEMP DIFFERENCE PER SQ FT																													
	.05	.07	.09	.09	.10	.11	.12	.13	.14	.15	.16	.17	.18	.19	.20	.21	.22	.23	.24	.25	.26	.27	.28							
	BTU HEAT LOSS AT 0-70 DEG TEMPERATURE DIFFERENCE																													
65	277	323	370	416	462	508	554	601	648	693	739	785	832	878	924	970	1016	1063	1109	1155	1201	1247	1294							
67	281	328	375	422	469	516	563	610	658	704	750	797	844	891	938	985	1032	1079	1125	1172	1219	1266	1313							
68	285	333	381	428	476	524	571	619	667	714	762	809	857	904	952	1000	1047	1095	1142	1189	1237	1284	1332							
69	290	338	386	435	483	531	580	628	677	725	773	821	869	918	966	1014	1063	1111	1159	1208	1256	1305	1353							
70	294	343	392	441	490	539	588	637	685	735	784	833	882	931	980	1029	1078	1127	1176	1225	1274	1323	1372							
71	298	347	396	447	497	547	596	646	696	746	795	845	895	944	994	1044	1093	1143	1193	1243	1292	1342	1392							
72	302	352	403	454	504	555	605	655	705	755	806	857	907	958	1008	1058	1109	1159	1210	1260	1310	1361	1411							
73	307	357	409	460	511	562	613	664	715	766	817	868	919	970	1021	1072	1123	1174	1225	1276	1327	1378	1429							
74	311	362	414	466	518	570	622	673	726	777	829	881	932	984	1035	1087	1139	1191	1243	1295	1347	1399	1450							
75	315	367	420	473	525	578	630	683	735	788	840	893	945	998	1050	1103	1155	1208	1260	1313	1365	1417	1470							
76	319	372	426	479	532	585	638	692	746	799	853	906	959	1013	1066	1119	1172	1225	1278	1331	1384	1437	1490							
77	323	377	431	485	539	593	647	701	755	809	862	916	970	1024	1078	1132	1185	1239	1293	1347	1401	1455	1508							
78	328	382	437	491	546	601	655	710	765	819	874	928	983	1037	1092	1146	1201	1255	1310	1365	1420	1475	1529							
79	332	387	442	498	553	608	664	719	775	830	885	940	995	1050	1105	1161	1217	1272	1327	1383	1438	1494	1549							
80	336	392	448	504	560	616	672	728	784	840	895	952	1008	1064	1120	1176	1232	1288	1344	1400	1456	1512	1568							
81	340	396	454	510	567	624	681	737	794	851	907	964	1021	1078	1134	1191	1248	1305	1362	1419	1476	1533	1590							
82	344	401	459	517	574	632	690	748	806	864	921	979	1037	1095	1153	1211	1269	1327	1385	1443	1501	1559	1617							
83	349	406	465	523	581	639	697	755	814	872	930	988	1046	1104	1162	1220	1278	1336	1394	1453	1511	1569	1627							
84	353	411	470	529	588	647	706	764	824	882	941	1000	1058	1117	1175	1234	1293	1352	1411	1470	1529	1588	1647							
85	357	415	475	535	595	655	714	774	834	893	952	1012	1071	1131	1190	1250	1309	1369	1428	1488	1547	1607	1666							
86	361	421	482	542	602	662	722	783	844	903	963	1023	1084	1144	1204	1264	1324	1385	1445	1505	1565	1625	1685							
87	365	426	487	548	609	670	731	792	854	914	974	1035	1096	1157	1218	1278	1339	1400	1460	1521	1581	1642	1702							
88	370	431	493	554	616	678	739	801	863	924	986	1047	1109	1170	1232	1293	1355	1417	1478	1540	1601	1662	1723							
89	374	436	498	561	623	685	748	810	873	935	997	1059	1121	1184	1246	1308	1371	1433	1495	1557	1619	1681	1743							
90	378	441	504	567	630	693	756	819	882	945	1008	1071	1134	1197	1260	1323	1386	1449	1512	1575	1638	1701	1764							
91	382	446	510	573	637	701	764	828	892	955	1019	1083	1147	1210	1274	1338	1402	1466	1530	1593	1657	1721	1784							
92	386	451	515	580	644	709	773	837	902	965	1030	1095	1159	1224	1288	1352	1417	1482	1546	1610	1675	1739	1803							
93	391	456	521	586	651	716	781	846	911	976	1041	1107	1172	1237	1302	1367	1432	1497	1562	1627	1692	1757	1822							
94	395	461	526	592	658	724	790	855	922	987	1053	1119	1184	1250	1316	1382	1448	1513	1579	1645	1711	1777	1842							
95	399	466	532	599	665	732	798	865	932	999	1065	1131	1197	1263	1330	1396	1463	1529	1595	1662	1728	1794	1860							
96	403	470	538	605	672	739	806	874	942	1009	1075	1142	1209	1276	1344	1411	1478	1545	1612	1679	1746	1813	1880							
97	407	475	543	611	679	747	815	883	952	1019	1086	1154	1222	1290	1358	1426	1494	1562	1630	1698	1766	1834	1902							
98	412	480	549	617	686	755	823	892	961	1029	1098	1166	1235	1303	1372	1441	1510	1579	1648	1717	1786	1855	1924							
99	416	485	554	624	693	762	832	901	971	1040	1109	1178	1247	1317	1386	1456	1525	1595	1665	1735	1805	1875	1945							
100	420	490	560	630	700	770	840	910	980	1050	1120	1190	1260	1330	1400	1470	1540	1610	1680	1750	1820	1890	1960							
200	840	1020	1200	1380	1560	1740	1920	2100	2280	2460	2640	2820	3000	3180	3360	3540	3720	3900	4080	4260	4440	4620	4800	4980						
300	1260	1530	1800	2070	2340	2610	2880	3150	3420	3690	3960	4230	4500	4770	5040	5320	5590	5860	6130	6400	6670	6940	7210	7480						
400	1680	2040	2400	2760	3120	3480	3840	4200	4560	4920	5280	5640	6000	6360	6720	7080	7440	7800	8160	8520	8880	9240	9600	9960						
500	2100	2550	3000	3450	3900	4350	4800	5250	5700	6150	6600	7050	7500	7950	8400	8850	9300	9750	10200	10650	11100	11550	12000	12450						
600	2520	3080	3640	4200	4760	5320	5880	6440	7000	7560	8120	8680	9240	9800	10360	10920	11480	12040	12600	13160	13720	14280	14840	15400						
700	2940	3610	4280	4950	5620	6290	6960	7630	8300	8970	9640	10310	10980	11650	12320	12990	13660	14330	15000	15670	16340	17010	17680	18350						
800	3360	4140	4920	5700	6480	7260	8040	8820	9600	10380	11160	11940	12720	13500	14280	15060	15840	16620	17400	18180	18960	19740	20520	21300						
900	3780	4680	5580	6480	7380	8280	9180	10080	10980	11880	12780	13680	14580	15480	16380	17280	18180	19080	19980	20880	21780	22680	23580	24480						
1000	4200	5200	6200	7200	8200	9200	10200	11200	12200	13200	14200	15200	16200	17200	18200	19200	20200	21200	22200	23200	24200	25200	26200	27200						

422		VALUE OF U IN BTU PER H2 PER DEG TEMP DIFFERENCE PER SQ FT																							
IN 50 FT		BTU HEAT LOSS AT 0-70 DEG TEMPERATURE DIFFERENCE																							
		.29	.30	.32	.34	.36	.38	.40	.42	.44	.46	.48	.50	.52	.54	.56	.58	.60	.70	.80	100	105	110	150	
11	231	231	245	262	277	291	303	313	323	333	343	353	363	373	383	393	403	413	423	433	443	453	463	473	
12	244	252	266	283	298	312	324	334	344	354	364	374	384	394	404	414	424	434	444	454	464	474	484	494	
13	264	273	287	304	319	333	345	355	365	375	385	395	405	415	425	435	445	455	465	475	485	495	505	515	
14	284	294	308	325	340	354	366	376	386	396	406	416	426	436	446	456	466	476	486	496	506	516	526	536	
15	305	315	329	346	361	375	387	397	407	417	427	437	447	457	467	477	487	497	507	517	527	537	547	557	
16	325	335	349	366	381	395	407	417	427	437	447	457	467	477	487	497	507	517	527	537	547	557	567	577	
17	345	355	369	386	401	415	427	437	447	457	467	477	487	497	507	517	527	537	547	557	567	577	587	597	
18	365	375	389	406	421	435	447	457	467	477	487	497	507	517	527	537	547	557	567	577	587	597	607	617	
19	385	395	409	426	441	455	467	477	487	497	507	517	527	537	547	557	567	577	587	597	607	617	627	637	
20	405	415	429	446	461	475	487	497	507	517	527	537	547	557	567	577	587	597	607	617	627	637	647	657	
21	425	435	449	466	481	495	507	517	527	537	547	557	567	577	587	597	607	617	627	637	647	657	667	677	
22	447	457	471	488	503	517	529	539	549	559	569	579	589	599	609	619	629	639	649	659	669	679	689	699	
23	467	477	491	508	523	537	549	559	569	579	589	599	609	619	629	639	649	659	669	679	689	699	709	719	
24	487	497	511	528	543	557	569	579	589	599	609	619	629	639	649	659	669	679	689	699	709	719	729	739	
25	507	517	531	548	563	577	589	599	609	619	629	639	649	659	669	679	689	699	709	719	729	739	749	759	
26	527	537	551	568	583	597	609	619	629	639	649	659	669	679	689	699	709	719	729	739	749	759	769	779	
27	547	557	571	588	603	617	629	639	649	659	669	679	689	699	709	719	729	739	749	759	769	779	789	799	
28	567	577	591	608	623	637	649	659	669	679	689	699	709	719	729	739	749	759	769	779	789	799	809	819	
29	587	597	611	628	643	657	669	679	689	699	709	719	729	739	749	759	769	779	789	799	809	819	829	839	
30	607	617	631	648	663	677	689	699	709	719	729	739	749	759	769	779	789	799	809	819	829	839	849	859	
31	627	637	651	668	683	697	709	719	729	739	749	759	769	779	789	799	809	819	829	839	849	859	869	879	
32	647	657	671	688	703	717	729	739	749	759	769	779	789	799	809	819	829	839	849	859	869	879	889	899	
33	667	677	691	708	723	737	749	759	769	779	789	799	809	819	829	839	849	859	869	879	889	899	909	919	
34	687	697	711	728	743	757	769	779	789	799	809	819	829	839	849	859	869	879	889	899	909	919	929	939	
35	707	717	731	748	763	777	789	799	809	819	829	839	849	859	869	879	889	899	909	919	929	939	949	959	
36	727	737	751	768	783	797	809	819	829	839	849	859	869	879	889	899	909	919	929	939	949	959	969	979	
37	747	757	771	788	803	817	829	839	849	859	869	879	889	899	909	919	929	939	949	959	969	979	989	999	
38	767	777	791	808	823	837	849	859	869	879	889	899	909	919	929	939	949	959	969	979	989	999	1009	1019	
39	787	797	811	828	843	857	869	879	889	899	909	919	929	939	949	959	969	979	989	999	1009	1019	1029	1039	
40	807	817	831	848	863	877	889	899	909	919	929	939	949	959	969	979	989	999	1009	1019	1029	1039	1049	1059	
41	827	837	851	868	883	897	909	919	929	939	949	959	969	979	989	999	1009	1019	1029	1039	1049	1059	1069	1079	
42	847	857	871	888	903	917	929	939	949	959	969	979	989	999	1009	1019	1029	1039	1049	1059	1069	1079	1089	1099	
43	867	877	891	908	923	937	949	959	969	979	989	999	1009	1019	1029	1039	1049	1059	1069	1079	1089	1099	1109	1119	
44	887	897	911	928	943	957	969	979	989	999	1009	1019	1029	1039	1049	1059	1069	1079	1089	1099	1109	1119	1129	1139	
45	907	917	931	948	963	977	989	999	1009	1019	1029	1039	1049	1059	1069	1079	1089	1099	1109	1119	1129	1139	1149	1159	
46	927	937	951	968	983	997	1009	1019	1029	1039	1049	1059	1069	1079	1089	1099	1109	1119	1129	1139	1149	1159	1169	1179	
47	947	957	971	988	1003	1017	1029	1039	1049	1059	1069	1079	1089	1099	1109	1119	1129	1139	1149	1159	1169	1179	1189	1199	
48	967	977	991	1008	1023	1037	1049	1059	1069	1079	1089	1099	1109	1119	1129	1139	1149	1159	1169	1179	1189	1199	1209	1219	
49	987	997	1011	1028	1043	1057	1069	1079	1089	1099	1109	1119	1129	1139	1149	1159	1169	1179	1189	1199	1209	1219	1229	1239	
50	1007	1017	1031	1048	1063	1077	1089	1099	1109	1119	1129	1139	1149	1159	1169	1179	1189	1199	1209	1219	1229	1239	1249	1259	
51	1027	1037	1051	1068	1083	1097	1109	1119	1129	1139	1149	1159	1169	1179	1189	1199	1209	1219	1229	1239	1249	1259	1269	1279	
52	1047	1057	1071	1088	1103	1117	1129	1139	1149	1159	1169	1179	1189	1199	1209	1219	1229	1239	1249	1259	1269	1279	1289	1299	
53	1067	1077	1091	1108	1123	1137	1149	1159	1169	1179	1189	1199	1209	1219	1229	1239	1249	1259	1269	1279	1289	1299	1309	1319	
54	1087	1097	1111	1128	1143	1157	1169	1179	1189	1199	1209	1219	1229	1239	1249	1259	1269	1279	1289	1299	1309	1319	1329	1339	
55	1107	1117	1131	1148	1163	1177	1189	1199	1209	1219	1229	1239	1249	1259	1269	1279	1289	1299	1309	1319	1329	1339	1349	1359	
56	1127	1137	1151	1168	1183	1197	1209	1219	1229	1239	1249	1259	1269	1279	1289	1299	1309	1319	1329	1339	1349	1359	1369	1379	
57	1147	1157	1171	1188	1203	1217	1229	1239	1249	1259	1269	1279	1289	1299	1309	1319	1329	1339	1349	1359	1369	1379	1389	1399	
58	1167	1177	1191	1208	1223	1237	1249	1259	1269	1279	1289	1299	1309	1319	1329	1339	1349	1359	1369	1379	1389	1399	1409	1419	
59	1187	1197	1211	1228	1243	1257	1269	1279	1289	1299	1309	1319	1329	1339	1349	1359	1369	1379	1389	1399	1409	1419	1429	1439	
60	1207	1217	1231	1248	1263	1277	1289	1299	1309	1319	1329	1339	1349	1359	1369	1379	1389	1399	1409	1419	1429	1439	1449	1459	
61	1227	1237	1251	1268	1283	12																			

81	1534	1701	1814	1929	2041	2155	2268	2381	2495	2608	2722	2835	2948	3062	3175	3289	3402	3515	3629	3742	3855	3968	4081	4194	4307	4420	4533	4646	4759	4872	4985	5098	5211	5324	5437	5550	5663	5776	5889	6002	6115	6228	6341	6454	6567	6680	6793	6906	7019	7132	7245	7358	7471	7584	7697	7810	7923	8036	8149	8262	8375	8488	8601	8714	8827	8940	9053	9166	9279	9392	9505	9618	9731	9844	9957	10070	10183	10296	10409	10522	10635	10748	10861	10974	11087	11200	11313	11426	11539	11652	11765	11878	11991	12104	12217	12330	12443	12556	12669	12782	12895	13008	13121	13234	13347	13460	13573	13686	13799	13912	14025	14138	14251	14364	14477	14590	14703	14816	14929	15042	15155	15268	15381	15494	15607	15720	15833	15946	16059	16172	16285	16398	16511	16624	16737	16850	16963	17076	17189	17302	17415	17528	17641	17754	17867	17980	18093	18206	18319	18432	18545	18658	18771	18884	18997	19110	19223	19336	19449	19562	19675	19788	19901	20014	20127	20240	20353	20466	20579	20692	20805	20918	21031	21144	21257	21370	21483	21596	21709	21822	21935	22048	22161	22274	22387	22500	22613	22726	22839	22952	23065	23178	23291	23404	23517	23630	23743	23856	23969	24082	24195	24308	24421	24534	24647	24760	24873	24986	25099	25212	25325	25438	25551	25664	25777	25890	26003	26116	26229	26342	26455	26568	26681	26794	26907	27020	27133	27246	27359	27472	27585	27698	27811	27924	28037	28150	28263	28376	28489	28602	28715	28828	28941	29054	29167	29280	29393	29506	29619	29732	29845	29958	30071	30184	30297	30410	30523	30636	30749	30862	30975	31088	31201	31314	31427	31540	31653	31766	31879	31992	32105	32218	32331	32444	32557	32670	32783	32896	33009	33122	33235	33348	33461	33574	33687	33800	33913	34026	34139	34252	34365	34478	34591	34704	34817	34930	35043	35156	35269	35382	35495	35608	35721	35834	35947	36060	36173	36286	36399	36512	36625	36738	36851	36964	37077	37190	37303	37416	37529	37642	37755	37868	37981	38094	38207	38320	38433	38546	38659	38772	38885	38998	39111	39224	39337	39450	39563	39676	39789	39902	40015	40128	40241	40354	40467	40580	40693	40806	40919	41032	41145	41258	41371	41484	41597	41710	41823	41936	42049	42162	42275	42388	42501	42614	42727	42840	42953	43066	43179	43292	43405	43518	43631	43744	43857	43970	44083	44196	44309	44422	44535	44648	44761	44874	44987	45100	45213	45326	45439	45552	45665	45778	45891	46004	46117	46230	46343	46456	46569	46682	46795	46908	47021	47134	47247	47360	47473	47586	47699	47812	47925	48038	48151	48264	48377	48490	48603	48716	48829	48942	49055	49168	49281	49394	49507	49620	49733	49846	49959	50072	50185	50298	50411	50524	50637	50750	50863	50976	51089	51202	51315	51428	51541	51654	51767	51880	51993	52106	52219	52332	52445	52558	52671	52784	52897	53010	53123	53236	53349	53462	53575	53688	53801	53914	54027	54140	54253	54366	54479	54592	54705	54818	54931	55044	55157	55270	55383	55496	55609	55722	55835	55948	56061	56174	56287	56400	56513	56626	56739	56852	56965	57078	57191	57304	57417	57530	57643	57756	57869	57982	58095	58208	58321	58434	58547	58660	58773	58886	59000	59113	59226	59339	59452	59565	59678	59791	59904	60017	60130	60243	60356	60469	60582	60695	60808	60921	61034	61147	61260	61373	61486	61599	61712	61825	61938	62051	62164	62277	62390	62503	62616	62729	62842	62955	63068	63181	63294	63407	63520	63633	63746	63859	63972	64085	64198	64311	64424	64537	64650	64763	64876	64989	65102	65215	65328	65441	65554	65667	65780	65893	66006	66119	66232	66345	66458	66571	66684	66797	66910	67023	67136	67249	67362	67475	67588	67701	67814	67927	68040	68153	68266	68379	68492	68605	68718	68831	68944	69057	69170	69283	69396	69509	69622	69735	69848	69961	70074	70187	70300	70413	70526	70639	70752	70865	70978	71091	71204	71317	71430	71543	71656	71769	71882	71995	72108	72221	72334	72447	72560	72673	72786	72899	73012	73125	73238	73351	73464	73577	73690	73803	73916	74029	74142	74255	74368	74481	74594	74707	74820	74933	75046	75159	75272	75385	75498	75611	75724	75837	75950	76063	76176	76289	76402	76515	76628	76741	76854	76967	77080	77193	77306	77419	77532	77645	77758	77871	77984	78097	78210	78323	78436	78549	78662	78775	78888	79001	79114	79227	79340	79453	79566	79679	79792	79905	80018	80131	80244	80357	80470	80583	80696	80809	80922	81035	81148	81261	81374	81487	81600	81713	81826	81939	82052	82165	82278	82391	82504	82617	82730	82843	82956	83069	83182	83295	83408	83521	83634	83747	83860	83973	84086	84199	84312	84425	84538	84651	84764	84877	84990	85103	85216	85329	85442	85555	85668	85781	85894	86007	86120	86233	86346	86459	86572	86685	86798	86911	87024	87137	87250	87363	87476	87589	87702	87815	87928	88041	88154	88267	88380	88493	88606	88719	88832	88945	89058	89171	89284	89397	89510	89623	89736	89849	89962	90075	90188	90301	90414	90527	90640	90753	90866	90979	91092	91205	91318	91431	91544	91657	91770	91883	91996	92109	92222	92335	92448	92561	92674	92787	92900	93013	93126	93239	93352	93465	93578	93691	93804	93917	94030	94143	94256	94369	94482	94595	94708	94821	94934	95047	95160	95273	95386	95499	95612	95725	95838	95951	96064	96177	96290	96403	96516	96629	96742	96855	96968	97081	97194	97307	97420	97533	97646	97759	97872	97985	98098	98211	98324	98437	98550	98663	98776	98889	99002	99115	99228	99341	99454	99567	99680	99793	99906	100019	100132	100245	100358	100471	100584	100697	100810	100923	101036	101149	101262	101375	101488	101601	101714	101827	101940	102053	102166	102279	102392	102505	102618	102731	102844	102957	103070	103183	103296	103409	103522	103635	103748	103861	103974	104087	104200	104313	104426	104539	104652	104765	104878	104991	105104	105217	105330	105443	105556	105669	105782	105895	106008	106121	106234	106347	106460	106573	106686	106799	106912	107025	107138	107251	107364	107477	107590	107703	107816	107929	108042	108155	108268	108381	108494	108607	108720	108833	108946	109059	109172	109285	109398	109511	109624	109737	109850	109963	110076	110189	110302	110415	110528	110641	110754	110867	110980	111093	111206	111319	111432	111545	111658	111771	111884	111997	112110	112223	112336	112449	112562	112675	112788	112901	113014	113127	113240	113353	113466	113579	113692	113805	113918	114031	114144	114257	114370	114483	114596	114709	114822	114935	115048	115161	115274	115387	115500	115613	115726	115839	115952	116065	116178	116291	116404	116517	116630	116743	116856	116969	117082	117195	117308	117421	117534	117647	117760	117873	117986	118099	118212	118325	118438	118551	118664	118777	118890	119003	119116	119229	119342	119455	119568	119681	119794	119907	120020	120133	120246	120359	120472	120585	120698	120811	120924	121037	121150	121263	121376	121489	121602	121715	121828	121941	122054	122167	122280	122393	122506	122619	122732	122845	122958	123071	123184	123297	123410	123523	123636	123749	123862	123975	124088	124201	124314	124427	124540	124653	124766	124879	124992	125105	125218	125331	125444	125557	125670	125783	125896	126009	126122	126235	126348	126461	126574	126687	126800	126913	127026	127139	127252	127365	127478	127591	127704	127817	127930	128043	128156	128269	128382	128495	128608	128721	128834	128947	129060	129173	129286	129399	129512	129625	129738	129851	129964	130077	130190	130303	130416	130529	130642	130755	130868	130981	131094	131207	131320	131433	131546	131659	131772	131885	131998	132111	132224	132337	132450	132563	132676	132789	132902	133015	133128	133241	133354	133467	133580	133693	133806	133919	134032	134145	134258	134371	134484	134597	134710	134823	134936	135049	135162	135275	135388	135501	135614	135727	135840	135953	136066	136179	136292	136405	136518	136631	136744	136857	136970	137083	137196	137309	137422	137535	137648
----	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------

Seated at rest	370	350	175	175	195	155	210	140	230	120	250	90
Seated, very light work	450	400	180	220	175	205	215	185	240	150	275	125
Office worker	475	450	180	270	200	250	215	235	245	205	285	165
Standing, walking slowly	550	500	180	370	200	300	220	250	255	245	290	210
Walking, seated	550	500	180	370	200	300	220	250	255	245	290	210
Standing, walking slowly	550	500	180	370	200	300	220	250	255	245	290	210
Severe, light work	500	550	190	360	220	310	240	310	230	270	320	230
Light bench work	600	750	190	550	220	530	245	535	295	455	335	365
Moderate dancing	500	650	220	650	245	605	275	575	325	525	405	450
Walking, 3 mph	1000	1050	270	730	300	700	330	670	350	620	420	540
Heavy work	1500	1450	450	1020	465	925	485	965	525	925	505	845

10. Thermal storage capacity of the house:

Heat gain sources in village houses will be:

	Radiant heat	Conv. heat
Solar: window without inside blinds	100%	--
Solar: window with inside blinds	58%	42%
People	40%	20%
Transmission	60%	40%
Infiltration and ventilation	--	100%

As the radiant heat from sources strikes on the walls, floor or ceiling, it is absorbed by the material of the surface, which makes the surface temperature higher. This temperature difference causes heat flow into the material by conduction and into the air by convection. The heat conducted away from the surface is stored, and the heat convected from the surface becomes an instantaneous cooling load.

Heat storage capacity of the materials:

Solar heat gain through ordinary glass:

Typical wood sash window-Glass area is equal to 85 percent of the sash area. The following table provides data for 40° North latitude, for each month of the year and for each hour of the day. The table also includes the direct and diffused radiation and that portion of the heat absorbed in the glass which gets into space.

-SOLAR HEAT GAIN THRU ORDINARY GLASS-

40°

Btu/(hr) (sq ft sash area)

40°

40° NORTH LATITUDE

Time of Year

Exposure

6

7

8

9

10

11

12 noon

1

2

3

4

5

6

40° SOUTH LATITUDE

Exposure

Time of Year

JUNE 21

North

37

20

11

13

14

14

14

14

14

14

13

12

10

32

South

112

123

112

73

56

44

33

24

14

11

12

10

6

Southeast

East

121

131

120

73

56

44

33

24

14

11

12

10

6

East

Southeast

51

55

107

111

73

41

34

24

14

11

12

10

6

Northeast

South

6

10

12

15

16

14

14

14

13

12

10

6

1

South

Southwest

6

10

12

15

16

14

14

14

13

12

10

6

1

Southwest

West

6

10

12

15

16

14

14

14

13

12

10

6

1

West

Northeast

31

32

103

127

140

130

112

92

71

51

31

11

12

Southeast

Horizontal

117

127

140

130

112

92

71

51

31

11

12

10

6

Horizontal

JULY 23

North

24

14

12

13

14

14

14

14

14

13

12

10

32

South

152

127

135

80

24

14

14

14

14

13

12

10

6

Southeast

East

117

127

135

80

24

14

14

14

14

13

12

10

6

East

Southeast

54

55

107

111

73

41

34

24

14

11

12

10

6

Northeast

South

5

10

12

15

16

14

14

14

13

12

10

6

1

South

Southwest

5

10

12

15

16

14

14

14

13

12

10

6

1

Southwest

West

5

10

12

15

16

14

14

14

13

12

10

6

1

West

Northeast

5

10

12

15

16

14

14

14

13

12

10

6

1

Northeast

Horizontal

24

23

103

127

140

130

112

92

71

51

31

11

12

Horizontal

AUG 24

North

7

7

11

13

14

14

14

14

14

13

12

10

32

South

65

102

91

46

33

24

14

11

12

10

6

Southeast

East

74

102

91

46

33

24

14

11

12

10

6

East

Southeast

25

25

107

111

73

41

34

24

14

11

12

10

6

Northeast

South

3

5

12

15

16

14

14

14

13

12

10

6

1

South

Southwest

3

5

12

15

16

14

14

14

13

12

10

6

1

Southwest

West

3

5

12

15

16

14

14

14

13

12

10

6

1

West

Northeast

9

8

10

13

14

14

14

14

14

13

12

10

6

Southeast

Horizontal

9

8

10

13

14

14

14

14

14

13

12

10

6

Horizontal

SEP 26

North

3

3

7

11

13

14

14

14

14

13

12

10

32

South

6

51

53

21

16

14

14

14

14

13

12

10

6

Southeast

East

6

51

53

21

16

14

14

14

14

13

12

10

6

East

Southeast

9

12

107

111

73

41

34

24

14

11

12

10

6

Northeast

South

6

12

12

15

16

14

14

14

13

12

10

6

1

South

Southwest

6

12

12

15

16

14

14

14

13

12

10

6

1

Southwest

West

6

12

12

15

16

14

14

14

13

12

10

6

1

West

Northeast

3

3

7

11

13

14

14

14

14

13

12

10

32

Southeast

Horizontal

3

3

7

11

13

14

14

14

14

13

12

10

32

Horizontal

OCT 27

North

3

3

7

11

13

14

14

14

14

13

12

10

32

South

6

51

53

21

16

14

14

14

14

13

12

10

6

Southeast

East

6

51

53

21

16

14

14

14

14

13

12

10

6

East

Southeast

9

12

107

111

73

41

34

24

14

11

12

10

6

Northeast

South

6

12

12

15

16

14

14

14

13

12

10

6

1

South

Southwest

6

12

12

15

16

14

14

14

13

12

10

6

1

Southwest

West

6

12

12

15

16

14

14

14

13

12

10

6

1

West

Northeast

3

3

7

11

13

14

14

14

14

13

12

10

32

Southeast

Horizontal

3

3

7

11

13

14

14

14

14

13

12

10

32

Horizontal

NOV 28

North

3

3

7

11

13

14

14

14

14

13

12

10

32

South

6

51

53

21

16

14

14

14

14

13

12

10

6

Southeast

East

6

51

53

21

16

14

14

14

14

13

12

10

6

East

Southeast

9

12

107

111

73

41

34

24

14

11

12

10

6

Northeast

South

6

12

12

15

16

14

14

14

13

12

10

6

1

South

Southwest

6

12

12

15

16

14

14

14

13

12

10

6

1

Southwest

West

6

12

12

15

16

14

14

14

13

12

10

6

1

West

Northeast

3

3

7

11

13

14

14

14

14

13

12

10

32

Southeast

Horizontal

3

3

7

11

13

14

14

14

14

13

12

10

32

Horizontal

COT 20 & FFB 20	North	0	0	2	5	10	14	18	22	26	30	34	38	42	46	50	54	58	62	66	70	74	78	82	86	90	94	98	102	106	110	114	118	122	126	130	134	138	142	146	150	154	158	162	166	170	174	178	182	186	190	194	198	202	206	210	214	218	222	226	230	234	238	242	246	250	254	258	262	266	270	274	278	282	286	290	294	298	302	306	310	314	318	322	326	330	334	338	342	346	350	354	358	362	366	370	374	378	382	386	390	394	398	402	406	410	414	418	422	426	430	434	438	442	446	450	454	458	462	466	470	474	478	482	486	490	494	498	502	506	510	514	518	522	526	530	534	538	542	546	550	554	558	562	566	570	574	578	582	586	590	594	598	602	606	610	614	618	622	626	630	634	638	642	646	650	654	658	662	666	670	674	678	682	686	690	694	698	702	706	710	714	718	722	726	730	734	738	742	746	750	754	758	762	766	770	774	778	782	786	790	794	798	802	806	810	814	818	822	826	830	834	838	842	846	850	854	858	862	866	870	874	878	882	886	890	894	898	902	906	910	914	918	922	926	930	934	938	942	946	950	954	958	962	966	970	974	978	982	986	990	994	998	1002	1006	1010	1014	1018	1022	1026	1030	1034	1038	1042	1046	1050	1054	1058	1062	1066	1070	1074	1078	1082	1086	1090	1094	1098	1102	1106	1110	1114	1118	1122	1126	1130	1134	1138	1142	1146	1150	1154	1158	1162	1166	1170	1174	1178	1182	1186	1190	1194	1198	1202	1206	1210	1214	1218	1222	1226	1230	1234	1238	1242	1246	1250	1254	1258	1262	1266	1270	1274	1278	1282	1286	1290	1294	1298	1302	1306	1310	1314	1318	1322	1326	1330	1334	1338	1342	1346	1350	1354	1358	1362	1366	1370	1374	1378	1382	1386	1390	1394	1398	1402	1406	1410	1414	1418	1422	1426	1430	1434	1438	1442	1446	1450	1454	1458	1462	1466	1470	1474	1478	1482	1486	1490	1494	1498	1502	1506	1510	1514	1518	1522	1526	1530	1534	1538	1542	1546	1550	1554	1558	1562	1566	1570	1574	1578	1582	1586	1590	1594	1598	1602	1606	1610	1614	1618	1622	1626	1630	1634	1638	1642	1646	1650	1654	1658	1662	1666	1670	1674	1678	1682	1686	1690	1694	1698	1702	1706	1710	1714	1718	1722	1726	1730	1734	1738	1742	1746	1750	1754	1758	1762	1766	1770	1774	1778	1782	1786	1790	1794	1798	1802	1806	1810	1814	1818	1822	1826	1830	1834	1838	1842	1846	1850	1854	1858	1862	1866	1870	1874	1878	1882	1886	1890	1894	1898	1902	1906	1910	1914	1918	1922	1926	1930	1934	1938	1942	1946	1950	1954	1958	1962	1966	1970	1974	1978	1982	1986	1990	1994	1998	2002	2006	2010	2014	2018	2022	2026	2030	2034	2038	2042	2046	2050	2054	2058	2062	2066	2070	2074	2078	2082	2086	2090	2094	2098	2102	2106	2110	2114	2118	2122	2126	2130	2134	2138	2142	2146	2150	2154	2158	2162	2166	2170	2174	2178	2182	2186	2190	2194	2198	2202	2206	2210	2214	2218	2222	2226	2230	2234	2238	2242	2246	2250	2254	2258	2262	2266	2270	2274	2278	2282	2286	2290	2294	2298	2302	2306	2310	2314	2318	2322	2326	2330	2334	2338	2342	2346	2350	2354	2358	2362	2366	2370	2374	2378	2382	2386	2390	2394	2398	2402	2406	2410	2414	2418	2422	2426	2430	2434	2438	2442	2446	2450	2454	2458	2462	2466	2470	2474	2478	2482	2486	2490	2494	2498	2502	2506	2510	2514	2518	2522	2526	2530	2534	2538	2542	2546	2550	2554	2558	2562	2566	2570	2574	2578	2582	2586	2590	2594	2598	2602	2606	2610	2614	2618	2622	2626	2630	2634	2638	2642	2646	2650	2654	2658	2662	2666	2670	2674	2678	2682	2686	2690	2694	2698	2702	2706	2710	2714	2718	2722	2726	2730	2734	2738	2742	2746	2750	2754	2758	2762	2766	2770	2774	2778	2782	2786	2790	2794	2798	2802	2806	2810	2814	2818	2822	2826	2830	2834	2838	2842	2846	2850	2854	2858	2862	2866	2870	2874	2878	2882	2886	2890	2894	2898	2902	2906	2910	2914	2918	2922	2926	2930	2934	2938	2942	2946	2950	2954	2958	2962	2966	2970	2974	2978	2982	2986	2990	2994	2998	3002	3006	3010	3014	3018	3022	3026	3030	3034	3038	3042	3046	3050	3054	3058	3062	3066	3070	3074	3078	3082	3086	3090	3094	3098	3102	3106	3110	3114	3118	3122	3126	3130	3134	3138	3142	3146	3150	3154	3158	3162	3166	3170	3174	3178	3182	3186	3190	3194	3198	3202	3206	3210	3214	3218	3222	3226	3230	3234	3238	3242	3246	3250	3254	3258	3262	3266	3270	3274	3278	3282	3286	3290	3294	3298	3302	3306	3310	3314	3318	3322	3326	3330	3334	3338	3342	3346	3350	3354	3358	3362	3366	3370	3374	3378	3382	3386	3390	3394	3398	3402	3406	3410	3414	3418	3422	3426	3430	3434	3438	3442	3446	3450	3454	3458	3462	3466	3470	3474	3478	3482	3486	3490	3494	3498	3502	3506	3510	3514	3518	3522	3526	3530	3534	3538	3542	3546	3550	3554	3558	3562	3566	3570	3574	3578	3582	3586	3590	3594	3598	3602	3606	3610	3614	3618	3622	3626	3630	3634	3638	3642	3646	3650	3654	3658	3662	3666	3670	3674	3678	3682	3686	3690	3694	3698	3702	3706	3710	3714	3718	3722	3726	3730	3734	3738	3742	3746	3750	3754	3758	3762	3766	3770	3774	3778	3782	3786	3790	3794	3798	3802	3806	3810	3814	3818	3822	3826	3830	3834	3838	3842	3846	3850	3854	3858	3862	3866	3870	3874	3878	3882	3886	3890	3894	3898	3902	3906	3910	3914	3918	3922	3926	3930	3934	3938	3942	3946	3950	3954	3958	3962	3966	3970	3974	3978	3982	3986	3990	3994	3998	4002	4006	4010	4014	4018	4022	4026	4030	4034	4038	4042	4046	4050	4054	4058	4062	4066	4070	4074	4078	4082	4086	4090	4094	4098	4102	4106	4110	4114	4118	4122	4126	4130	4134	4138	4142	4146	4150	4154	4158	4162	4166	4170	4174	4178	4182	4186	4190	4194	4198	4202	4206	4210	4214	4218	4222	4226	4230	4234	4238	4242	4246	4250	4254	4258	4262	4266	4270	4274	4278	4282	4286	4290	4294	4298	4302	4306	4310	4314	4318	4322	4326	4330	4334	4338	4342	4346	4350	4354	4358	4362	4366	4370	4374	4378	4382	4386	4390	4394	4398	4402	4406	4410	4414	4418	4422	4426	4430	4434	4438	4442	4446	4450	4454	4458	4462	4466	4470	4474	4478	4482	4486	4490	4494	4498	4502	4506	4510	4514	4518	4522	4526	4530	4534	4538	4542	4546	4550	4554	4558	4562	4566	4570	4574	4578	4582	4586	4590	4594	4598	4602	4606	4610	4614	4618	4622	4626	4630	4634	4638	4642	4646	4650	4654	4658	4662	4666	4670	4674	4678	4682	4686	4690	4694	4698	4702	4706	4710	4714	4718	4722	4726	4730	4734	4738	4742	4746	4750	4754	4758	4762	4766	4770	4774	4778	4782	4786	4790	4794	4798	4802	4806	4810	4814	4818	4822	4826	4830	4834	4838	4842	4846	4850	4854	4858	4862	4866	4870	4874	4878	4882	4886	4890	4894	4898	4902	4906	4910	4914	4918	4922	4926	4930	4934	4938	4942	4946	4950	4954	4958	4962	4966	4970	4974	4978	4982	4986	4990	4994	4998	5002	5006	5010	5014	5018	5022	5026	5030	5034	5038	5042	5046	5050	5054	5058	5062	5066	5070	5074	5078	5082	5086	5090	5094	5098	5102	5106	5110	5114	5118	5122	5126	5130	5134	5138	5142	5146	5150	5154	5158	5162	5166	5170	5174	5178	5182	5186	5190	5194	5198	5202	5206	5210	5214	5218	5222	5226	5230	5234	5238	5242	5246	5250	5254	5258	5262	5266	5270	5274	5278	5282	5286	5290	5294	5298	5302	5306	5310	5314	5318	5322	5326	5330	5334	5338	5342	5346	5350	5354	5358	5362	5366	5370	5374	5378	5382	5386	5390	5394	5398	5402	5406	5410	5414	5418	5422	5426	5430	5434	5438	5442	5446	5450	5454	5458	5462	5466	5470	5474	5478	5482	5486	5490	5494	5498	5502	5506	5510	5514	5518	5522	5526	5530	5534	5538	5542	5546	5550	5554	5558	5562	5566	5570	5574</
-----------------------	-------	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	--------

1. Family Group

1 single
 2 "
 3 "
 4 "
 1 couple
 " " 1 single
 " " 2 "
 " " 3 "
 " " 4 "
 " " 5 "
 " " 6 "
 " " 7 "
 2 "
 " " 1 "
 " " 2 "
 " " 3 "
 " " 4 "
 " " 5 "
 " " 6 "
 3 "
 " " 1 "
 " " 2 "
 " " 3 "
 " " 4 "

2. Number of Rooms

1
 2
 3
 4
 5
 6
 7
 8
 9
 10
 11
 12

3. Room Area

M2 Ft²
 10
 11
 12
 13
 14
 15
 16
 17
 18
 19
 20
 21
 22
 23
 24
 25

6. Dwelling form
(Type)

Detached
 Equal
 Linear
 Patio
 Court
 Atrium

7. Roof type

Flat
 Shed
 Gable
 Curve

9. Orientation
(Direction)

NE
 E
 SE
 S
 SW
 W
 NW
 N

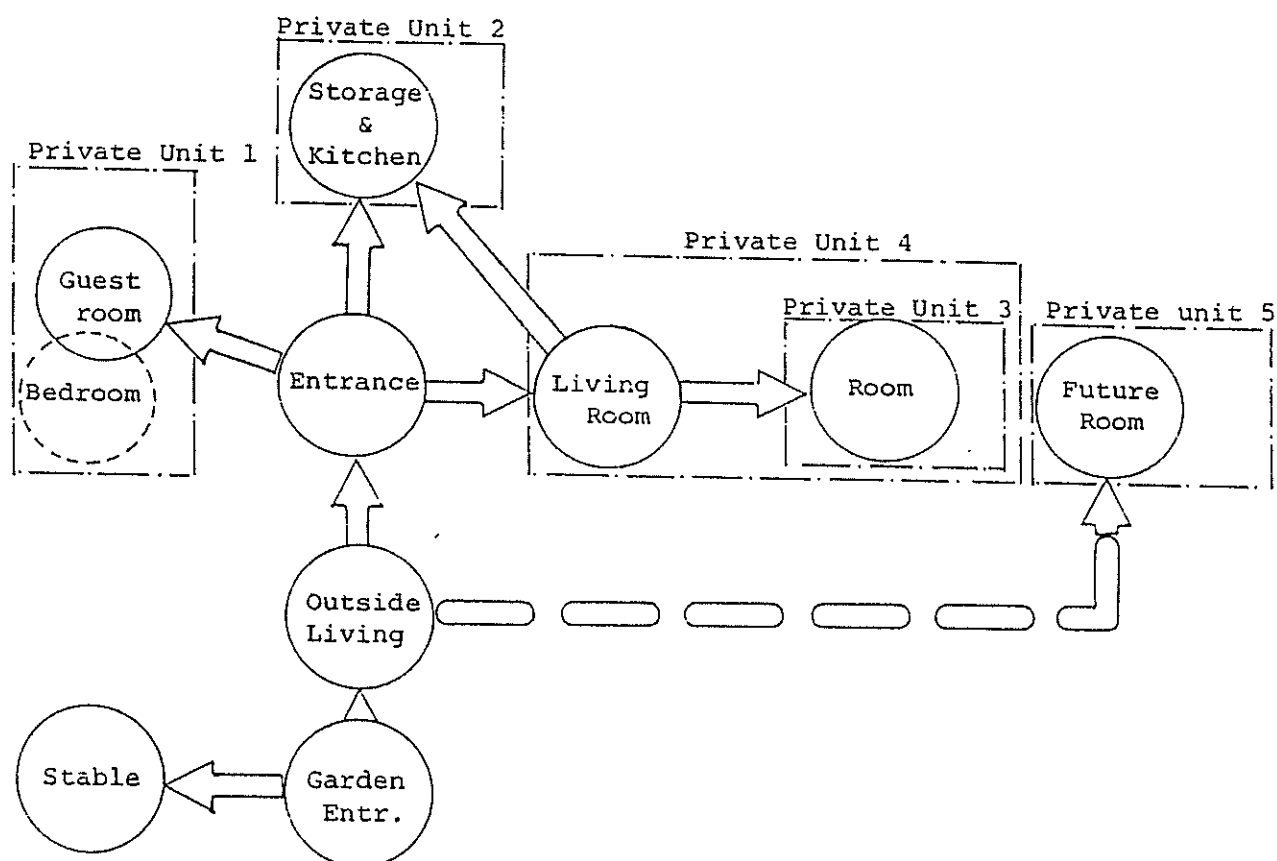
10. Life Cycle

40
 50
 100
 150
 200
 250
 300
 350

11. Material (type)

Fiber
 Paper
 Cloth
 Plastic
 Wood
 Earth
 Masonry
 Concrete
 Steel
 Aluminum

1. Influence of culture to the plan:



2. Influence of climate on plan:

Orientation 17.5 S-SE

Building shape



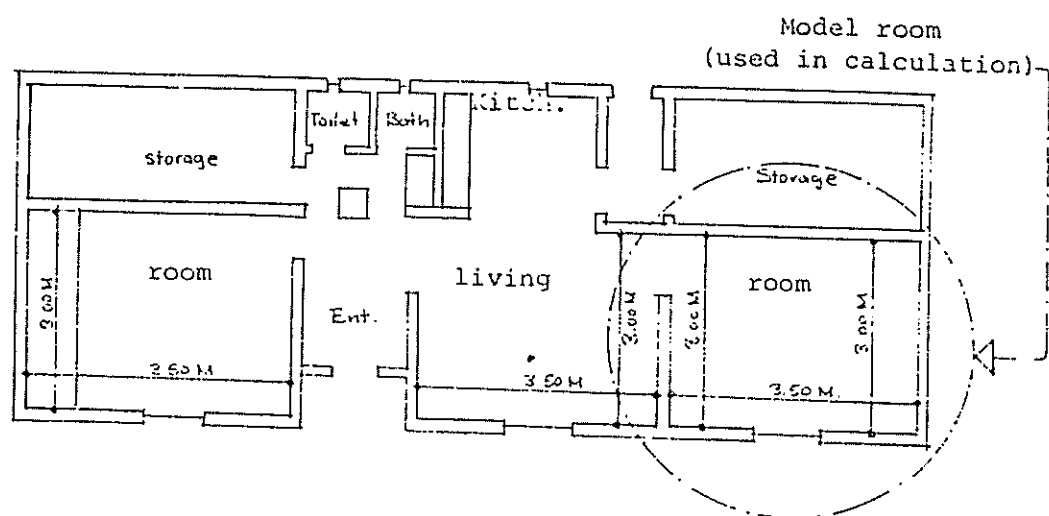
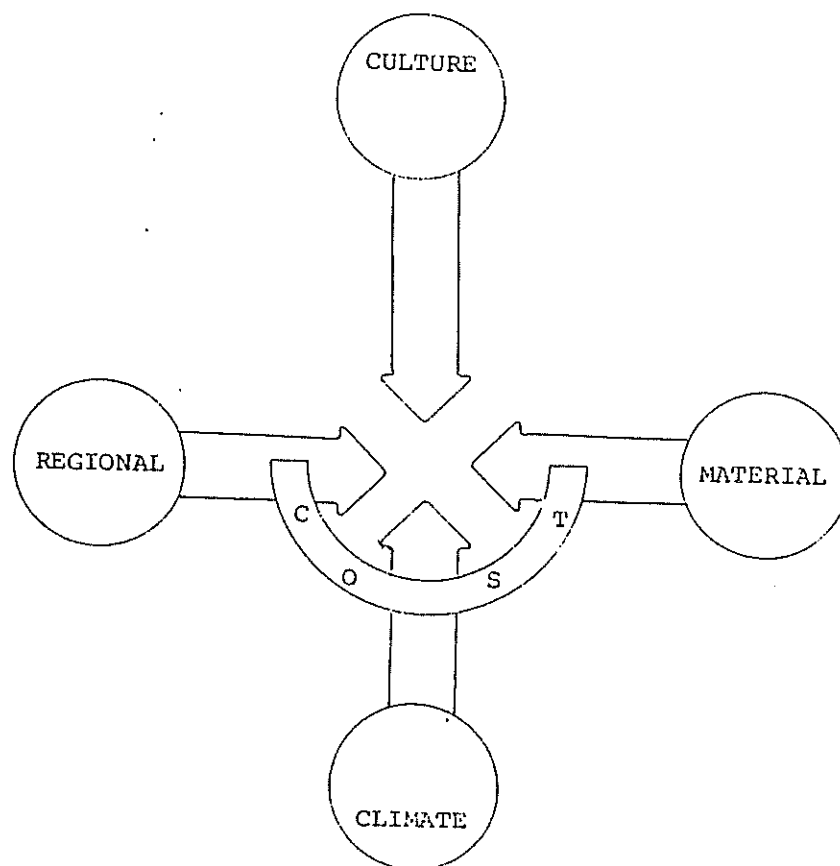
"U" values of building materials

Window size, orientation

Roof shape

Central plan (for heating purposes)

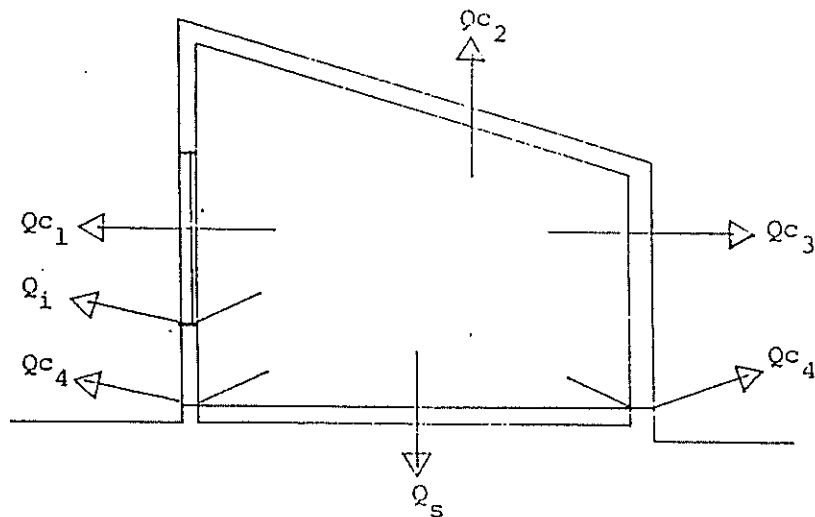
3. Regional influences on the plan:
 - Availability of the materials.
4. Influence of materials:
 - Construction system.



Heat Loss Calculation Methodology

As we see before, heat loss in the building occurs in three ways: conduction, convection and radiation.

Each material in the building envelope has a resistance value, "R". The total resistance R_T of the material is the sum of the individual component resistances. $\frac{1}{R_T}$ is called the "U" value, and it is used to calculate how much heat is lost in Btu or calories through one square foot (or cm^2) of material. Once the "U" values have been determined for all building sections, they are plugged into the following formulae:



Q_{c1} = Conduc. heat loss through window in Btu U.

Q_{c2} = Conduc. heat loss through roof in Btu U.

Q_{c3} = Conduc. heat loss through walls in Btu U.

Q_{c4} = Conduc. heat loss through slab edges in Btu U.

Q_i = Convec. heat loss around window and doors.

Q_s = Conduc. heat loss through floor.

Heat loss formulas:

$$Q_{c_{1,2,3}} = A [U (t - t_o)]$$

where:

A - area of assembly in square feet

U - overall coefficient of heat trans. in Btu/Ft²/°F

t - indoor temperature

t_o - outdoor temperature

$$Q_{c_4} = F [P (t - t_o)]$$

where:

F - edge loss factor

P - perimeter of floor slab in feet

$$Q_i = 0.018 g (t - t_o)$$

where:

g - total infiltration air volume in cubic feet
per hour

Total heat loss in Btu:

$$Q = \sum Q_{1,2,3} + Q_4 + Q_i + Q_s$$

Transmission Coefficient "U"

Transmission coefficient, or "U", value is the rate of which heat is transferred through a building structure in Btu/(hr)(sq. ft.)(°F). In Turkish village houses, the "U" value of construction materials is as follows:

Materials	Thickness (inches)	Weight lb. per sq. ft.	"U" Btu/ hr.-sq.ft.-°F	3/8" gypsum	5/7" Plaster
Stone	8	100	0.67	0.55	0.63
	12	150	0.55	0.47	0.52
	16	200	0.47	0.41	0.45
	24	300	0.36	0.32	0.35
Adobe	8	26	0.34	0.30	0.32
	12	40	0.25	0.23	0.24
Wood	1		0.69		
	1-1/4		0.59		
	1-1/2		0.52		
	1-3/4		0.51		
	2		0.46		
	2-1/2		0.38		
	3		0.33		

Suggested "U" Coefficients for Walls

According to ASREA standards, in winter, a surface temperature of about 5° F (or less) below indoor air temperature provides satisfactory comfort conditions. For the northeastern part of Turkey, following are the given satisfactory U coefficient values. (Reference: T. S. Rogers, Thermal Design of Building, New York, J. Milly, 1964.)

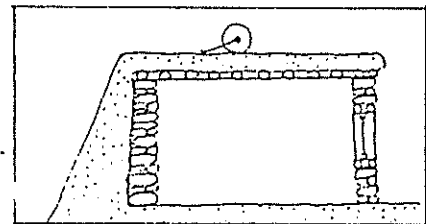
Wall surface Temperature °F	"U" Value
74	0.03
72	0.05
70	0.09
68	0.12
66	0.16
64	0.19
62	0.23
60	0.26

Suggested "U" Values for Ceiling

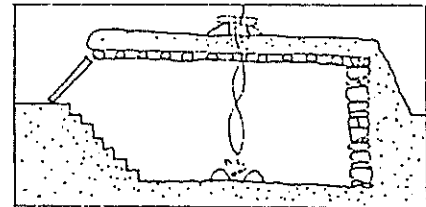
74	0.03
72	0.05
70	0.10
68	0.13
66	0.18
64	0.21
62	0.26
60	0.29

When we made the comparison between "U" coefficients of walls and roofs with the tables of suggested "U" coefficients, we find out that in the northeastern part of Turkey the building envelope can not be efficient with traditional wall and roof types. Rural people of this region reached the same conclusion through their own experiences. For this reason, today we can find "bermed," "underground," or "dug-in houses" in the area of interest.

Bermed house: built on flat lots, with soil pushed around and on the roof of the house.



Underground house: built partly or completely below grade. Chimney and entrance door ventilate the house and bring in sunshine.



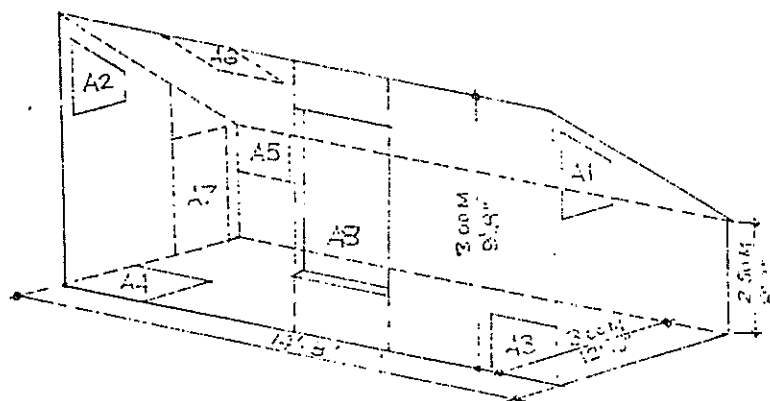
Dug-in house: Excavated into slopes of hillsides.



As Thomas Bligh (Professor, University of Minnesota) points out, going underground can mean energy savings of 75 percent or more in a typical home. It is not because of the insulation value or temperature of the earth that this savings occurs. Soil moderates temperature extremes. By moderating temperatures, the highs and lows of the climate are removed, and the heating system has only to cope with a steady temperature. According to Bligh, the wide

surface fluctuation of temperatures is essentially eliminated below eight inches of soil.

I believe that combining the thermal moderating properties of soil with the thermal-mass concept of passive solar heating can achieve our goal in this specific region of Turkey. Of the bermed, underground and dug-in houses, I believe bermed houses are the most efficient ones because of precipitation and lack of insulation materials. But in most developing countries, where hot and dry climate occurs, all types of earth integrated architecture can be used successfully.



Areas:

A ₁ - East wall	108.9 ft ²	
A ₂ - West "	90.96 "	
A ₃ - South "	135.04 "	
A ₄ - Floor	179.08 "	
A ₅ - North wall	121.36 "	
A ₆ - Roof	180.56 "	
A ₇ - Door	17.94 "	
A ₈ - Window	10.00 "	
Total wall area	456.26 ft ²	0.16
Roof area	180.56 "	0.18
Floor area	179.08 "	0.16
Door area	17.94 "	0.37
Window area	10.00 "	1.13 day
		0.7 night
Room temperature constant 65°		
Outside temperature - coldest day		
	max: 45° F	
	Min: 15° F	

Time:	A.M.						DAY												P.M.					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Temp:	15	15	15	15	15	15	21	27	33	39	45	45	45	39	33	27	21	15	15	15	15	15	15	15
($t_i - t_o$)	50	50	50	50	50	50	44	38	32	26	20	20	20	26	32	38	45	50	50	50	50	50	50	50

Wall $456.26 \times 0.16 = 73.0016$

Roof $180.56 \times 0.18 = 32.5008$

Floor $179.08 \times 0.16 = 28.6528$

Door $17.94 \times 0.37 = 6.6378$

140.793

Window: day $10 \times 1.13 = 11.3$

night $10 \times 0.7 = 7.0$

HL - Daytime / H $140.793 + 11.3 = 152.093$

Nighttime/H $140.793 + 7 = 147.793$

AM	1	147.793
	2	"
	3	"
	4	"
	5	"
	6	"
	7	152.093
	8	"
	9	"
	10	"
	11	"
	12	"
PM	13	"
	14	"
	15	"
	16	"
	17	"
	18	147.793
	19	"
	20	"
	21	"
	22	"
	23	"
	24	"

Heat Loss 147777.07 Btu/day

Heat gain from window: $1086 \times 10 = 10860 \text{ Btu}$

Passive solar collector: $18 \text{ sq. ft.} \times 300 = 5400 \text{ Btu/hr.}$

Max. 4 collectors for each room

$5400 \times 4 = 21,600 \text{ Btu/hr.}$

in 10 hours operation: $216,000 \text{ Btu/day}$

$\Sigma \text{Heat gain} = 216,000 + 10,860 = 226,860 \text{ Btu/day}$

$\Sigma \text{Heat loss} = 147777.07 \text{ Btu/day}$

$\Sigma \text{Heat gain} = 226860.0 \text{ Btu/day}$

Solution 1

2 collectors for each room

$5400 \times 2 = 104,000 \text{ Btu/day}$

$\Sigma \text{Heat loss} = 147,777.07 \text{ Btu/day}$

a) Heat gain = $\frac{104,000.0}{32,917} \text{ Btu/day for collector}$

$\frac{3950}{8.5 \text{ pound wood}}$

b) Heat gain $10,860.0 \text{ Btu/day from window}$

c) Heat gain $32,917.0 \text{ Btu from stove (8.5 pounds wood)}$

Solution 2

$\Sigma \text{Heat loss} = 147,777.07 \text{ Btu/day}$

a) Heat gain = $10,860.0 \text{ Btu/day from window}$

b) Heat gain = $136,917.07 \text{ Btu from stove (34.8 pounds wood)}$

Solution 3

CHAPTER IV
IMPROVED SELF-SUFFICIENT HOUSE CONSTRUCTION
FOR TURKISH RURAL FAMILIES

Improved housing for rural families means a home that is, above all, low in cost, easily maintained, self-sufficient, planned for cultural and traditional needs, and equipped for better family living. These requirements should be met with the equipment, skills and materials already available in the villages.

In the building of a low-cost home, price must be considered at every step: design, selection of materials (readily available or not), construction, the type of foundations, the amount of wood used in construction, the kind of windows and doors, kitchen cabinets, floor covering, plumbing. All can vary immensely and generally influence the overall cost of the house. A small house can be constructed at a reasonable cost and can provide good family living, be as pleasant in appearance as higher costing houses if accompanied by good planning and adequate available construction materials.

BUILDING CONSTRUCTION

We can generalize major parts of a building as follows:

1. foundation system
2. wall system
3. floor system
4. roof system
5. openings (windows, doors)

Foundations:

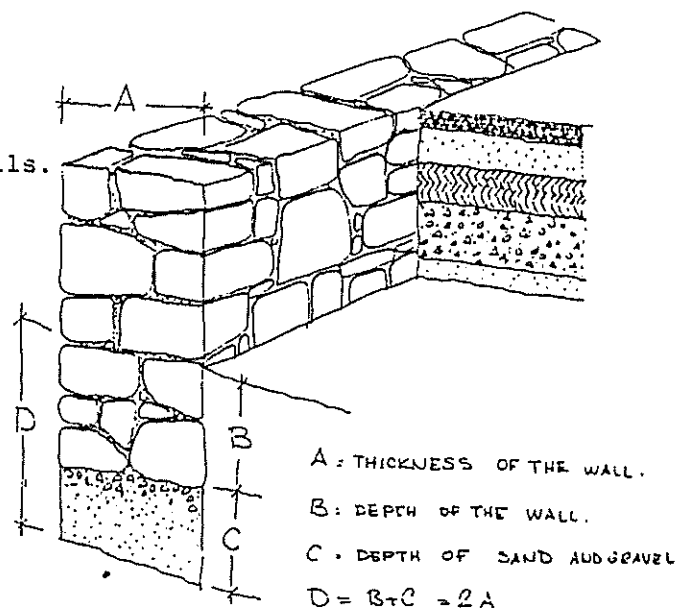
a) Site selection: One of the first essentials in house construction is to select the most advantageous property site (planning of the environmental influences to the house orientation). When we know the most efficient orientation, we can look at other important factors which can cause problems during or after the building is constructed. For example, the level of the land should permit natural drainage, low areas should be avoided, soil conditions should be favorable for excavation of the foundation walls; large rocks or other obstructions will require selection of another site.

b) Foundation: In many respects, foundations are the most important parts of any structure, and once built, little can be done to alter them. I believe the Turkish rural man was aware of this problem, since in many examples, foundations are thicker and deeper than the norm. Foundations normally consist of two principal parts:

- 1- footings
- 2- walls

Materials generally employed are sand, gravel and rubble masonry walls.

Footings are generally required under foundation walls, to spread the load to such an extent that settlement is negligible, or uniform under all portions of the structure. Generally



speaking, the depth of the footing should be the same as the thickness of the wall above it. However, in some Turkish villages, depth is two times more than the thickness of the wall above it. In the regions where there are fewer earthquake problems, the depth of the footing is the same as the thickness of the wall (50-65 cm.).

More than 70 percent of rural houses are built with adobe in Turkey today. Due to the weight and size of the adobes, foundations of the adobe buildings should be built thicker than those of contemporary wooden or brick houses. The depth of the foundation should depend as much on soil conditions as the weight they are intended to support. Foundation footings must be extended beyond the foundation wall on both sides by 50 percent of the width of the wall.

Walls of the foundations consist predominantly of random rubble which we will study along with wall structure types.

From the examples studied, foundation walls need immediate change. Filling a shallow trench with field or river rock and using mud mortar is ineffective as well as unhealthy. Cement must be used in order for the house to be square and to provide resistance to earthquakes.

Wall structures:

Based on the materials villagers use in wall construction, three categories can be observed:

- a. mud brick walls
 - massive mud brick walls
 - mud brick walls in a timber skeleton

- b. stone walls
- c. timber walls

a. mud brick walls: When a villager has to choose his materials, he will opt for the easiest to obtain rather than the most efficient. This accounts for the wide usage of mud brick houses which are predominant in Turkey.

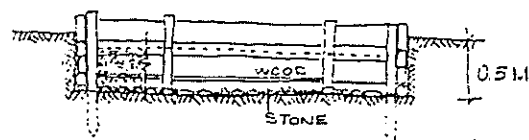
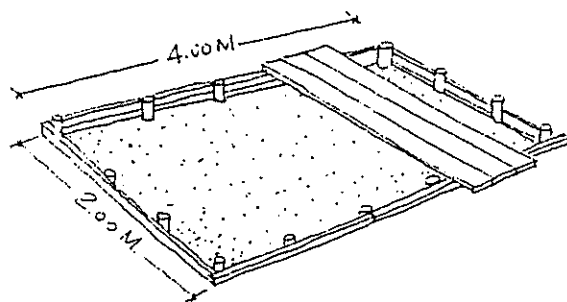
Soil is abundant and the least expensive material known. Villagers can often use the soil already on the site to build their homes.

The basic and common methods of building with soil are:

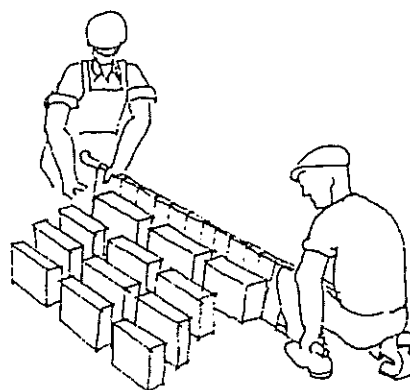
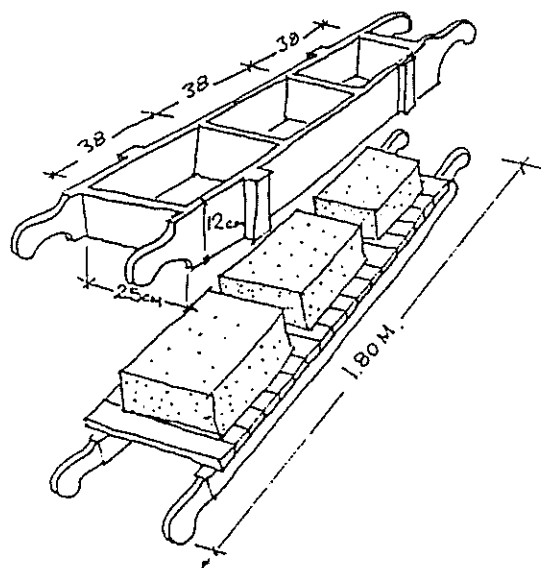
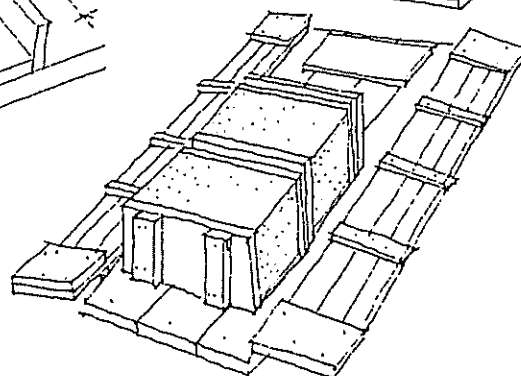
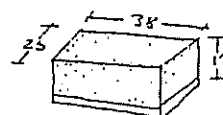
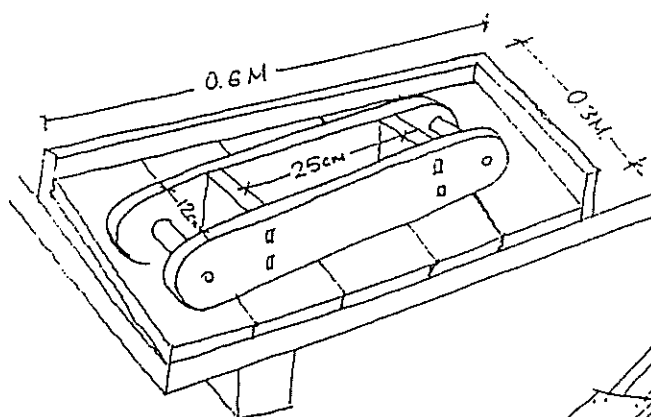
- 1. adobe bricks
- 2. rammed earth

Adobe bricks usually are made of soil and straw and then set with mortar to make a wall. Rammed earth is made when moisture is added to the earth and it is then molded into forms to make a finished wall.

The traditional way of making adobe bricks is a simple process: Earth, sand, water and straw are combined in a mixing pool. Through their experiences, villagers know that straw does not give added strength to adobes but serves to make the brick dry and shrink as one unit. Sharp, coarse sand is better than fine grained or rounded types. Too much clay develops cracks when brick dries. Too little clay makes the bricks less strong. Preparation of adobe requires hard work. One person spreads the soil on a level area; another



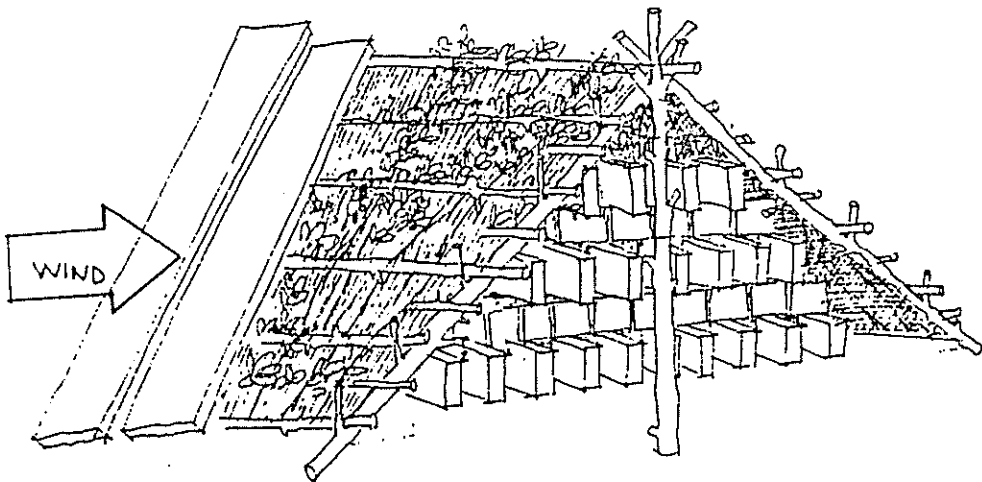
person sprays water over it lightly before it is shoveled into the mixing pool, where a third person mixes the mud. A mixture is ready to be poured into the molds when it falls easily from a raised hoe. Wooden molds should be carefully constructed with tight corners fastened by wood screws. The sizes of the molds show the differences:



The success of brick molds is centered on the smoothness of their inner surfaces. Of course, metal-lined molds are best, but villagers have difficulty obtaining them.

After pouring the mixture into the molds, and when the top of the brick becomes smooth, the mold can then be lifted off. The person who is working with the mold has to wash it after each use, since mud builds up quickly.

Bricks should never be allowed to dry in direct sun. Sun and wind are the foremost enemies of new bricks, as both will result in quick drying which almost guarantees cracking. Bricks need protection during the first five days, and as I have seen in practice, villagers will wait one week before using the new bricks.

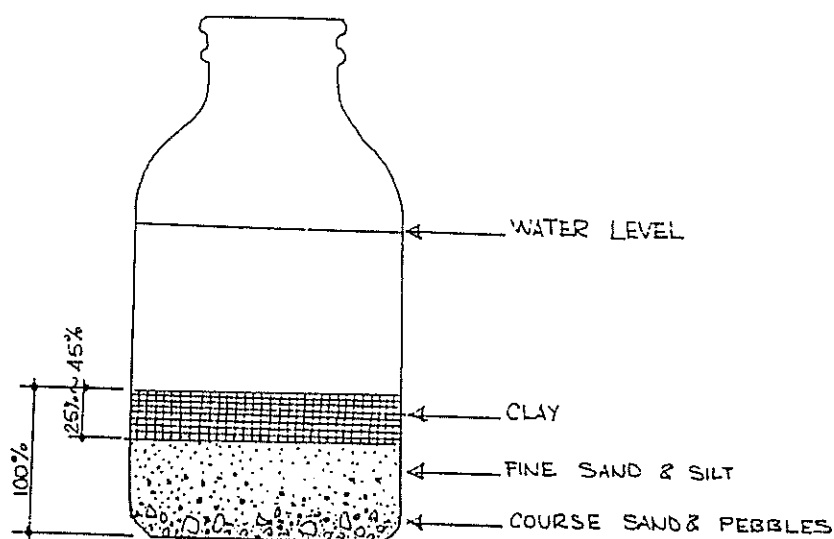


Drying in the Shade

New ways of making adobe: After two thousand years of experience, villagers have found that water and humidity are major enemies of adobe. The adobe they have been using is not strong enough vertically and horizontally to withstand the vibration of earthquakes.

Because of availability and low cost, "emulsified asphalt" should be used in any construction as a stabilizer for the adobes. It serves to waterproof adobes, but it does not add to their strength. In fact, superfluous amounts can weaken the brick. Adobes should be stabilized to such an extent that, if they come in contact with water, they will absorb no more than 2.5 percent, in relation to 100 percent of their weight. Portland cement should be added to soil in order to increase the strength of adobes. With the addition of cement the strength is increased, but it is not waterproofed as are those made with emulsified asphalt.

Preparation of new types of adobes: Mixture of the soil (from different depths of the test site) should be combined with water inside a jar. By shaking we can turn the soil into mud. Afterwards, we should set the jar down and wait until the water becomes clear. When the water becomes clear, we can examine our soil. The heaviest part of the soil will be at the bottom (pieces of rocks), sand and clay will form on the upper part of the sand. The clay should be between 25 and 45 percent of the complete height of the mixture. By adding more clay or sand mixture, it can be balanced to obtain a 1/3 ratio.

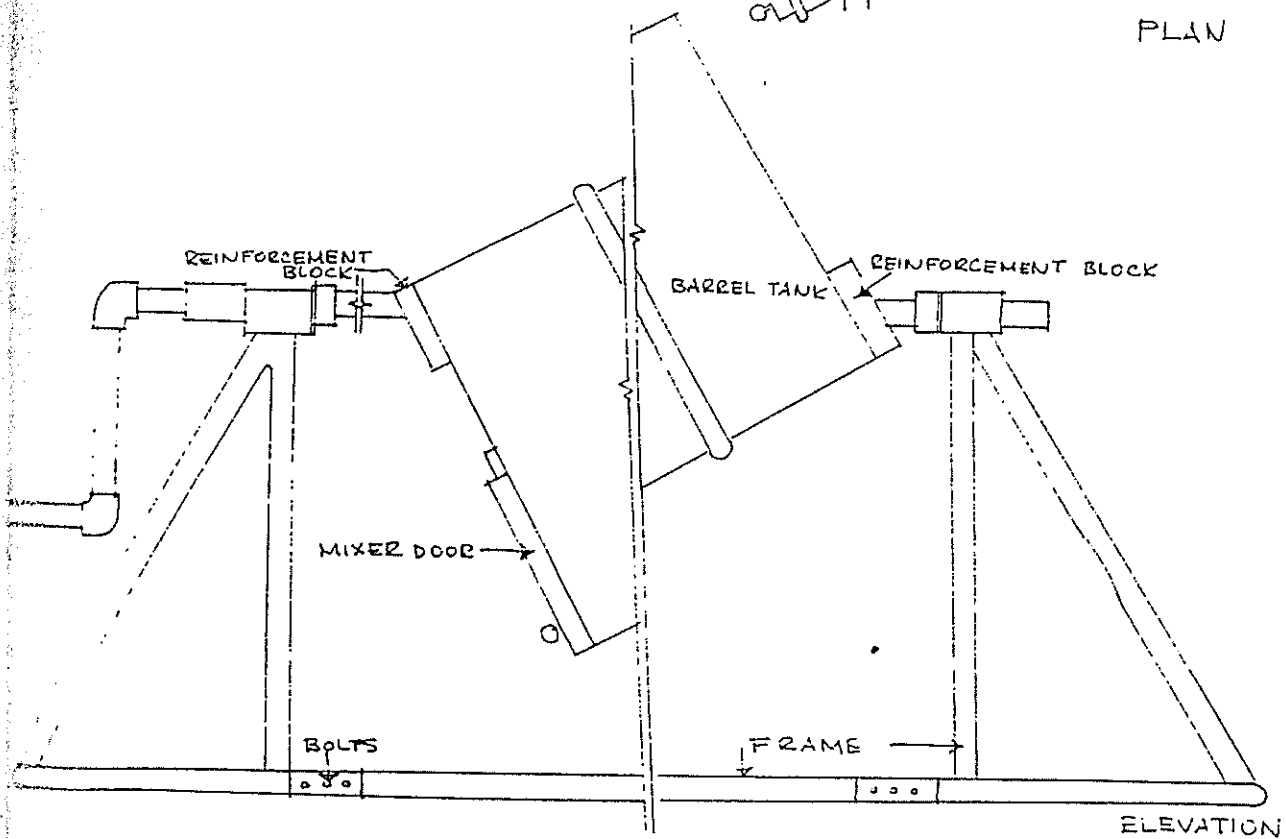
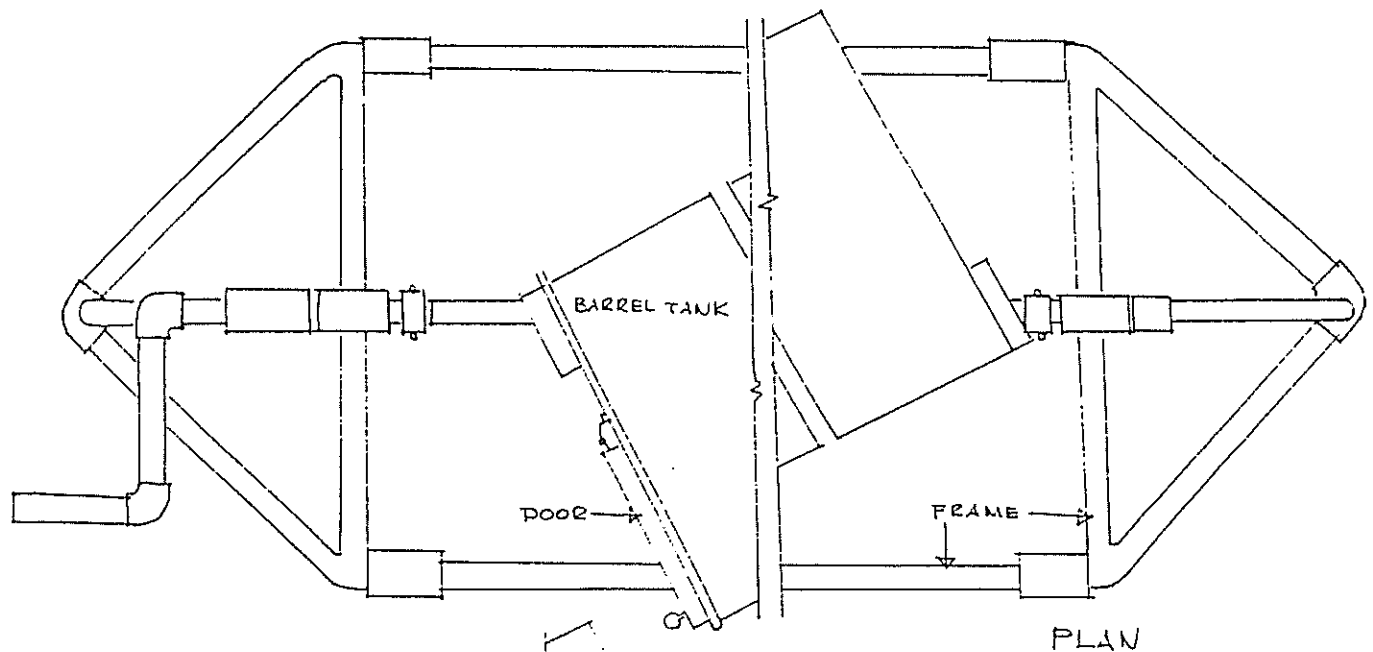


Testing the stabilized brick: Another simple test can be done to determine the amount of emulsified asphalt needed to stabilize adobes (made from the soil which is also tested by bottle method and found suitable for use).

Mix one cubic foot of soil with enough water to make a stiff mud. Add one-half gallon of emulsified asphalt to the mud and mix until the asphalt is no longer discernable. Make some bricks and leave them to dry. When the bricks are dry, put them in water for several hours. Afterwards, we take the bricks out to study them. They should be as hard as when they were dry. Corners should be sharp. If after the test there are some parts missing, or if the adobe becomes soft, the test should be repeated by adding more emulsified asphalt. If this test is satisfactory, it should be repeated with the use of less stabilizer to find out the most economic stabilizer-to-soil ratio.

Do-It-Yourself Hand-Powered Mud or Cement Mixer

It is possible to make mud mixers from a 55-gallon oil drum on a frame of galvanized pipe. This can improve the quality of adobes, and it saves time and labor.

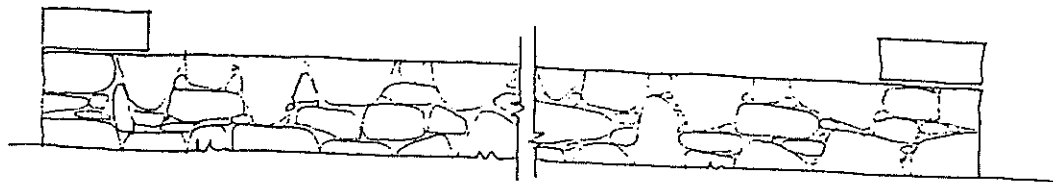


Preparation of the adobe: The process of mixing clay will not differ from the traditional method used by the villagers. When the stiff mud is ready in the mixing pool, the required amount of cement should be added to the stiff mud. After mixing with some water, the required amount of emulsified asphalt should be added, and the mixing is continued. When the asphalt is mixed, a mixture of straw should be added, and as soon as this is fairly scattered throughout the mass, preparation of casting starts, and molding occurs in the traditional way. (A mud mixer can be devised -- see previous illustration.)

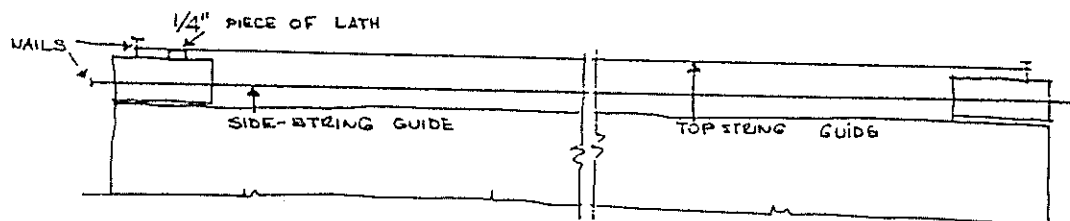
Laying-up with adobe: When the foundation walls are done, adobes are dry and ready to use, preparation of the mortar should start. Mortar is mixed in the proportion of one part portland cement to two-and-one-half parts clean, salt free, sharp sand. Next, emulsified asphalt should be added to the mixture in the proportion of one-and-one-half gallons per sack of cement used.

Laying of the adobes should start from the corner bricks. The bricklayers should wet the top of the foundation wall before placing mortar on it. Afterwards the mortar can be spread on it and leveled to a thickness of approximately $\frac{3}{4}$ inch. Next, the bottom of an adobe should be cleaned of loose dirt, wet and set on the mortar, and slid back and forth so that the bottom is completely in contact with mortar.

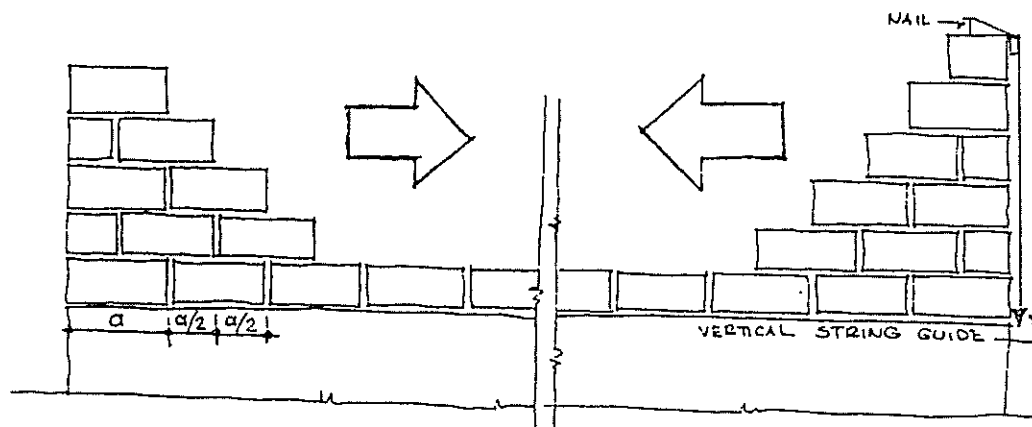
By using small amounts, it is possible to see that the top of the corner adobes are level both lengthwise and crosswise, and also the bricklayer should ensure that the outboard sides are in the same vertical plane as the sides of the foundation.



After the corner bricks are set and the mortar is dry, the bricklayer should place the string guides (one on the top and one on the exterior side) which help in laying the rest of the bricks on course.

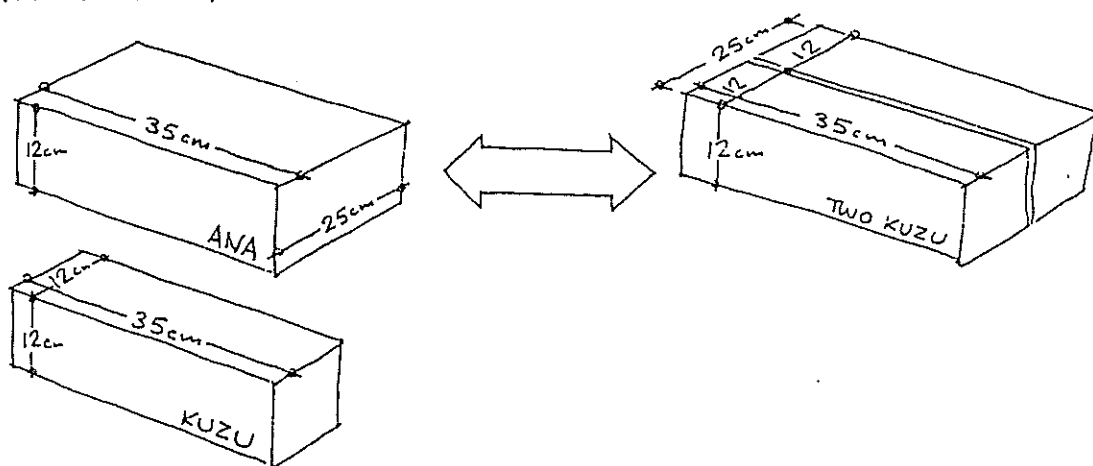


These string guides will allow the bricklayer to place the adobes between the corner bricks without any recourse to the level. After the first course of the adobes is done, a third string guide should be used for leveling the corner bricks vertically with the side of the foundation.



Laying of the adobes should start from the corners towards the center of the walls, and adobes should overlap at the top of each other by 50 percent.

There are two kinds of bricks made today. One is a large piece called "ana" (15x35x12 cm); the other is a small piece called "kuzu" (7.5x35x12 cm). Two kuzu = one ana.



According to their size, mud brick walls may be arranged into two broad categories:

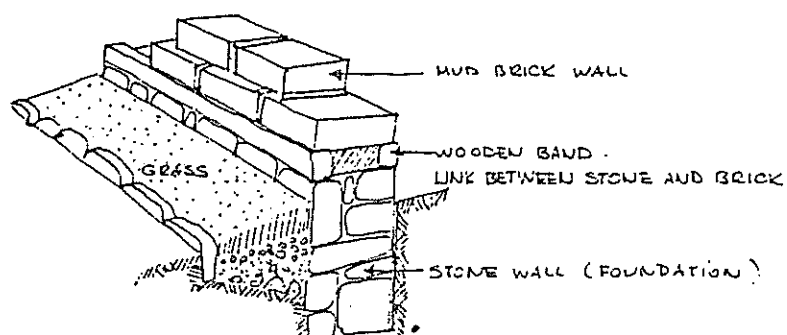
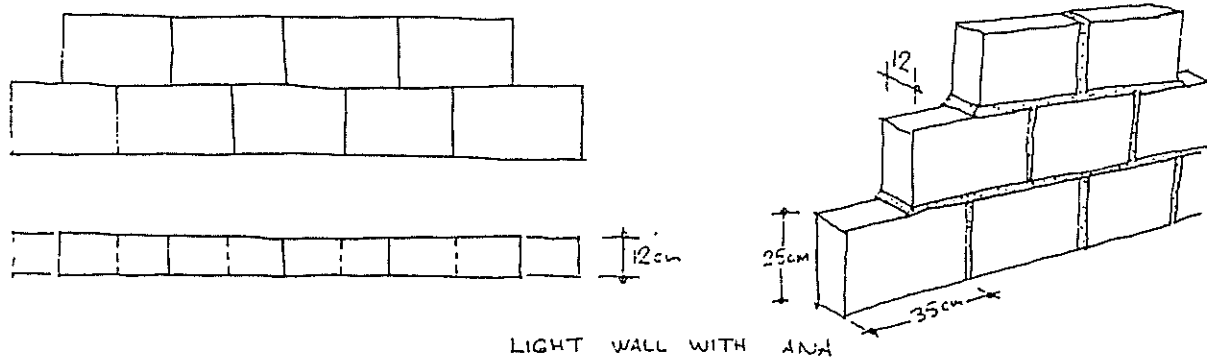
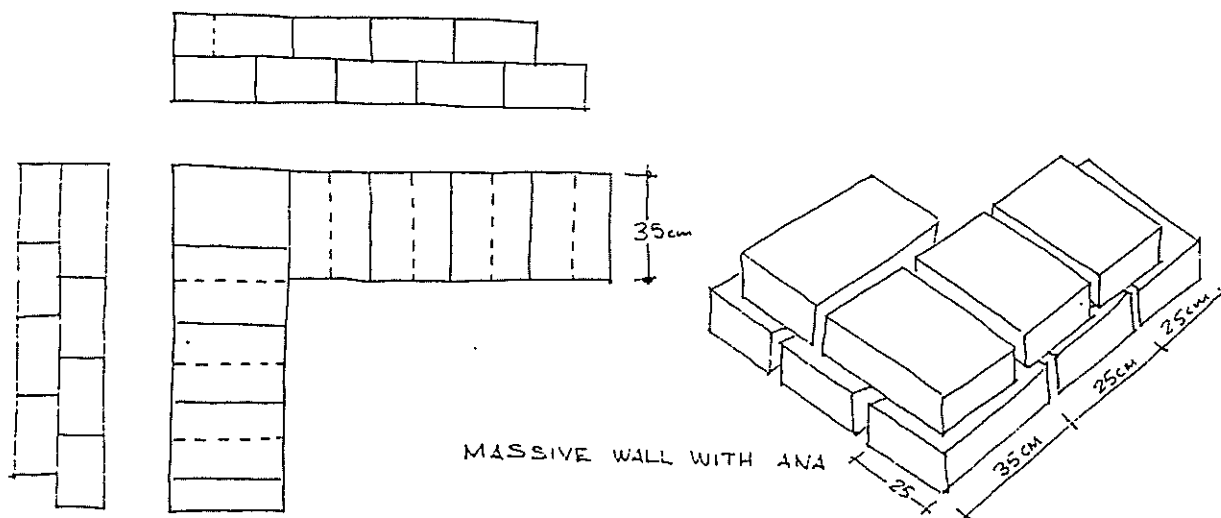
1. massive mud brick walls
2. light mud brick walls

Massive walls are mainly used for the outside walls of the building, while the light walls are on the inside. The difference is in their thickness, which depends on the methods of laying up.

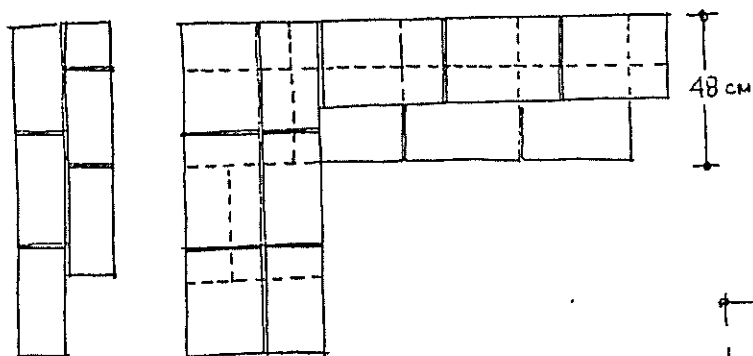
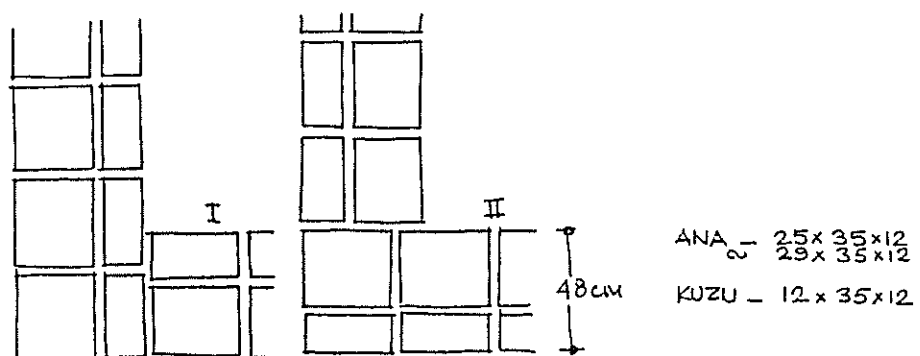
Thickness of massive wall (without plaster) = min. 38 cm.

Thickness of light wall (without plaster) = min. 25 cm.

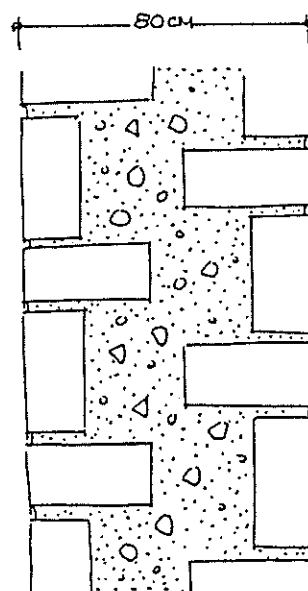
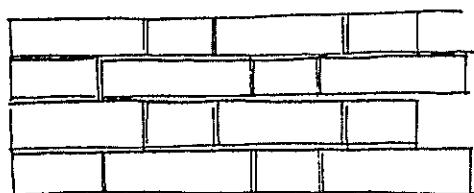
Lying-up with "ana":



Lying-up with "ana-kuzu" combination:

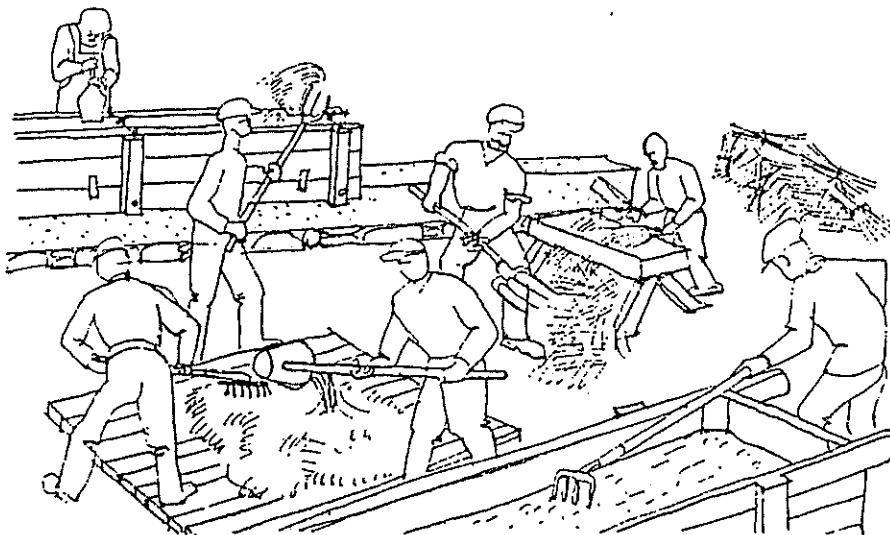
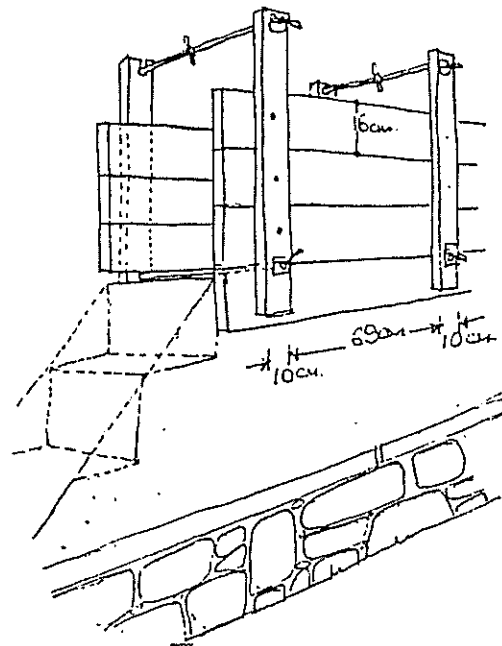


Lying-up with "kuzu":

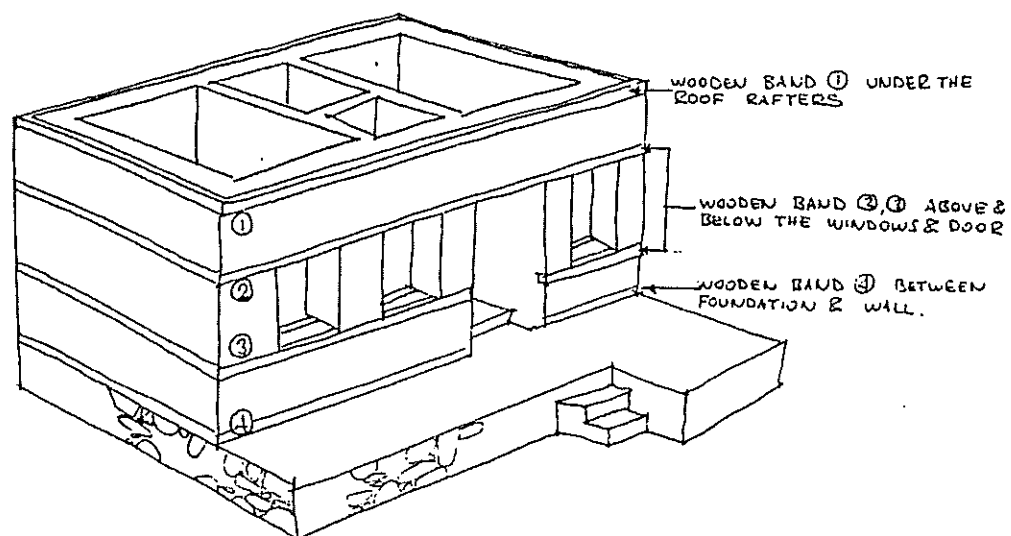


Rammed earth walls: Speed is the main reason for using this system. However, since this large wooden mold is similar to a modular solution, it is more complicated and technical to use. It is designed to save time and work and must be built carefully in order to support the horizontal pressures of mud.

Preparation of this mixture is the same as the mud brick mixture. When the mixture is ready, it has to be poured into the large wooden mold with pressure. After ten minutes, the mold can be removed.



Wooden bands (Hatil) have to be run around mud houses, especially those made without a skeleton. They are carefully joined to form a continuous girdle preventing the walls from bulging out in the older buildings. They would naturally take up the stress resulting from unequal settlement or earthquake shocks. There are usually two of these bands above and below the large windows on the bottom, acting as sill and head, with sometimes another one running through the stonework below.



b. Stone walls:

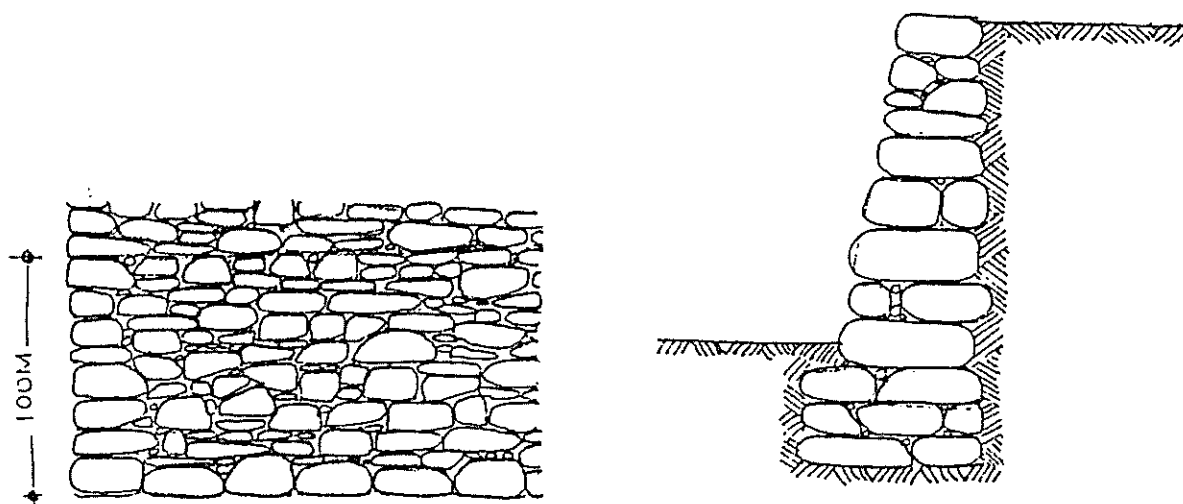
Before the villager begins construction, he has two choices of stones: good quality, flat and expensive stones which are available on the market, or free field stones found on the construction site. Because of his economic problems, the village man always prefers the second choice. All Turkish villages use stone at least for the foundation walls. However, certain regions have more stone than others, and in those regions almost every house is made from stone.

Size, shape and joining of the stones are irregular. They use the roughest and most casual type of stone works such as drywall or random rubble. Little attention is given to ideas of coursing, but each layer should contain stones bonding through the wall in sufficient numbers to produce a closely knit structure. The remaining interstices are filled with smaller stones of convenient size and shape characteristic of the stone. Such walls are frequently used for both foundation and walls and may be laid "dry" or with mortar.

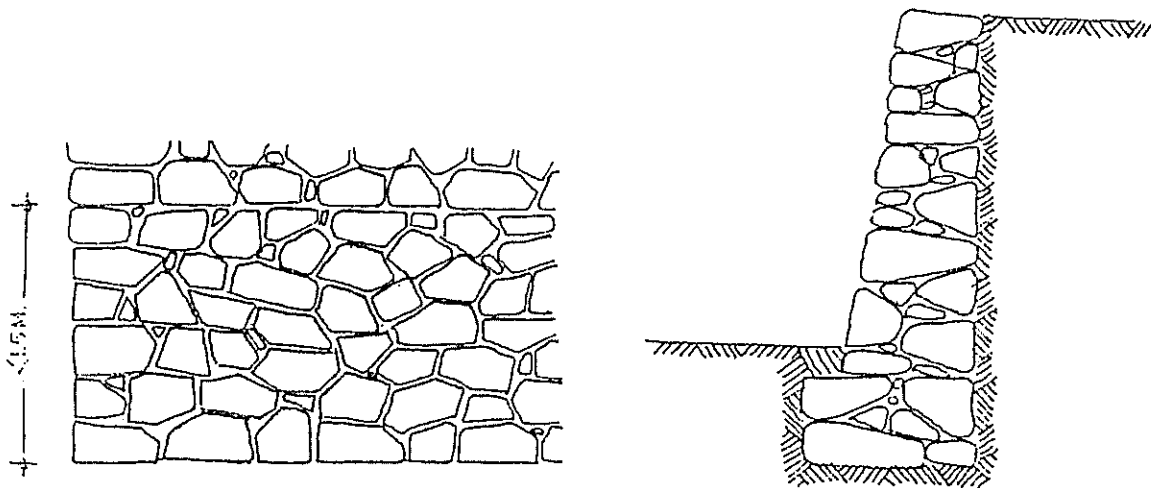
Random rubble varies in thickness: minimum 40 cm. to 70 cm. The footing should be wider than the wall above it, and should be built from the larger and more regularly shaped stones.

They use "bond stones" only at the corner of the rooms. Bond stones are laid in one piece entirely through the wall, and in good work should be placed at least once in each 6-10 square feet of wall surface.

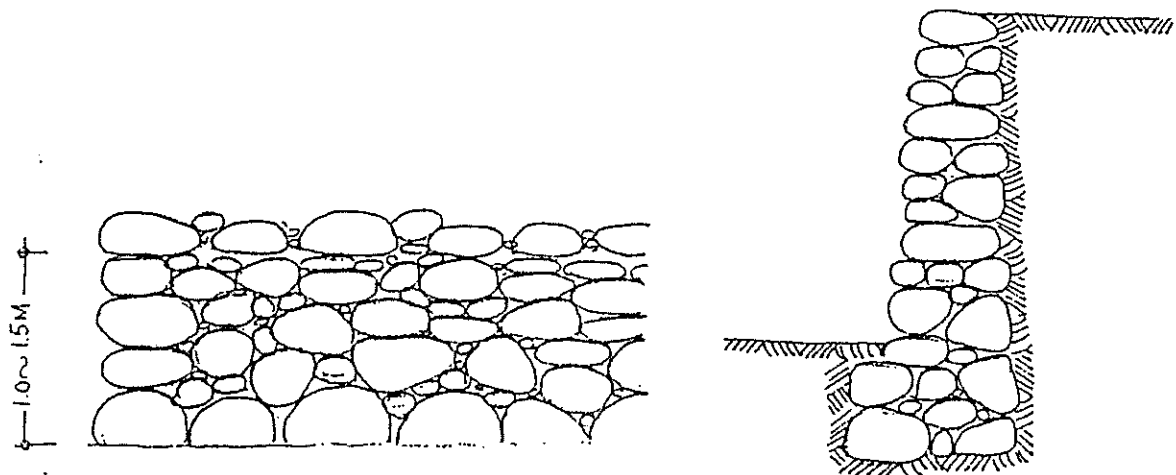
Dry Wall

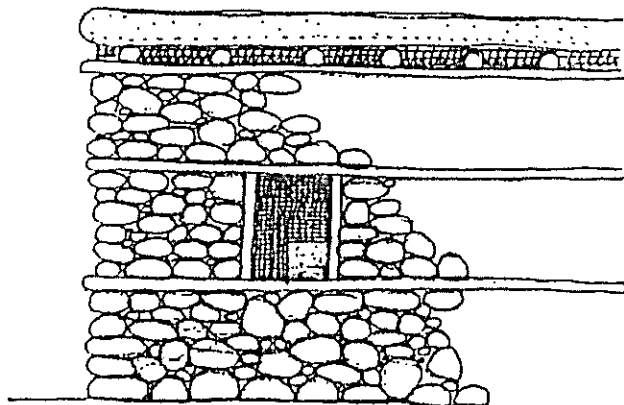


Random Rubble



The use of round stones is very common in Turkey, since it is very easy to find them in dry river beds. When mud is used as a mortar between the stones, the strength and resistance are less than mud brick walls, which is the reason why hundreds of people are lost during earthquakes in Turkey.



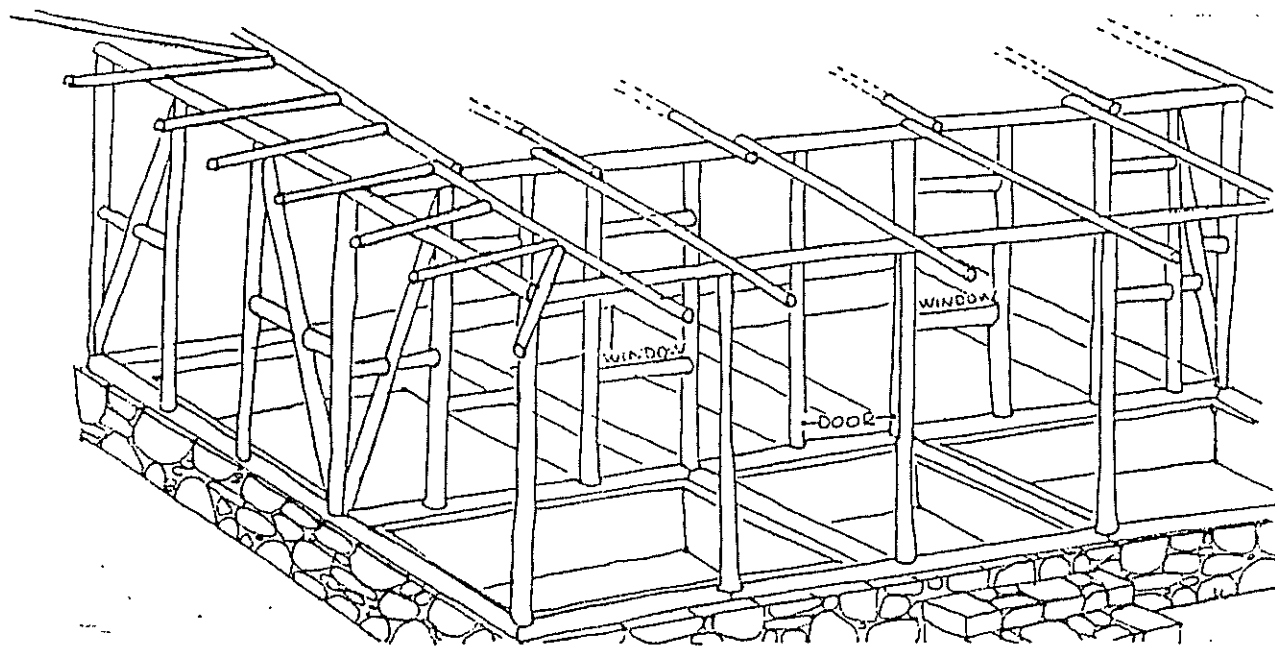


Like mud brick houses, stone houses are built of small stone blocks with horizontally placed wooden beams, regularly dividing the walls. They are again above and below the windows.

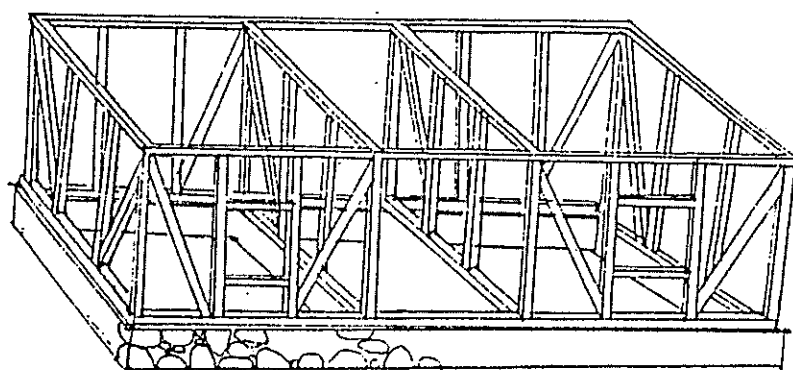
c. Framing and timber walls: The frame is the structural skeleton of the building. The portions of the frame are assembled on the foundation walls and windows, doors, roof covering, exterior covering, interior covering and floor are fastened to them.

The types of wood used in framing varies with the locality and what is most readily available and economical is employed. Poplar is abundant and is commonly used throughout Turkey. This lumber needs no work on the structural skeleton, since it is a rough lumber. For exterior or interior covering, as sheathing boards, one or two sides of a surfaced lumber is used.

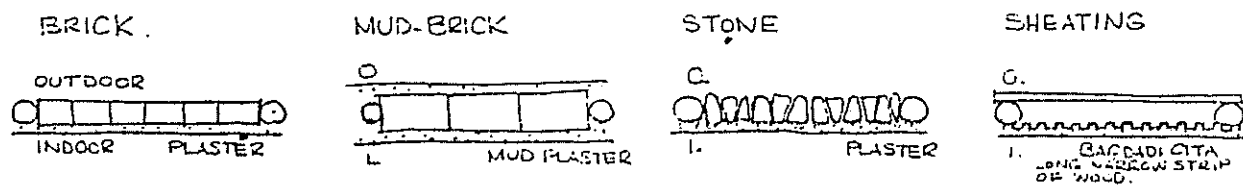
The following illustration shows the traditional framing of Turkish village houses.

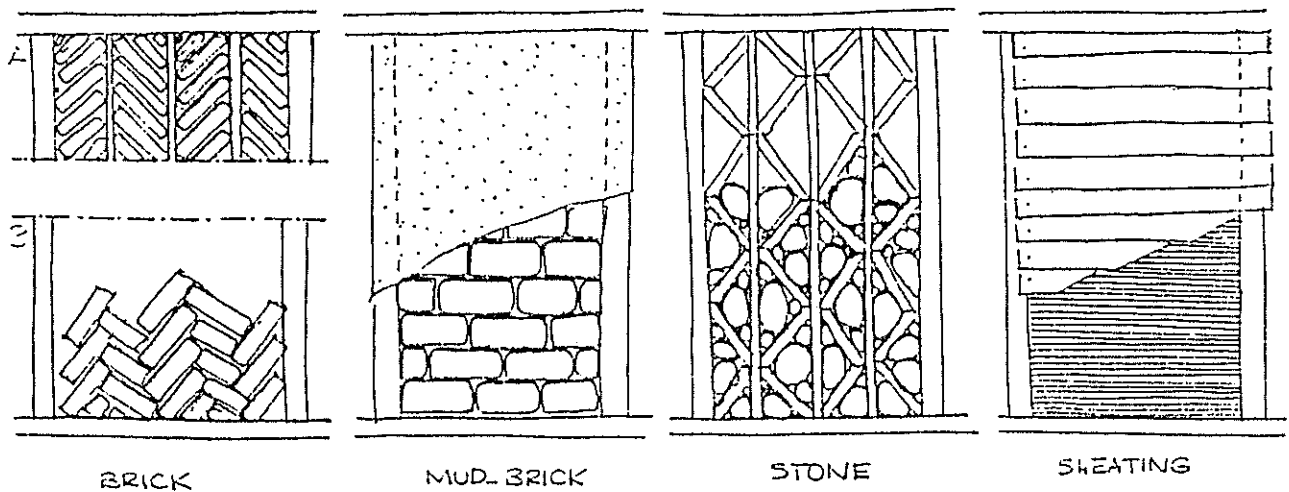


Until the structural skeleton is done, Turkish village houses have great similarity.



The differences occur from the type of materials found in the region which is used for filling between the posts, headers, studs and girths.





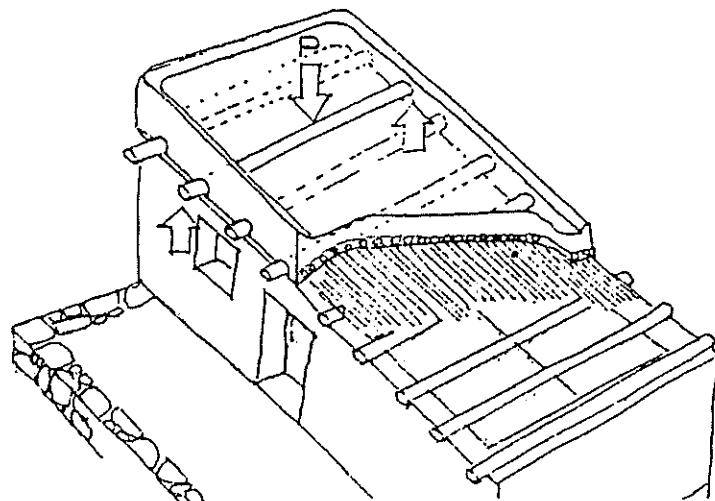
4. Roofs:

The function of a roof is to protect the house from the elements of nature. In addition to this function, the roof of the Turkish village house contains the space where green products are dried.

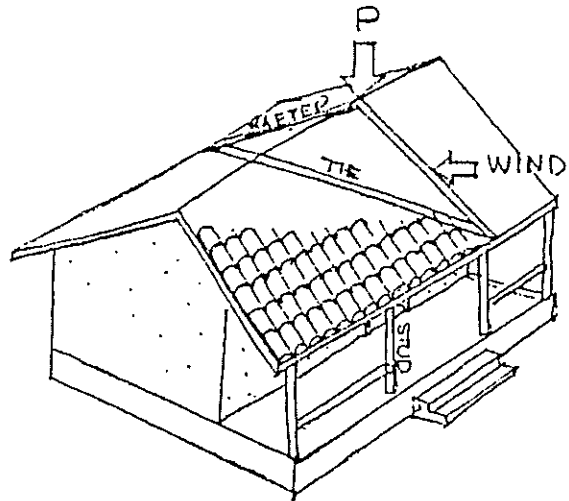
Its shape is therefore dictated both by climatic and by structural concerns, which relate to structural materials. Like any place in the world, low flat roofs have been used in hot climates where only water has to be shed (like the southern part of Turkey), whereas steep roofs have been used in cold climates in order to shed snow as well as water (like the northeastern part of Turkey).

In Turkey the most commonly found roofs are the following:

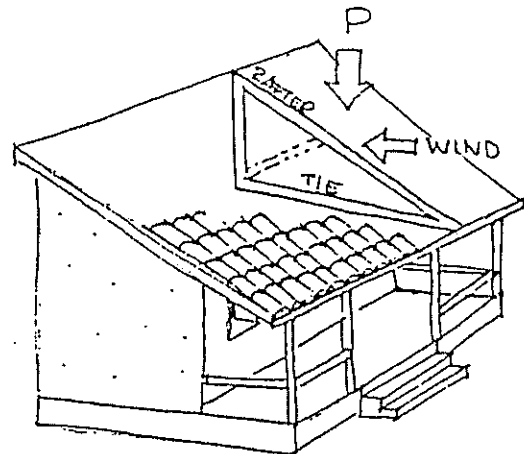
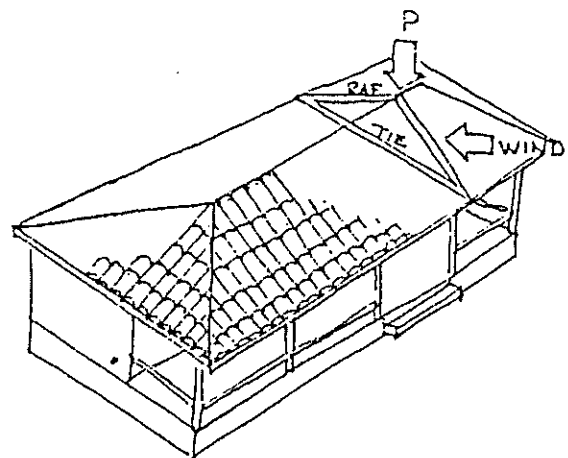
1. Earth covered flat roof --



2. Gable roof

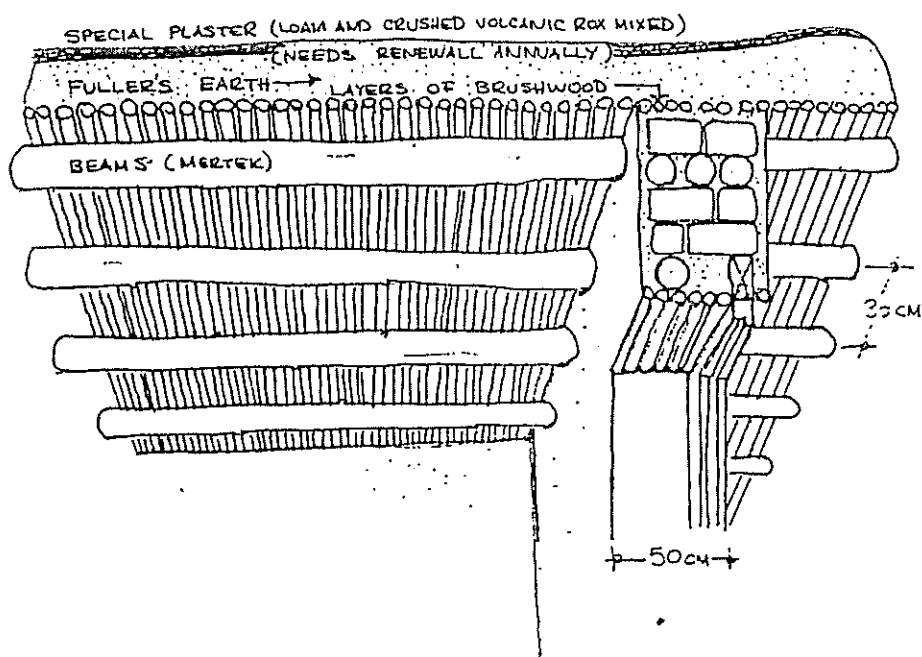


3. Shed roof

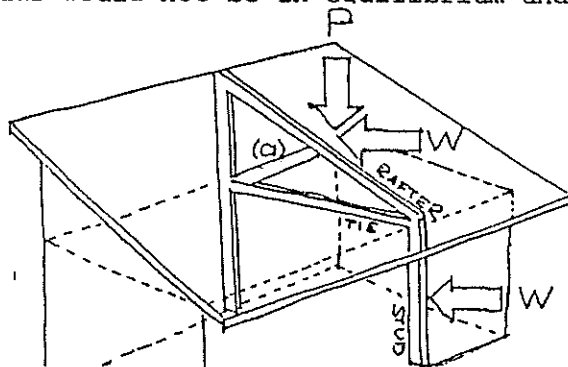
4. Hip roof
(rectangular)

Flat and shed roofs: The shed roof, as its name implies, is merely a single inclined plane which covers the main structure or covers an ell which adjoins a higher structure. Most so-called "flat" roofs are in reality shed roofs with a very small slope. Theoretically, a flat roof could be perfectly flat and still shed water. Realistically, it is impossible to build a perfect plane, so all roofs must have some slope to prevent pockets of water from forming, unless water is wanted on the roof for cooling purposes.

As trees of Anatolia are relatively rare and small, the architecture of the country relies as little as possible on the use of wood. Flat roofs and floors are made possible by using twisted small beams, most of them spanning no more than three meters, covered with layers of brushwood and earth, on top of which horizontal, plaster-and-earth or in some cases stone surfaces are placed.



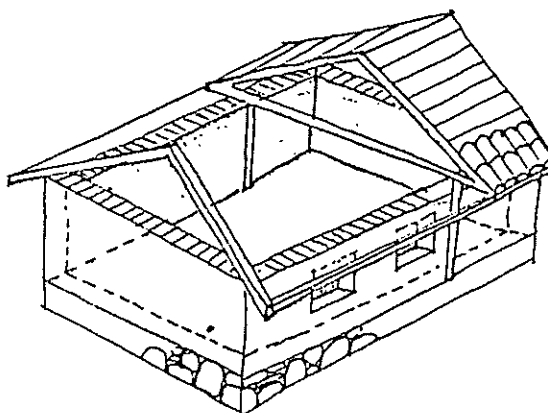
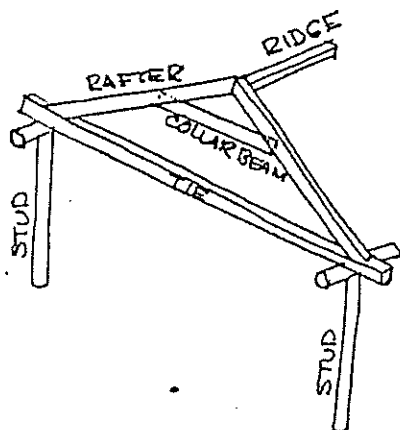
The diagram on shed roofs shows the vertical load (P). The simple frame consisting of rafter and studs would not be in equilibrium under vertical loads. Any lateral load such as the (W) wind load would tend to overturn the frame unless the connections of studs to sills and rafters were rigid. When rafters are long, they can be strengthened by a strut inserted as shown by (a).



But in Turkish village examples, villagers are unable to find rafters which are longer than 3.20 m. This makes all village rooms the same width (around 3.00 m.), and struts are not used.

The gable roof consists of two inclined planes which meet in a peak over the center line of the house and slope down to two opposite roof plates.

When a vertical load (P) acts on the roof, the rafters tend to push out at the eaves and to displace the studs unless some kind of tie is provided. The stud-rafter-joist combination is unstable against lateral loads such as winds. There must be a resistance by the end walls and by interior partitions.



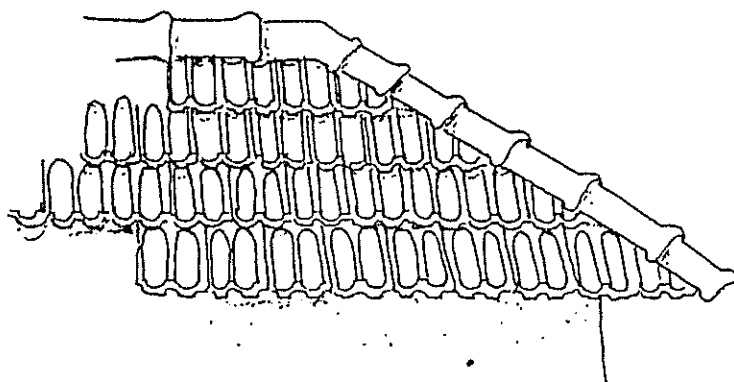
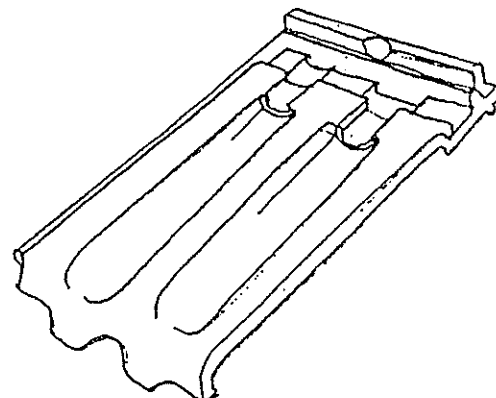
When the roof slopes down in four inclined planes to four plates, it is called a hip roof. A vertical load applied to the peak of a hip roof is distributed among the four hips, and vertical components are transmitted to the corner posts. Any spreading tendency caused by the horizontal components is taken up by the skin of the roof.

Roofing

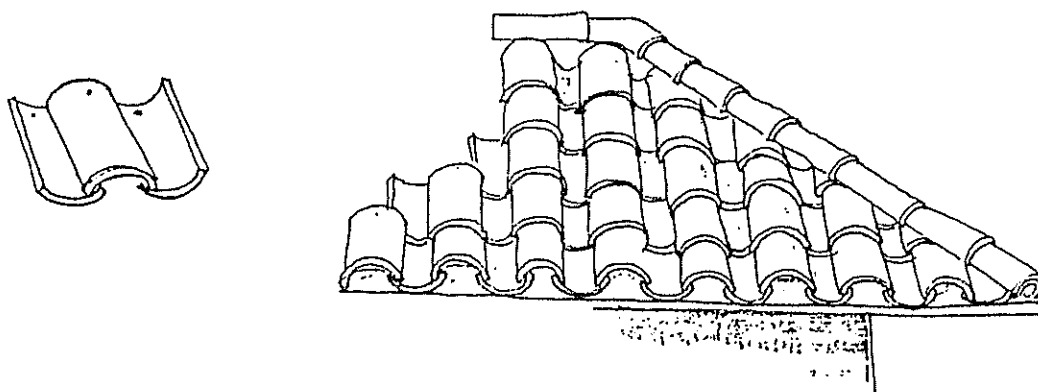
Because of new transportation facilities, Turkish villagers began to use new construction materials such as tiles. Today French or mission tile covered roofs are taking the place of earth covered roofs.

French tiles are a variation of the flat shingle tile, which is heavily grooved on top and has corresponding projecting lugs on the lower side which fit into the grooves on the next lower course. These tiles interlock and thus provide maximum coverage with minimum material.

Special return pieces are required at the rakes, and special hip and ridge rolls are needed.



Mission tiles: The roof is covered by merely turning adjacent tiles alternatively concave forming "pans" and convex "covers." The covers fit down over the upturned edges of the pans, both are nailed with a single nail at the upper end. At the eaves special closure pieces cover the opening and the rake of the roof is usually covered with a tile turned down over the edge.



It would not be right to say "we will cover all the roofs with tiles in rural parts of Turkey." Because of its extra functions (food drying, sleeping, field control), flat roofs are more preferable than gable, shed or hip roofs. I believe in the region where asphalt, bituminous felts or nuralit is available, villagers should use these materials for waterproofing.

Asphalt: It is possible to find it everywhere, at a very low price, and it is easy to work with. The only disadvantage in working with melted asphalt is the temperature can reach up to 400°F. During the work, asphalt should be continuously stirred with rods. Pails should be used for carrying and applying the material to the dry, hardened and clean surface of the roof. The asphalt should be applied in a minimum of two layers, with a thickness of 3/8 inch each, reaching a total of 3/4 inch.

It is important to provide a minimum of three inches of insulation (sawdust) under the asphalt layers to provide a continuous vapor barrier.

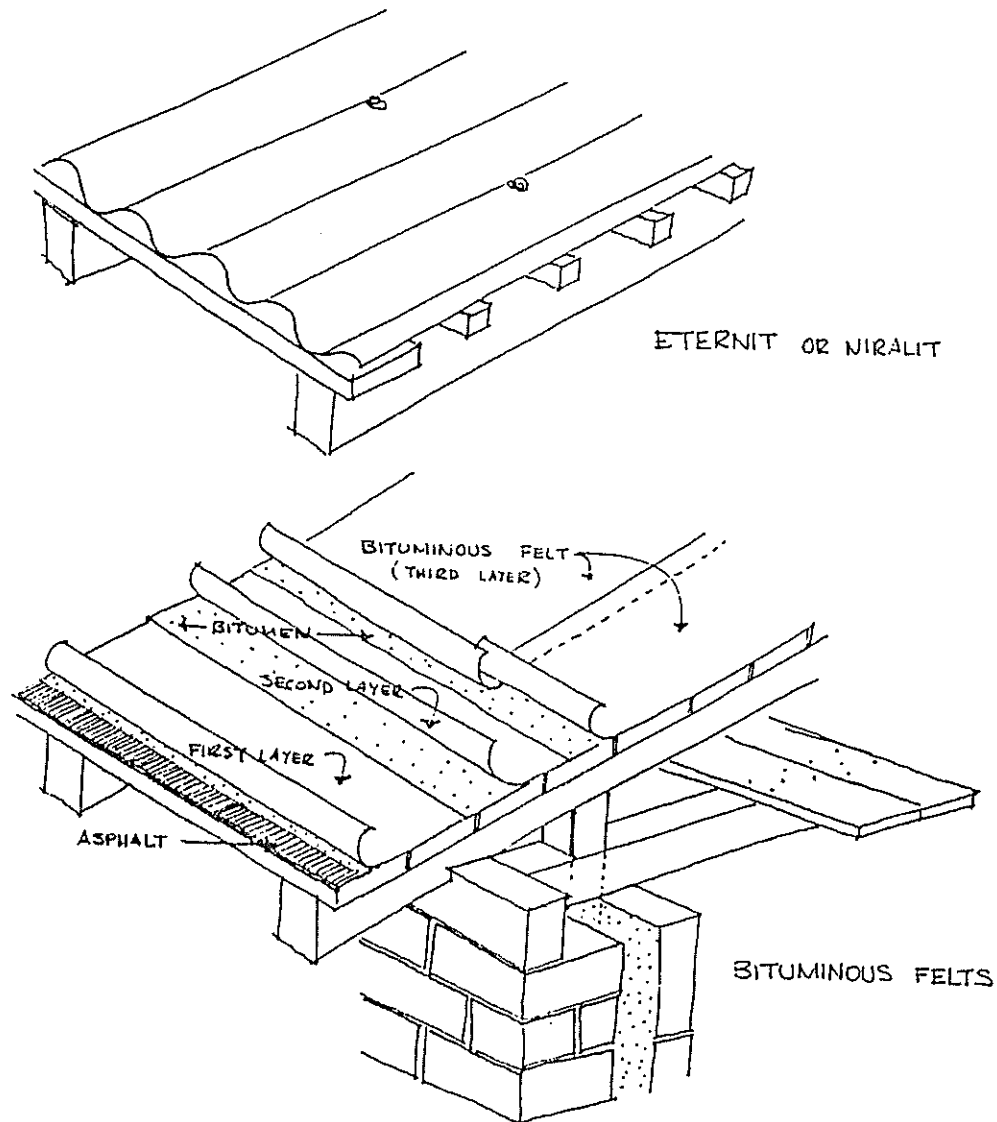
Bituminous felts: There are four types of roofing felts which can be used in village construction:

1. Fibre felt - The base consists of a close-textured absorbent sheet made from a mixture of animal and vegetable fibers, saturated with bitumen. It can be used on the top or under the layers of roofing.

2. Asbestos base felts - The base consists of an absorbent sheet of asbestos fiber containing not less than 80 percent asbestos.

Roofs with asphalt and bituminous felts should be protected from the sun, since ultraviolet light breaks down the bitumen with time. For this reason every asphalt or bituminous felt roof should be covered with a white material such as spare limestone chippings.

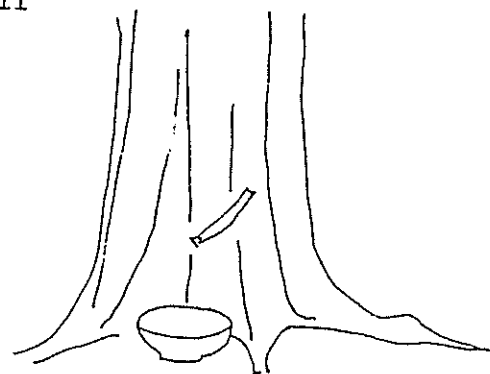
Niralit and eternit: This material is coming into use as a substitute for roofing metals because of their inexpensiveness and durability. Nuralit is black in color and is composed of asbestos and contains bitumens. Eternit is gray in color and is made by cement. Both are sold in sheets of different sizes. They can be used in any kind of roofing, and because of their lightness, must be well secured to prevent damage by high winds.



Natural Waterproofing Substances for Soil Constructions

When asphalt, bituminous felts or modern waterproofing products are not available, gums, resins and oils obtained from the native vegetation in the regions can be used for waterproofing. Without killing them, sap can be drawn out of trees. The best way to test a tree is to cut through the bark to the wood, leaving a bare place on the wood

about one inch in width and as long as four inches. This cut should cause a direct downward flow towards the lower end, at which a cut should be placed to collect any sap which flows out. The sap collected in the cup should be tested to determine if it will serve to waterproof adobe walls. To do this we should apply sap on the dry wall, and wait until it dries (two days). Afterwards, water is thrown on the test area; if the color of the wall becomes darker, it means the sap will not waterproof the wall. If it does not change in color, the sap will work as a waterproofing agent.



EARTHQUAKE RESISTANT STRUCTURAL SYSTEM

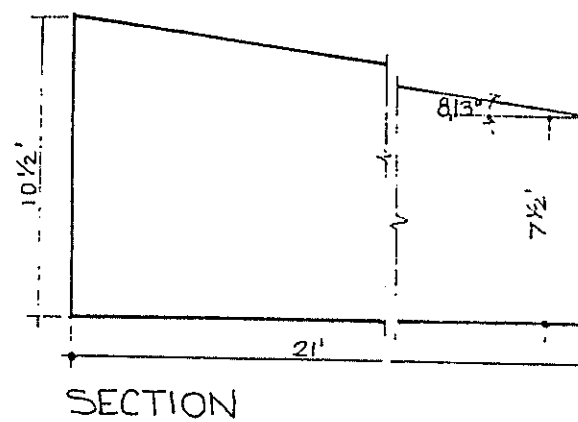
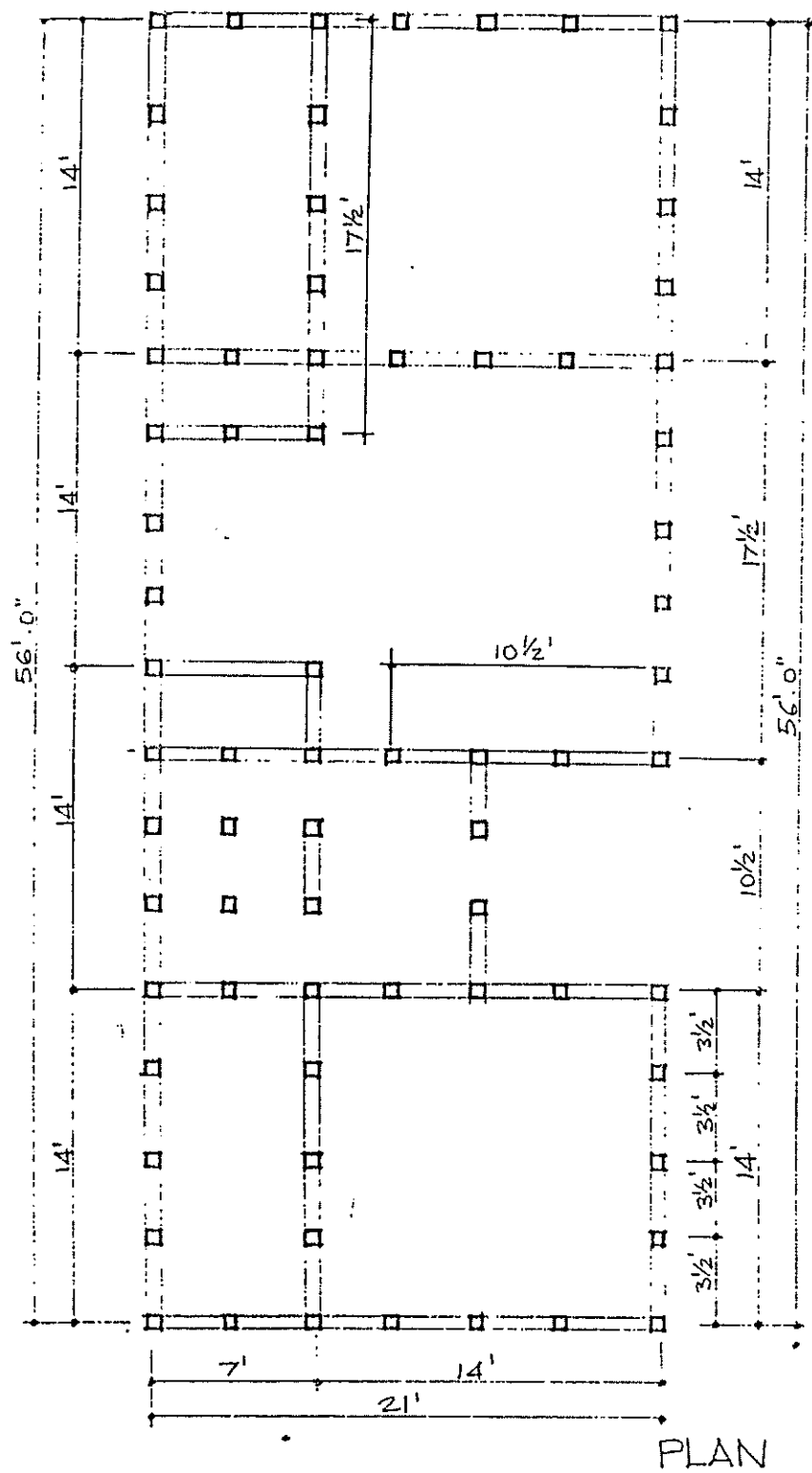
Next in importance after the architectural requirements, low cost, and maintenance, energy efficiency, cultural requirements are taken care of, earthquake resistant structures are necessary. The villagers should learn techniques other than contemporary methods to be able to obtain acceptable performance. Structural features contributing to seismic resistance under earthquake conditions are discussed below.

Earthquake resistant rural structures can be designed and taught to villagers. The designers' aim should be minimum structural damage, maximum safety, and still remain within economic limits.

Vertical and horizontal forces are controlled frame structures, sheer walls or a combination of both. In rural parts of Turkey, since there is a lack of materials, resisting frame structures and sheer walls should both be used in controlling earthquake damage. Due to seismic motions, foundation movement is an important cause of structural damage. Any kind of displacement between the parts of the foundation and the structure should be minimized. Unsymmetrical buildings have a greater susceptibility to earthquake damage than symmetrical structures. Symmetry should continue with the future expansion of the building. If a building loses its symmetrical character, structural separation is required. Connection points between the floor and the roof are the weakest spots of the building and require special attention.

In every village house, expansion is related to the birth and death ratio, and the villager should know where the second or third expansion should be built. He should provide for complete structural separation between the two phases, or the first increment must be designed for both conditions, before and after expansion.

STRUCTURAL CALCULATIONS



1. LOADS:

D.L. Tile	15 p.s.f.	
D.L. Wood	30 p.s.f.	
L.L. Roof	20 p.s.f.	
Wind load	5 p.s.f.	$\left\{ \begin{array}{l} \text{wind velocity 6 mph} \\ \text{velocity pressure 7 p.s.f.} \\ \text{external pressure coeff. 0.7} \\ 7 \times (0.7) \approx 5 \text{ p.s.f.} \end{array} \right.$
Snow load	12 p.s.f.	$\left\{ \begin{array}{l} \text{max. 15 pound/ft}^2 \text{ snow} \\ \text{basic snow load coeff. 0.8} \\ 15 \times (0.8) \approx 12 \text{ p.s.f.} \end{array} \right.$

Lateral load due to earthquake:

$$V = ZKCW$$

$$Z = \text{risk zone coefficient} = 1.00$$

$$K = \text{Structural coefficient} = 1.00$$

$$W = \text{Total dead load} + 25\% \text{ of floor liveload}$$

$$C = \text{coefficient of base shear}$$

$$C = \frac{0.05}{\sqrt[3]{T}}$$

$$T = \frac{0.05h}{\sqrt{D}}$$

$$T = \text{fundamental natural period}$$

$$h = 10.5'$$

$$D = 56'$$

$$T = \frac{0.05(10.5)}{56} = 0.00938 \text{ (sec.)}$$

$$C = \frac{0.05}{\sqrt[3]{0.00938}} = 0.237$$

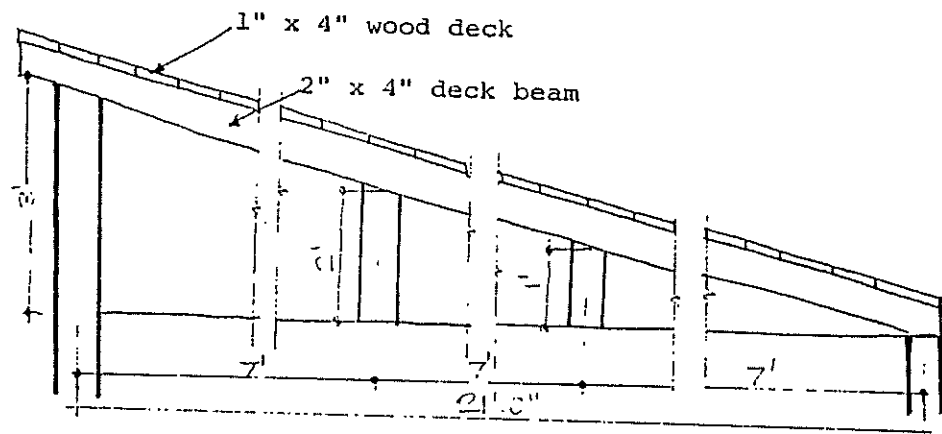
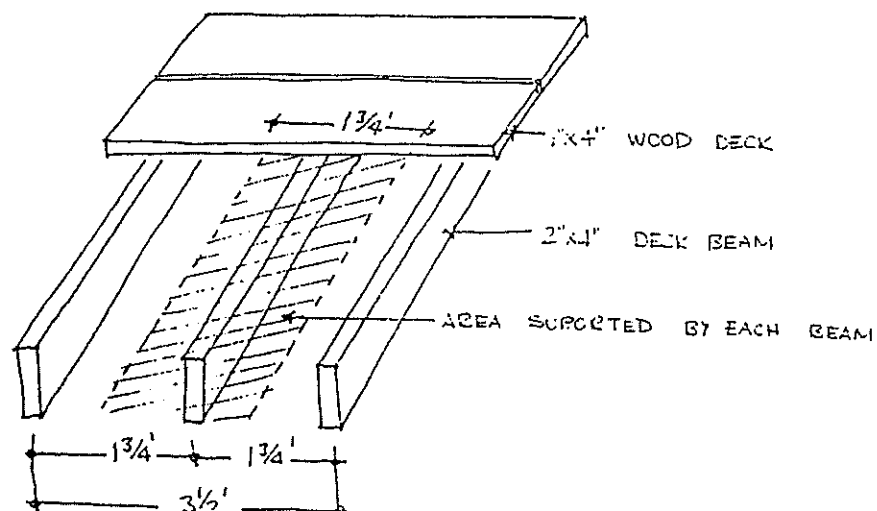
$$V = (1.00)(1.00)(0.237)W$$

$$V = 0.237 W$$

2. PROPERTIES OF WOOD

- $E = 1,600,000$ psi: Modulus of elasticity
 $\sigma_f' = 2,000$ psi: Allowable flexural strength
 $\tau_s' = 155$ psi: Allowable shear strength
 $\tau_c' = 600$ psi: Allowable compressive strength perpendicular to grain
 $\tau_c' = 1,550$ psi: Allowable compressive strength parallel to grain
 $\tau_b' = 600$ psi: Bearing strength.

3. DESIGN OF ROOF

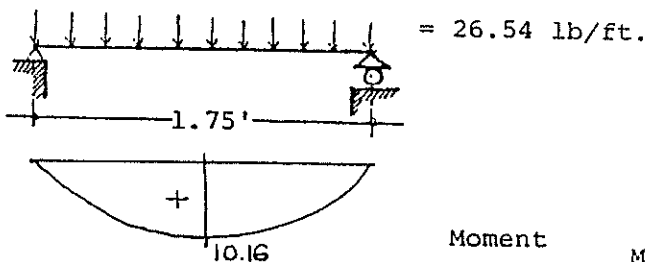
a. Spacing

b. Loads on the Wood Deck

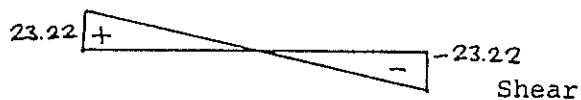
D.L. Tile	15 p.s.f.
D.L. Wood deck ($\frac{30}{12}$)	2.5 p.s.f.
L.L. Roof	20 p.s.f.
Wind Load (5) $\tan 8.13$	0.7 p.s.f.
Snow Load	12 p.s.f.
Total	50.2 p.s.f.

$$\text{Load on each 4" x 1" wood} = 3 \frac{5}{8} \quad (1.75) 50.2 = 26.54 \text{ lb/ft.}$$

(American standard dressed size of 4" x 1" is $\frac{25}{32}$ x $3 \frac{5}{8}$)



$$M_{\max} = \frac{26.54 (1.75)^2}{8} = 10.16 \text{ ft.lb.}$$



$$V_{\max} = 23.22 \text{ lb.}$$

$$(\sigma_f)_{\max} = \frac{M_{\max}}{S} = \frac{10.16(12)}{0.37} = 329.51 \text{ (psi)} < \sigma_f' = 2000 \text{ psi}$$

$$(\sigma_s)_{\max} = \frac{V_{\max} Q}{I t} = \frac{23.22(0.27)}{0.14 \frac{25}{64}} = 114.64 \text{ (psi)} < \sigma_s' = 155 \text{ psi.}$$

Section is OK

NOTE: S, I, t, Q values (section modulus, moment of inertia, half of the thickness, static moment of area above/below neutral axis respectively) are taken from the tables of American Standard Lumber Sizes.

c. Loads on the Roof Beams

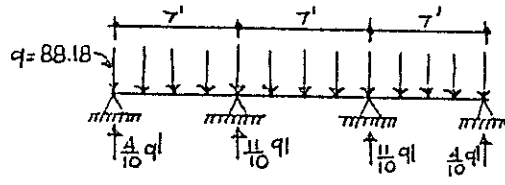
$$\text{Loads on the roof deck} = 50.2 \text{ p.s.f.}$$

$$\text{D.L. of beam} = 30 \frac{(5.89)}{1.44} = 1.23 \text{ lb/ft.}$$

$$\text{Area supported by each beam} = (1.75)(21) = 36.75 \text{ ft}^2$$

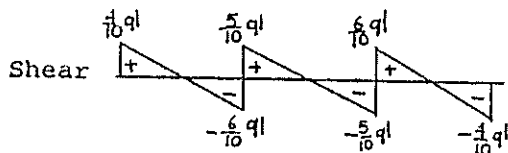
$$\text{Total load on each beam} = 1.23 + (50.2) \frac{(36.75)}{21} = 89.08 \text{ lb/ft.}$$

$$\text{Total vertical load} = 89.08 (\cos 8.13^\circ) = 88.18 \text{ lb/ft.}$$

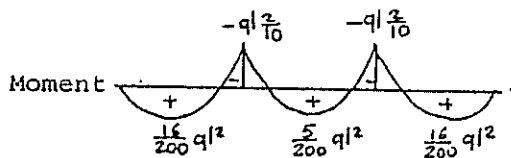


From the tables
2"x4" beam
(1 $\frac{5}{8}$ x 3 $\frac{5}{8}$) A.S.L.S.)

$$\begin{aligned} A &= 5.89 \text{ in}^2 \\ I &= 6.45 \text{ in}^4 \\ S &= 3.56 \text{ in}^3 \\ Q &= 2.57 \text{ in}^3 \\ t &= 1.87 \text{ in} \end{aligned}$$



$$V_{\max} = \frac{11}{10} (88.18)(7) = 679 \text{ (lb.)}$$



$$M_{\max} = \frac{8(88.18)(7)^2}{100} = 345.67 \text{ (ft.lb.)}$$

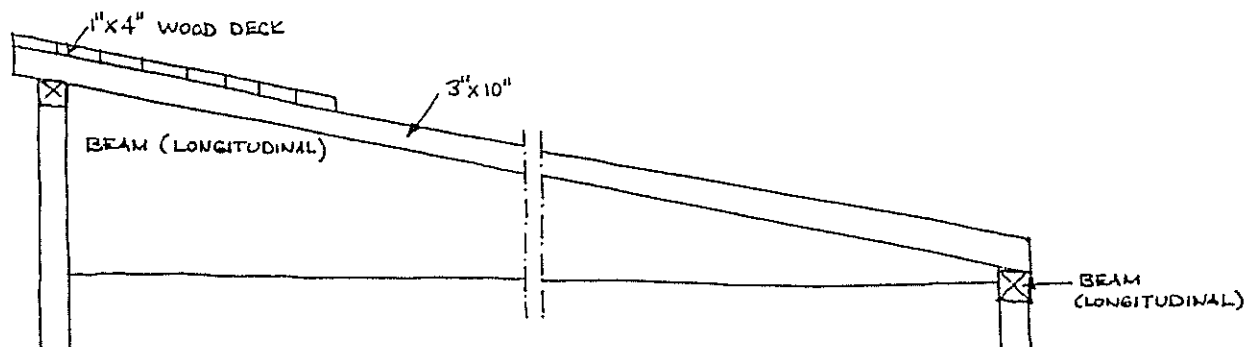
$$M_{\min} = \frac{(88.18)(7)^2}{10} = 431.98 \text{ (ft.lb.)}$$

$$(\sigma_f)_{\min} = \frac{(431.98)(12)}{3.56} = 1456.11 \text{ psi} < 2000 \text{ psi} = \sigma_f'$$

$$(\sigma_s)_{\max} = \frac{679(2.57)}{(6.45)(1.87)} = 144.7 \text{ psi} < 155 \text{ psi} = \sigma_s'$$

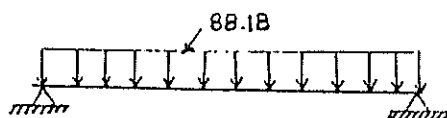
Section is OK

3'. ALTERNATIVE DESIGN OF ROOF (Without supports)

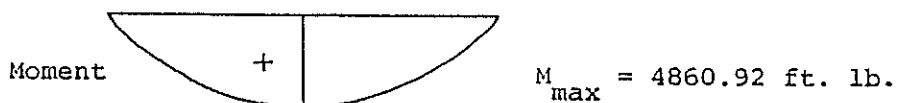
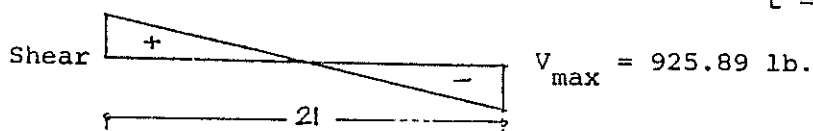


Total vertical load = 88.18 lb/ft.

3" x 10" beam (2 $\frac{5}{8}$ x 9 $\frac{4}{8}$) American Standard Lumber



$$\begin{aligned} A &= 24.94 \text{ in}^2 \\ I &= 187.55 \text{ in}^4 \\ S &= 39.48 \text{ in}^3 \\ Q &= 59.23 \text{ in}^3 \\ t &= 4.75 \text{ in} \end{aligned}$$



$$(\sigma_f)_{\max} = \frac{4860.92(12)}{39.48} = 1477.48 \text{ psi} < 2000 \text{ psi} = \sigma_f'$$

$$(\sigma_s)_{\max} = \frac{925.89(59.23)}{187.55(4.75)} = 61.56 \text{ psi} < 155 \text{ psi} = \sigma_s'$$

Section is OK

3''. DESIGN OF LONGITUDINAL BEAMS

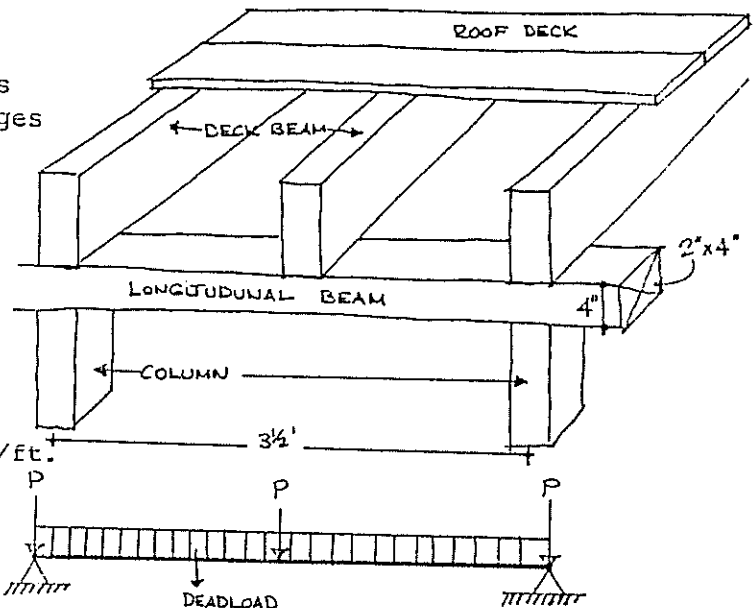
- a. For roof with two supports under deck beams - see pages 159, 160, 161.

$$P = 246 \text{ lb.} \quad \left(\frac{679 (4)}{(11)} \right)$$

use 2" x 4" beam

$$\begin{aligned} A &= 5.89 \\ I &= 6.45 \\ S &= 3.56 \\ Q &= 2.57 \\ t &= 1.87 \end{aligned}$$

$$q = 1.23 \text{ lb/ft.}$$



$$M_{\max} = \frac{qL^2}{8} + \frac{PL}{4} = \frac{1.23(3.5)^2}{8} + \frac{246(3.5)}{4}$$

$$M_{\max} = 217.13 \text{ lb.ft.}$$

$$V_{\max} = P = 246 \text{ lb.}$$

$$(\sigma_f)_{\max} = \frac{217.13}{3.56} = 60.99 < 2000$$

$$(\sigma_s)_{\max} = \frac{246 (2.57)}{(6.45) (1.87)} = 52.4 < 155$$

Use 2" x 2" beam

$$\begin{aligned} A &= 2.64 \text{ in}^2 \\ I &= 0.58 \\ S &= 0.72 \\ Q &= 0.78 \\ t &= 0.81 \end{aligned}$$

$$(\sigma_f)_{\max} = \frac{217.13}{0.72} = 301.57 < 2000$$

$$(\sigma_s)_{\max} = \frac{246 (0.78)}{(0.58) (0.81)} = 408 > 155$$

Not good

Thus, 2" x 4" should be used (since 2" x 3" is not available).

D. For the roof without supports at the middle, see page 161.

Design for the longitudinal beams

$$P = 925.89$$

$$V_{\max} = 925.89$$

Use 4 x 10 beams

$$A = 34.44 \text{ in}^2$$

$$I = 259.00$$

$$q = 30 \frac{34.44}{144} = 7.17 \text{ lb/ft.}$$

$$Q = 40.90$$

$$S = 54.53$$

$$t = 4.75$$

$$M_{\max} = \frac{qL^2}{8} + \frac{PI}{4} = \frac{7.17 (3.5)^2}{8} + \frac{925.89}{4} (3.5) = 821.13 \text{ ft. lb.}$$

$$(\sigma_f)_{\max} = \frac{821.13 (12)}{54.53} = 180.7 \quad 2000$$

$$(\sigma_s)_{\max} = \frac{925.89 (40.9)}{259.00 (4.75)} = 30.7 \quad 155$$

Section is too big

Use 4 x 4 beam

$$A = 13.14$$

$$q = 30 \frac{13.44}{144} = 2.8$$

$$I = 14.39$$

$$S = 7.94$$

$$Q = 5.95$$

$$t = \frac{3.625}{2}$$

$$M_{\max} = 814.44 \text{ (ft. lb.)}$$

$$V_{\max} = 925.89$$

$$(\sigma_f)_{\max} = \frac{814.44 (12)}{7.94} = 1230 \text{ psi} < 2000 = \sigma_f'$$

$$(\sigma_s)_{\max} = \frac{925.89 (5.95)}{(14.39) \left(\frac{3.625}{2}\right)} = 211 > 155 = \sigma_s' \quad \text{Not good - Use 4"x6" beam}$$

Notice that roof beams (or deck beams) without support increases the sections of deck beams and longitudinal beams. Thus we shall use roof deck with two supports from now on.

a. Design of deck wood

It is already shown that 1" x 4" deck wood is OK (see page 160).

$$\text{load on each wood} = 3 \frac{5}{8} (1.75) 52.5 = 27.75$$

b. Design of secondary beams (try 2" x 8" section)

$$\text{loads from deck wood} = 52.5 \text{ lb/ft}^2 \quad A = 12.19$$

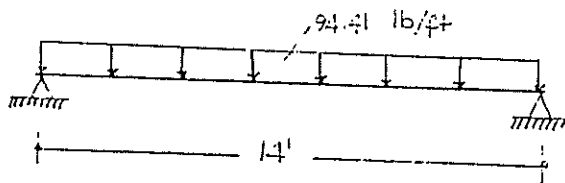
$$\text{D.L. of beam} = 30 \frac{12.19}{144} = 2.54 \text{ lb/ft.} \quad I = 57.13$$

$$\text{Area supported by each beam} = (1.75)(14) = 24.6 \text{ ft.}^2 \quad S = 15.23$$

$$Q = 11.4$$

$$t = 3.75$$

$$\text{Total load on each beam} = 2.54 + 52.5 \frac{24.6}{14} = 94.41 \text{ lb/ft}$$



$$V_{\max} = \frac{94.41}{2} (14) = 660.90 \text{ lb.}$$

$$M_{\max} = \frac{94.41 (14)^2}{8} = 2313.0 \text{ ft.lb.}$$

$$(\sigma_f)_{\max} = \frac{2313.0(12)}{15.23} = 1822.49 \quad 2000 \quad (\text{OK})$$

$$(\sigma_s)_{\max} = \frac{660.9 (11.4)}{(57.13)(3.75)} = 35.16 \quad 155 \quad (\text{OK})$$

For 14' span THUS SECONDARY BEAMS SHOULD BE 2" x 8"

For 17.5' span USE 2" x 10" SECTIONS FOR SECONDARY BEAMS

c. Design of main beams

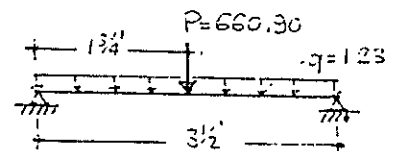
Try 2" x 4" beams

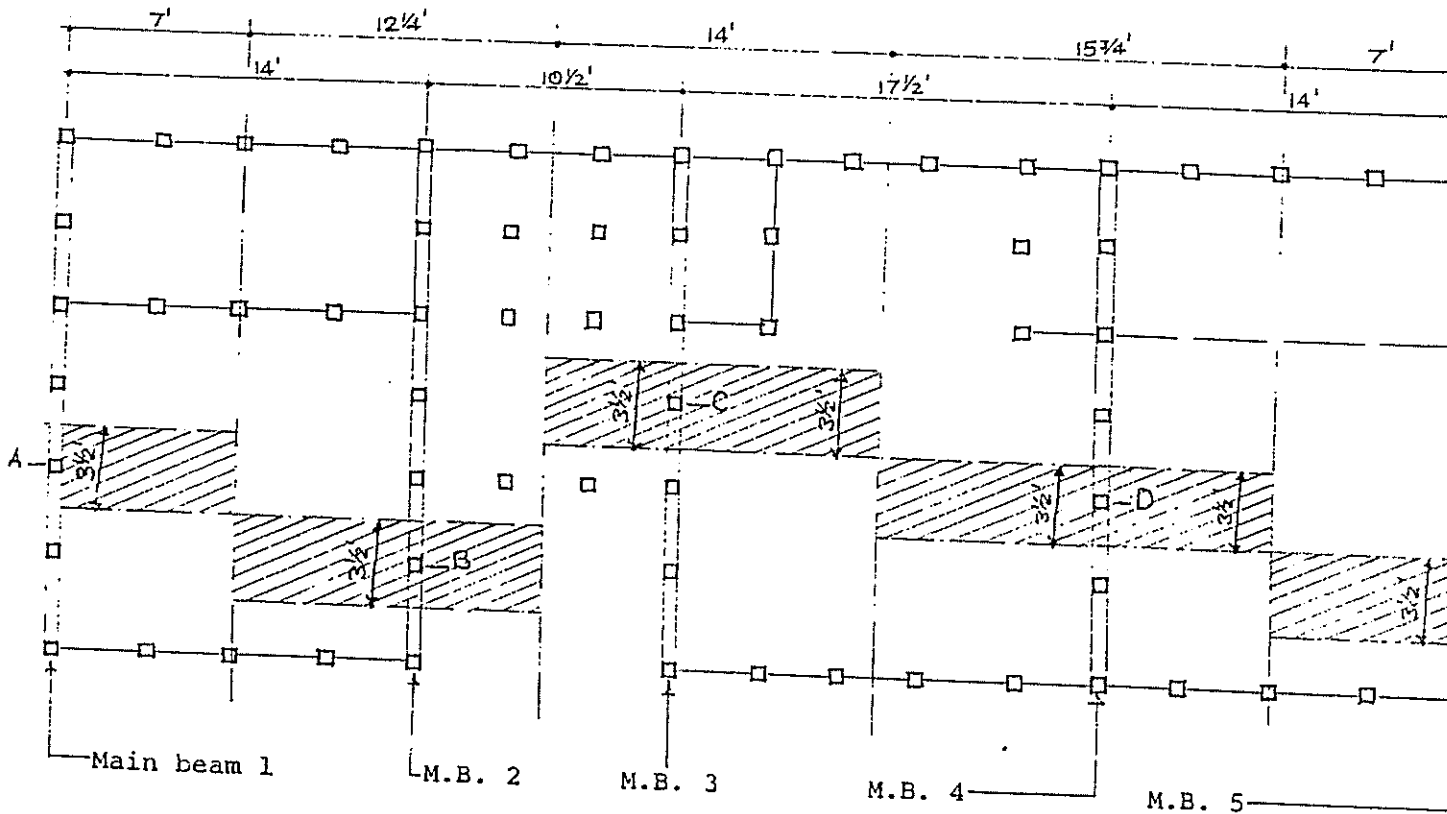
$$V_{\max} = P = 660.90 \text{ lb.}$$

$$M_{\max} = 578.47 \text{ ft.lb.}$$

$$(\sigma_f)_{\max} = \frac{578.47(12)}{3.56} = 1949 \text{ psi} < 2000 \text{ psi}$$

$$(\sigma_s)_{\max} = \frac{660.9 (2.57)}{(6.45)(1.87)} = 140.82 \text{ psi} < 155 \text{ psi} \quad \text{Section is OK}$$





Main beam carries the attic floor loads to the columns. The columns under the main beams (M.B. 1, M.B. 2, . . . M.B. 5) due to the size of area which they support could be numbered as Type A, Type B. . . . Type E.

Type	Area supported (ft ²)	Load supported (lb)	Required area (in ²)
A	3.5 (7) = 24.50	55(24.50) = 1347.5	0.869
B	3.5(12.25) = 42.875	55(42.875) = 2358.13	1.52
C	3.5 (14) = 49.00	55(49.00) = 2696.0	1.74
D	3.5(15.75) = 55.125	55(55.125) = 3031.88	1.96
E	3.5 (7) = 24.50	55 (24.50) = 1347.5	0.869

Example

Compressive strength = $\sigma_c' = 1550$ psi

Type A $P = 1347.5$ lb. $A \geq \frac{P}{\sigma_c'} = \frac{1347.5}{1550} = 0.869 \text{ in}^2$

This is the same way the rest of them are calculated.

As we can see, these areas are very small. Notice here that we did not include the roof loads which are going to be carried by these same columns. Thus we should double the areas of the columns. However, we have to satisfy Euler's buckling criteria.

According to Euler's formula for allowable column load for timber constructions:

$$L = \text{maximum unsupported length} = (7.5)(12) = 90"$$

$$d = \text{Try } 2" \left(1 \frac{5}{8}" \text{ dressed size}\right) \text{ least dimension of section} = 1.625"$$

$$\frac{L}{D} = \frac{90}{1.625} = 55.38 \text{ This should be smaller than } 50.$$

$$\text{Allowable compressive strength} = \frac{0.3E}{(L/D)^2} = \frac{0.3 (1.6 \times 10^6)}{(50)^2} = 192 \text{ psi}$$

Thus, we should calculate the areas of columns accordingly:

Type	Load (P) (lb)	Trail area (in) ²	Allowable σ_c' (psi)	Design area	Selected Dimensions
A	(1347.5)	7.02	780	1.72	4" x 4"
B	(2358.13)	12.28	780	3.02	4" x 4"
C	(2696.0)	14.04	780	3.44	4" x 4"
D	(3031.9)	15.79	780	3.88	4" x 4"
E	(1347.5)	7.02	780	1.72	4" x 4"

from p.165 $\sigma_c' = 192$ used σ_c' recalculated
from Euler's formula
for each type.

Thus, for all columns (Type A . . . Type E) 4" x 4" section should be used since 2" x 2" is not satisfactory and 3" x 3" is not available.

However, 3" x 4" can also be used.

For the rest of the columns (except the ones under main beams), 2" x 2" should be used.

6. SEISMIC ANALYSIS

Lateral load due to earthquake = $V = 0.237W$

W = total dead load + 25% floor live load

$W = W_{\text{roof}} + W_{\text{attic floor}} + W_{\text{walls}} + \%L.L. \text{ (for each of them)}$

$$\begin{aligned}
 W_{\text{roof}} &= 18 \times 21 \times 56 + 40.5 + 4.58 \\
 &\quad + \frac{25}{100} 20 (21 \times 56) \\
 &= 27093.08 \text{ lb.}
 \end{aligned}$$

$$\begin{aligned}
 \text{D.L. Tile} &= 15 \text{ lb/ft}^2 \\
 \text{D.L. wood deck} &= 2.5 \text{ lb/ft}^2 \\
 \text{deck beams D.L.} &= \frac{(33)(30)(5.89)}{144} = 40.5 \text{ lb.} \\
 \text{D.L. longitudinal beams} &= \frac{2(56)5.89}{144} = 4.58 \text{ lb.} \\
 \text{D.L. of rest} &\approx 0.561/\text{ft}^2
 \end{aligned}$$

$$\begin{aligned}
 W_{\text{attic}} &= 4(21 \times 56) + \frac{25}{100} 50(21 \times 56) \text{ D.L. wood deck} = 2.5 \\
 &= 19404. \text{ lb.} \\
 \text{D.L. secondary beams} &= (30) \frac{12.19}{144} \frac{1}{1.75} = 1.45 \\
 \text{D.L. main beams} &= 0.15
 \end{aligned}$$

Weight of adobe brick assumed 100 lb/ft^3

$$W_{\text{walls}} = \left\{ [2(56) + 2(21)] 100 \left(\frac{23}{12} \right) + [3(21) + 56] 100 \left(\frac{18}{12} \right) \right\} \frac{7.5 + 10.5}{2} = 341817 \text{ lb.}$$

$$W = 27093.08 + 19404.0 + 341817 = 388314 \text{ lb.} = 388 \text{ kips.}$$

$$V = 0.237 (388) = 92 \text{ kips}$$

Total area of columns = ?

$$\text{Number of type A, B, C, D, E} = 5 \times 7 = 35 \quad (4" \times 4") \quad (13.14 \text{ in}^2)$$

$$\text{Number of } 2" \times 2" = 32 \quad (2" \times 2") \quad (2.64 \text{ in}^2)$$

$$\text{Total column area} = 35(13.14) + 32(2.64) = 544.38 \text{ in}^2$$

Shear strength of wood = 155 psi

$$V_{\text{allowable}} = 155 (544.38) = 84378 \text{ lb.} = 84 \text{ kips}$$

Comparing 92 kips versus 84 kips and realizing that strength of adobe brick portion of the wall is not included in above calculation at all, this result is acceptable.

If lateral load resistance of adobe wall is completely going to be ignored, 2"x2" columns should be increased to 3"x4". In that case:

$$\text{Total column area} = 35(13.14) + 32(9.52) = 764.54 \text{ in}^2$$

Shear strength of wood = 155 psi

$$V_{\text{allowable}} = (764.54)(155) = 119 \text{ kips} \quad \underline{\text{OK}}$$

The last alternative is to design all the columns with 3"x4" section

$$\text{Total column area} = 67(9.52) = 637.84$$

$$V_{\text{allowable}} = (637.84)(155) = 99 \text{ kips} \quad \underline{\text{OK}}$$

ENERGY

Energy which is currently in use or potential energy sources surround us: movement, light, heat, magnetism, gravity, and sound. All life functions which are produced and supplied by nature are still untapped. We have a very limited amount of fossil fuels and these should be used to continue producing petrochemicals, medicine, plastics, and other fossil fuel products.

In the next twenty years we will need new sources of energy. Unlike fossil fuels and nuclear energy, they should be readily available and do a minimum amount of damage to the environment of future generations. There are many books and articles coming out regarding new energy sources, such as:

- wind energy
- water energy
- organic matter
- sun energy

There is very little information about the history of these sources, but we know they are not new at all and were in use for centuries. Only 150 years ago, we switched from renewable sources to non-renewable sources which are in use today. Historic drawings have proved to us that windmills and waterwheels were used in ancient Persia and China. The Babylonians irrigated their fields with water pumped from windmills in 1700 B.C.

Before the 17th century, Europeans were using solar cookers and solar stills. In the 17th century, development of natural energy sources reached a point where solar furnaces were used to melt metals and glass. The first solar engine was invented then as well.

The only way to be able to use these "new" energy sources is to develop the required technology and knowledge. Today, our existing technology (in limited cost) can harness these natural energy sources on a small scale. These sources can give satisfactory results for the energy needs of the rural parts of the world which contain more than half of the world's population.

The general goals of the power sources in rural areas should be:

1. low cost
2. maximum efficiency

3. adaptability to the diverse conditions of different regions
4. use of locally available materials
5. use of locally available tools
6. use of local skills
7. ease of understanding, reparation and maintenance

In today's houses, sun, wind, water, human wastes and organic garbage are considered as our enemies. We are trying to keep sun and wind out of our buildings. Human wastes and garbage are our current economic and environmental problem. Now is the time to use them as future sources of power. The following examples will show the application of these new sources of power to Turkish villages. However, it should be understood that any single source of power will not be sufficient to supply the complete energy needs of a village unit or a small farm. Different energy sources should work in harmony with each other to fulfill the energy needs of a family unit.

There are numerous existing technologies, low in cost, simple in construction and maintenance, using available materials, and having no pollution or destruction which can be found in the villages. Energy conservation is cheaper than energy production.

The best application for wind power is water pumping, since wind is always available. Water tanks do the job of batteries when there is a lot of wind, and they provide stored water when there is no wind. Wind generators can be used for lighting, operating radios, and supplying groups of small homes with a maximum of 500 watts.

Solar energy is used for heating purposes; for example, solar water heaters, steam cookers, and ovens can be used. The technology is simple, low in cost, and beneficial. Solar water heaters are already highly utilized and economical. Solar water wheels can be used to grind grains and drive light machinery. Many are slow and propelled by moving or falling water. The water turbine is the best for small scale generation of electricity.

The methand gas digester is the most difficult system compared to the one mentioned above. Animal wastes are mixed with water and decomposed with the help of bacteria in a sealed container. As decomposition takes place, one of the by-products is methane gas, which can be used for cooking, lighting, operating non-electric refrigeration, as well as for agricultural needs.

Calculation of Energy Needs of a Village Unit and Available Energy Around the House

It would be wrong to generalize the energy needs of a village household. The reasons for this are differences in social structure, climate, local geography, personal lifestyle, health, sex, and age of the people, etc. As an example, the following table can be useful for estimating approximate energy needs;

Energy Use	Annual Energy (KWH) (1KWH=3413 Btu)	Probable Energy Source
Irrigation	300/acre-ft	wind-water-solar-methane
Grinding-food mixing	50/family	wind-water-methane
Water pumping	1000/family	wind-water-methane
Lighting & small power	850/family	wind-water-organic fuels sun-methane
Refrigeration for farm units	200/farm	wind-water-sun-methane
Space heating	400-500/family	sun-organic fuels
Water heating	3500/family	sun-organic fuels
Cooking	400/family	sun-organic fuels-methane

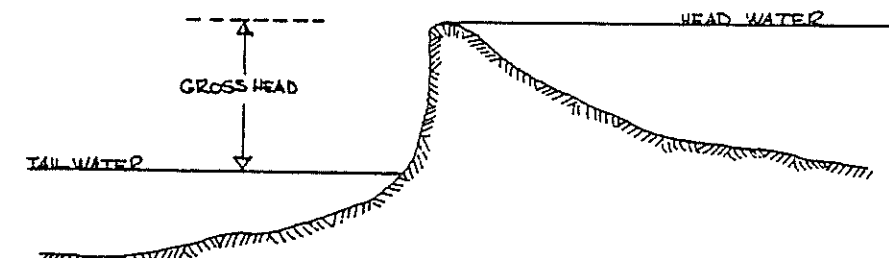
When we know how many KWH of energy are needed to maintain a household independently, we can try to strike a balance with the energy that is available to the household. The available data should be known in order to calculate the energy potential of the area under study.

1. Solar data: See "Climate in different regions of Turkey."
2. Wind data: See "Climate in different regions of Turkey."
3. Water flow: Must be calculated at the site.

$$\text{Gross power} = \frac{\text{Min. water flow (cubic ft/second)} \times \text{gross head (feet)}}{8.8} \quad \text{OR}$$

$$= \frac{1000}{75} \text{ flow (cubic meter/second) } \times \text{head (meter)}$$

Section shows how to measure distance of gross head.



$$\text{Water flow} = \frac{\text{Volume of bucket (cubic feet)}}{\text{Filling time (seconds)}}$$

(cubic feet per second)

4. Methane - calculate the available digestible wastes per year from the people, animals and fields.

Wind energy can be used to pump water or to generate electricity as well as to propel machinery. There are various designs for wind machines: Water pumping windmills which have a slow turning wheel with many blades, or wind generators which have two or three narrow blades turning at a very high speed. The wind speed determines the amount of power available.

Wind generators can be used wherever there is enough wind (10 miles per hour or greater). The amount of power received from the generator is not substantial, but the power received is always free, non-polluting and environmentally safe. Windmills for electrical generation can be available on the market either already built and fully assembled, or they can be built at home on a limited budget. Some windplants consist of four parts:

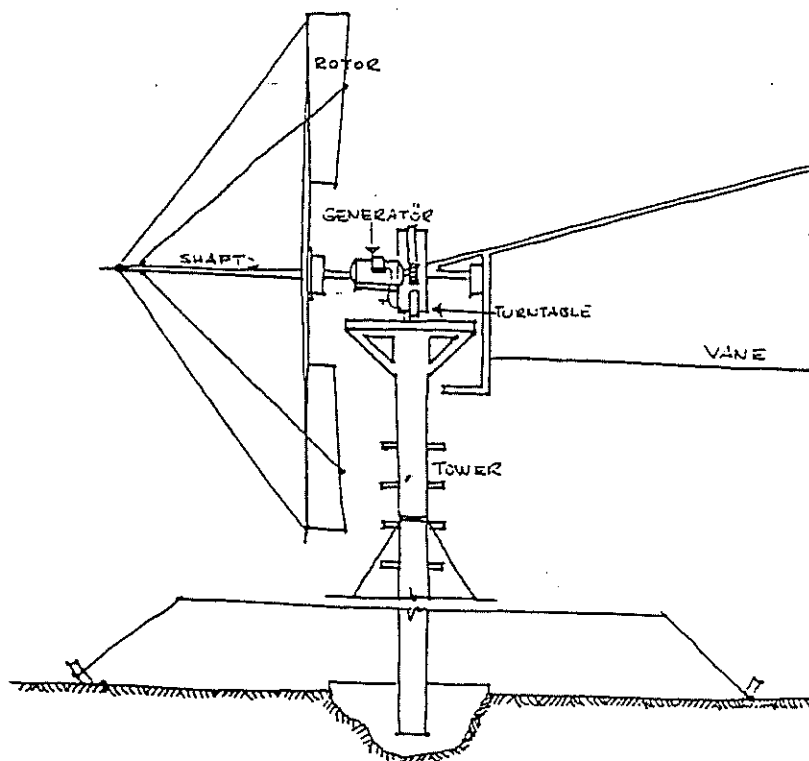
1. Power plant to produce power
2. Storage

3. Conversion devices to convert existing power to a usable form (house current)
4. Back-up system such as methane generator for times when power from the wind generator is insufficient.

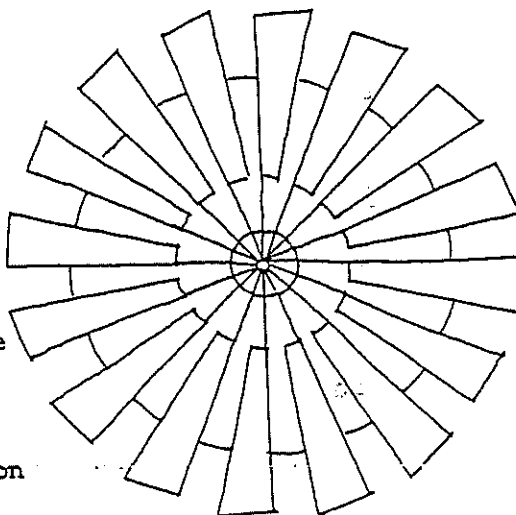
Electricity in a power plant is produced by a rotating electric generator, turned by a propeller which is then pushed around by wind force. The amount of electricity produced by the power system depends on:

- amount of wind
- diameter and weight of the propeller
- size of the generator
- efficiency of the whole system

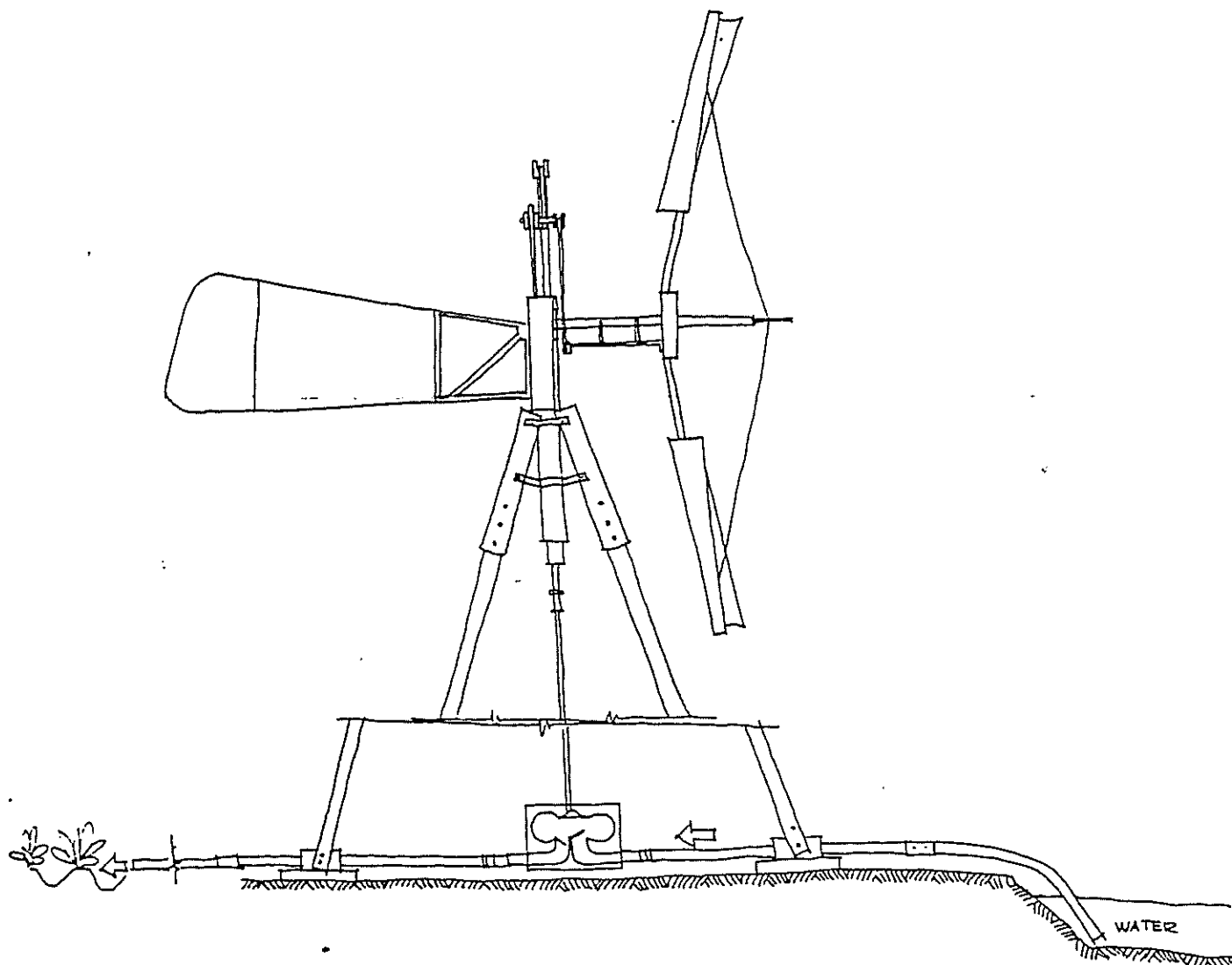
At the moment there are no complete kits or plans available to build "do-it-yourself" wind plants. The only way a villager can make a wind plant without the help of the government is to use old automobile or tractor alternators (which are the least expensive generators available), recycled components, and building many parts himself.

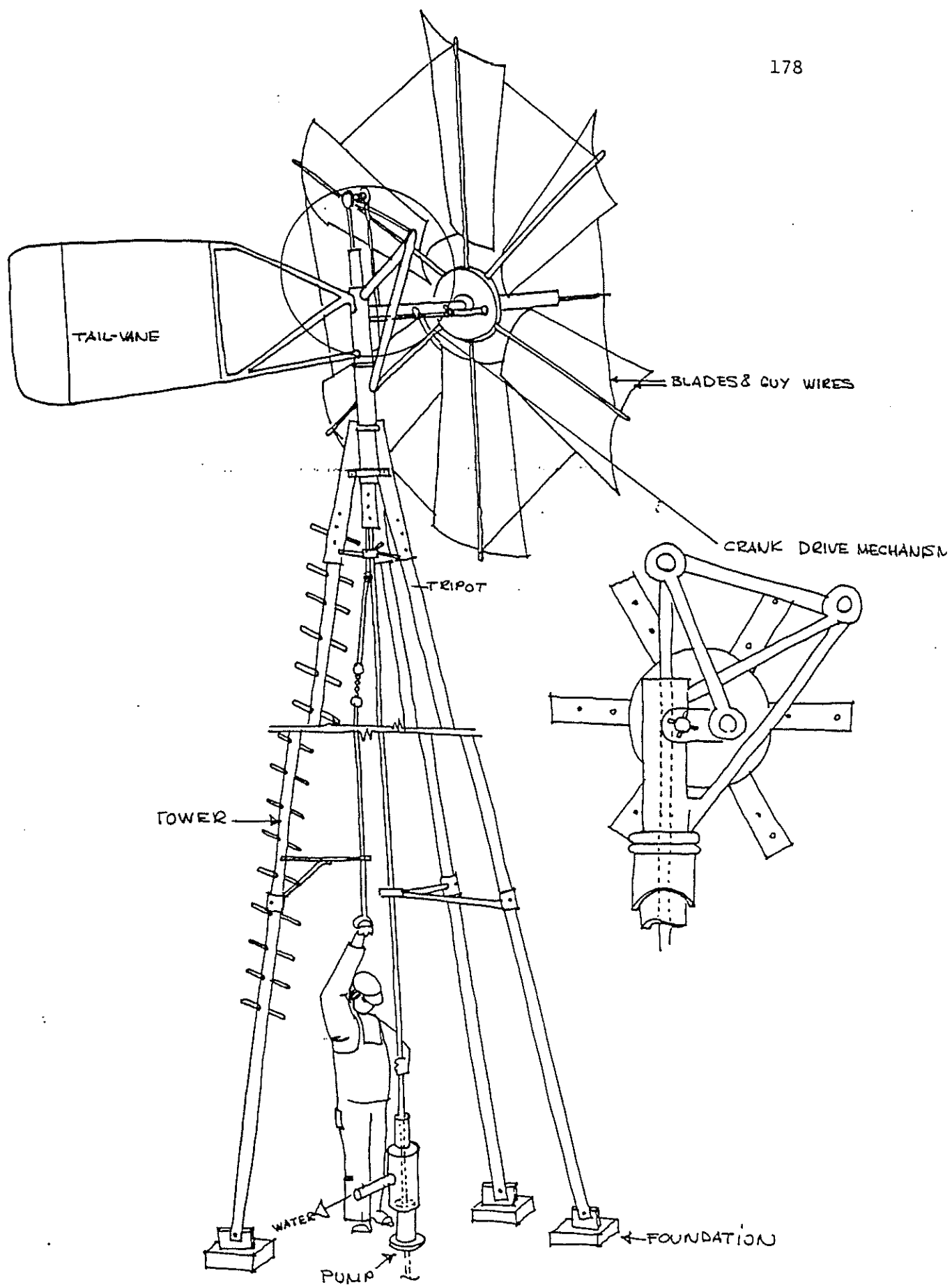


The generator must be free to turn in any direction in order to capture the full power of the wind. The job of the tailvane is to keep the rotor blades face to face with the wind. Rotor blades should be readily available on the market for maximum efficiency.



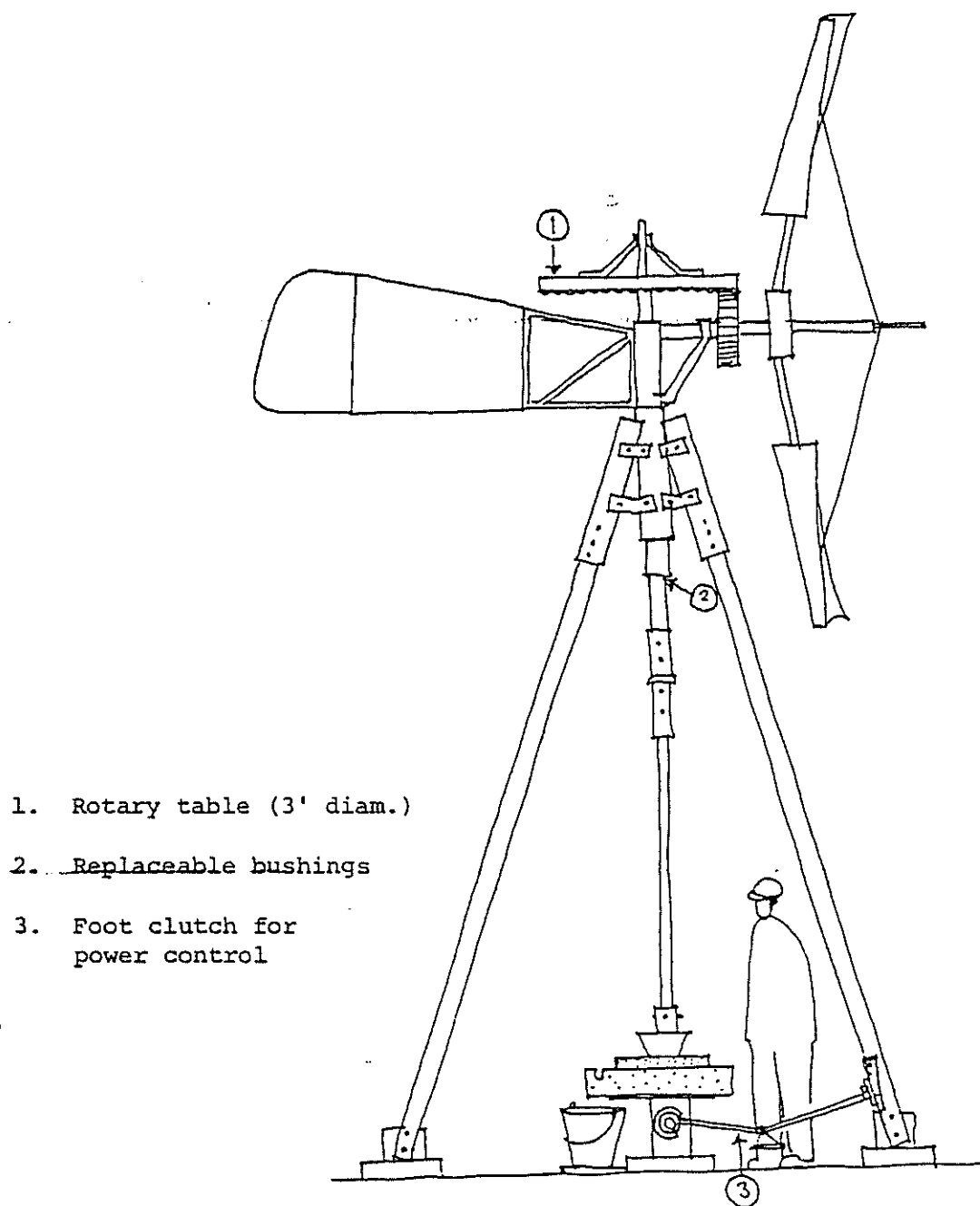
The use of a windmill for pumping water to the field:





THE USE OF WINDMILL FOR PUMPING UNDERGROUND WATER

The use of a basic windmill for grain grinding:



The Vita windmill, built and tested by W. Delameter and P. Miller, is a very successful design for developing countries. (For more information, see "Windmill Design," Hartmut Bossel.)

A windmill produces one horsepower in a wind of 6.4 miles/sec. (4.3 mph), or two horsepower in a wind of 8.1 miles/sec. (18.0 mph). The windmill uses the rear axle of a small car and other parts can be built from sheetmetal, pipes, rods, angle iron and wood. No precision work or machining is required. The rotor blades feather automatically in high winds to prevent damage.

Maintenance and operation

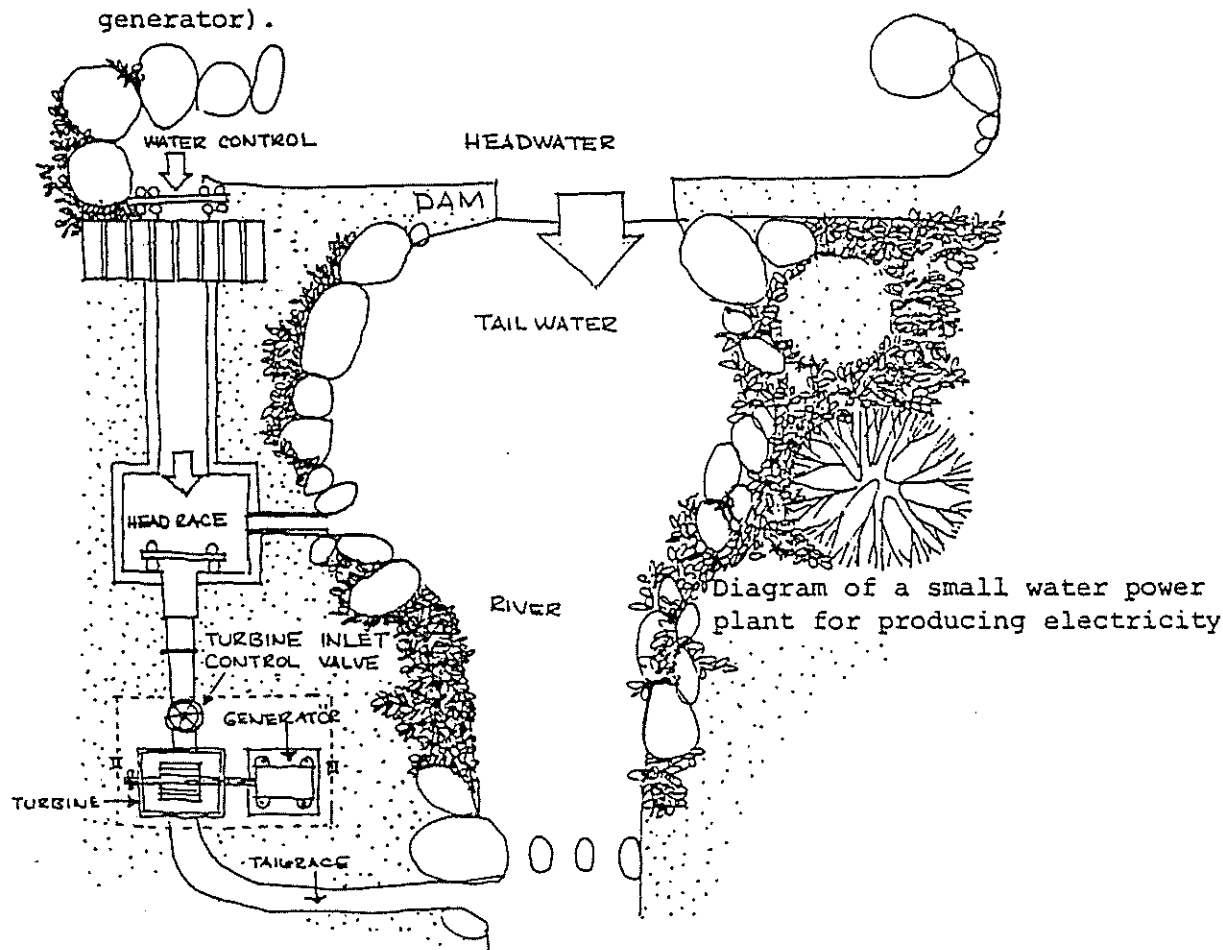
All sliding and rotating parts of the windmill should be greased or oiled a minimum of once every month. If breakage or misalignment occurs, it should be repaired immediately. All metal parts should be rustproofed a minimum of once a year.

Water Power

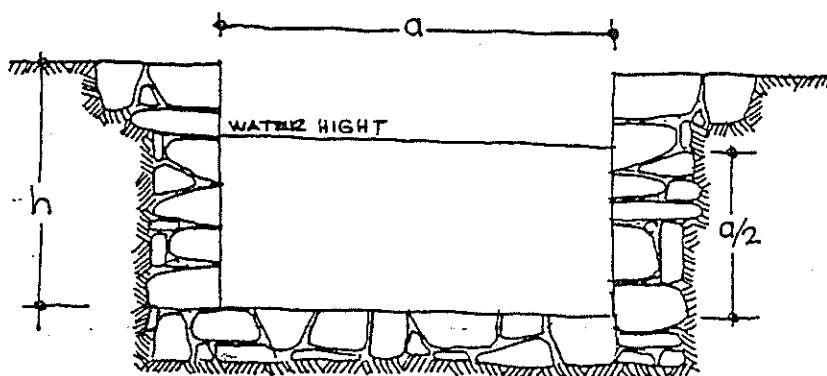
Water energy is used basically to grind grain for flour. Since it is more reliable, it is more effective than wind power. It consists of a slow turning waterwheel (20 rpm) for direct mechanical use, and the quick-turning water turbine produces a large amount of electricity even though it is small in size.

The Banki turbine, built in a small metal workshop, uses only steel plates and blades cut from a large steel pipe, and it is the best home built turbine available to generate electricity.

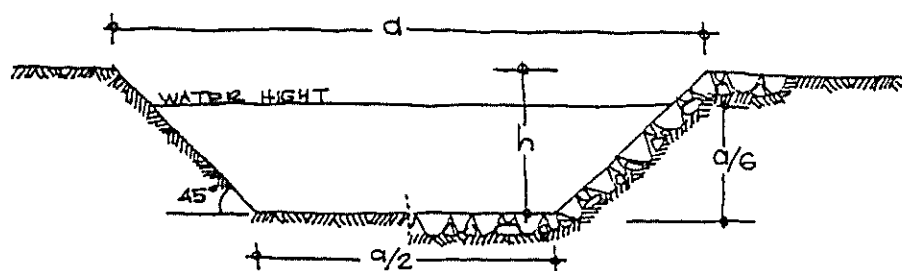
Small water power installation: Water can be used to transfer the energy of the water into mechanical work or electric power. It can also be used to pump itself through a simple device known as a "hydraulic ram." Water power plants consist of three parts: (1) the channel and headrace; (2) the dam; and (3) power unit (turbine and generator).



The channel walls and a dam can be built using virtually any materials available: timber, masonry, concrete, rock with cement mortar.

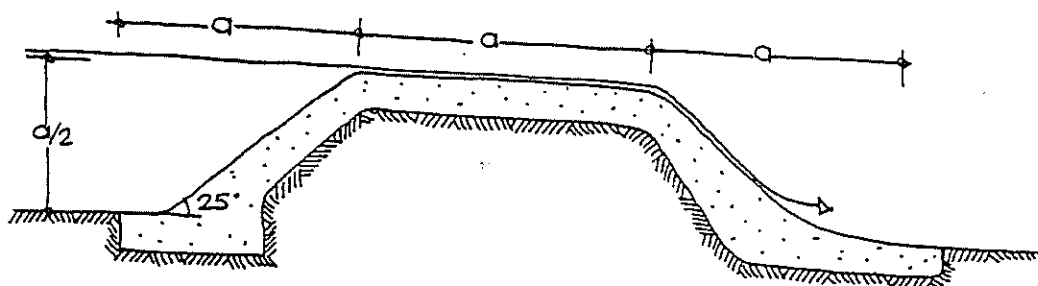


Rock without mortar or earth in channel wall construction:

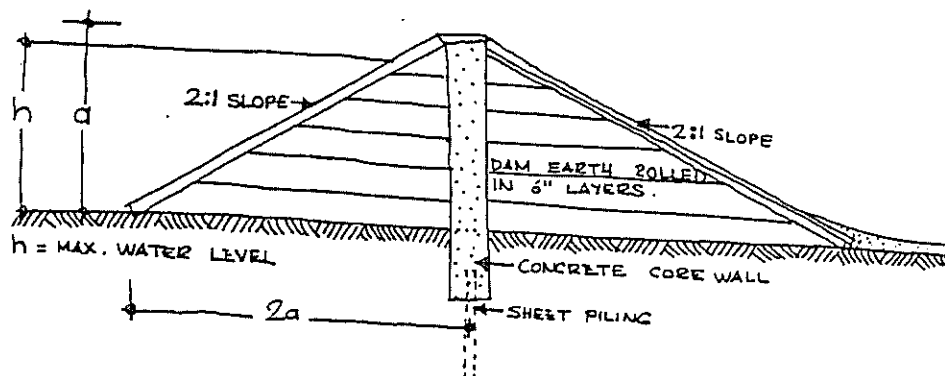


Also, a dam can be built by using earth, wood, stone or concrete. In places where concrete is not available or is too expensive, a dam built from earth, wood, stone, or a combination of those materials results in a strong and resilient dam. Only in earth dams of considerable size should a separate spillway be constructed to carry off excess water. Without a spillway, earth dams will erode and be destroyed.

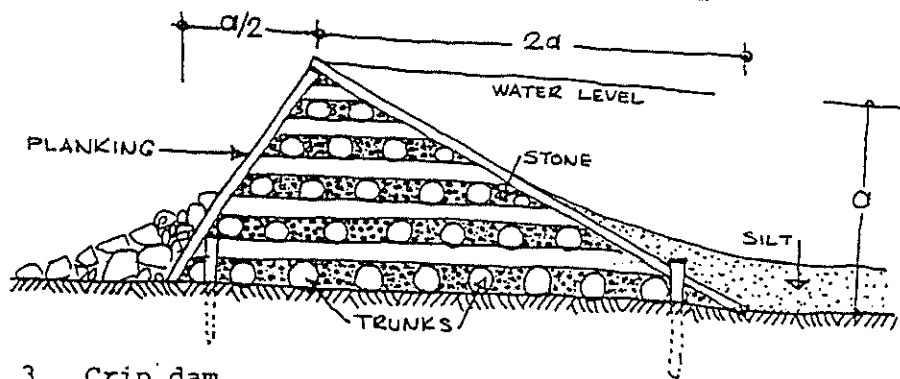
The crib dams requiring tree trunks, planking and stones make very economical and simple dams. Stone dams should be built by using only concrete and must be built with a solid and permanent footing to prevent leakage and shifting.



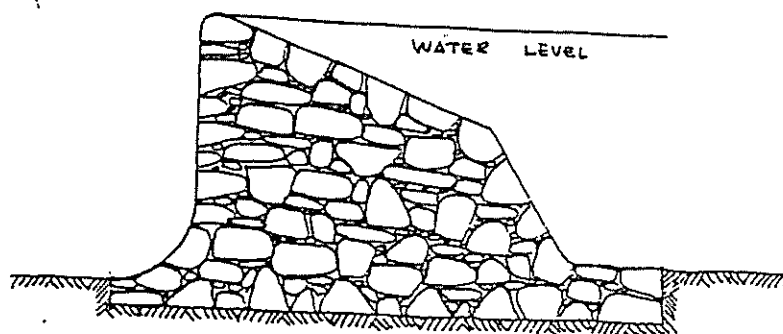
1. Earth dam with concrete spillway



2. Earth fill dam with concrete core wall



3. Crib dam



4. Stone dam with concrete

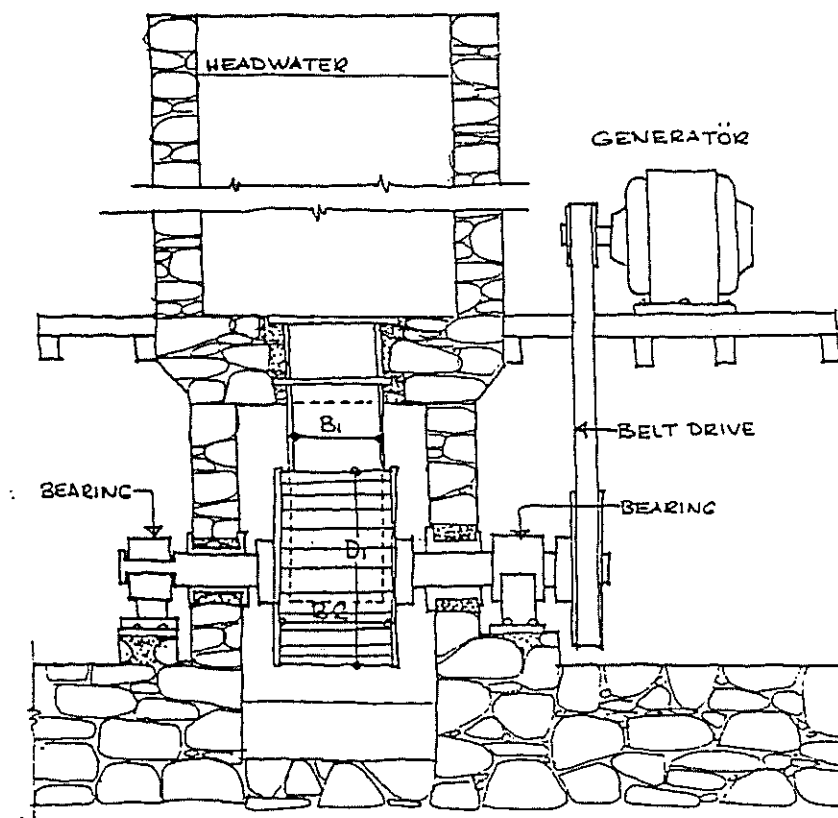
Water turbines, the most sophisticated part of the plant, can be built where there is a welding shop available; it produces direct or alternating current electricity. Calculation of the principal turbine dimensions:

$$B_1 = \frac{210 \times \text{flow (cubic feet per second)}}{\text{runner outside diam. (inches} \times \text{head (feet))}}$$

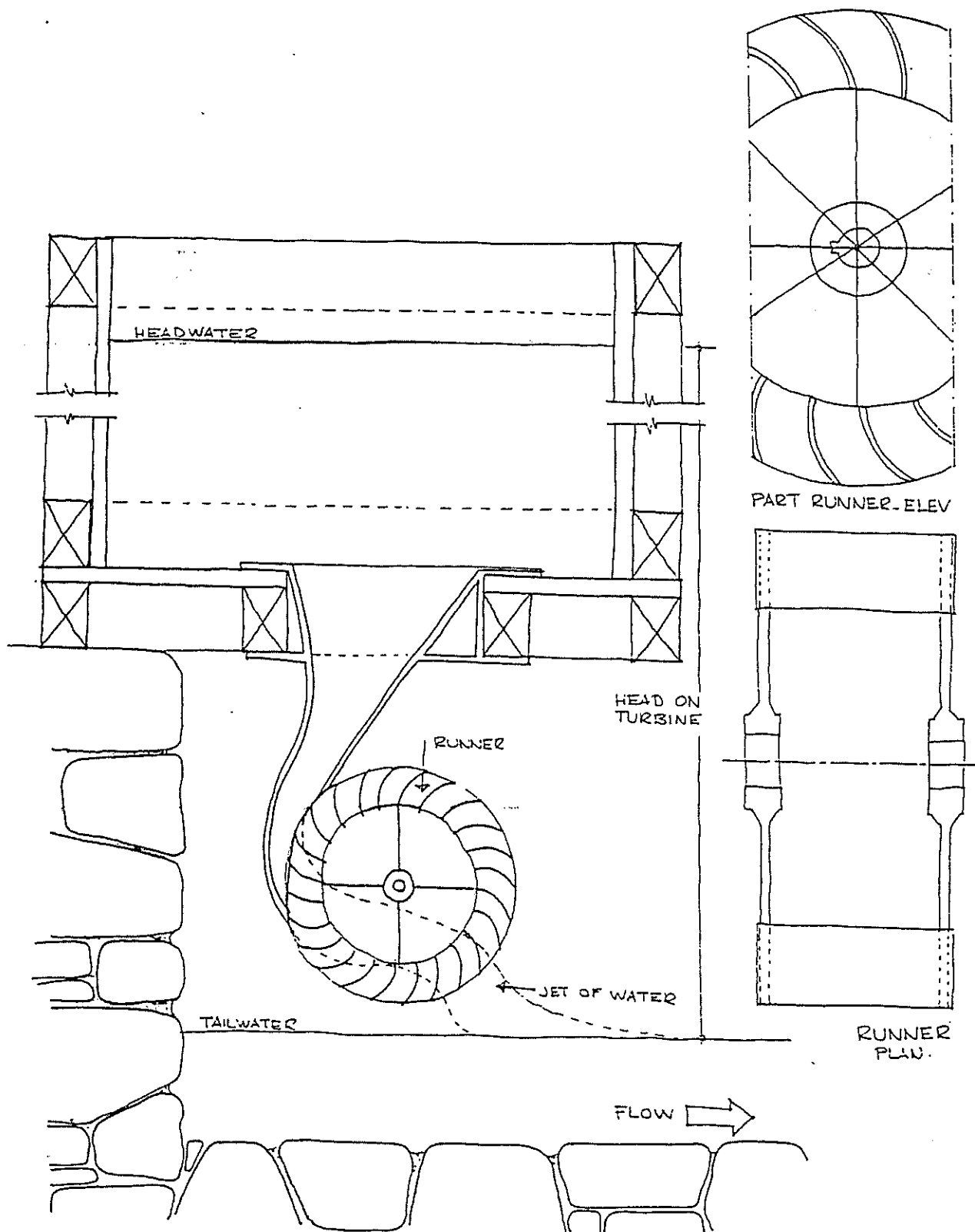
$$B_2 = \frac{862 \times \text{head (feet)}}{\text{runner outside diameter}}$$

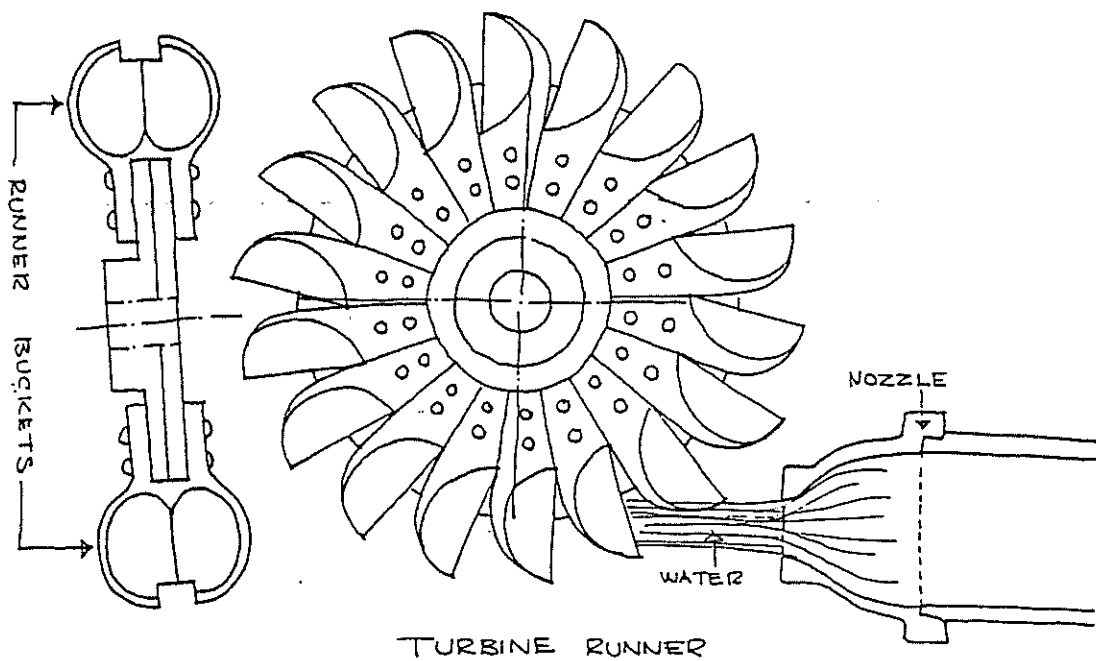
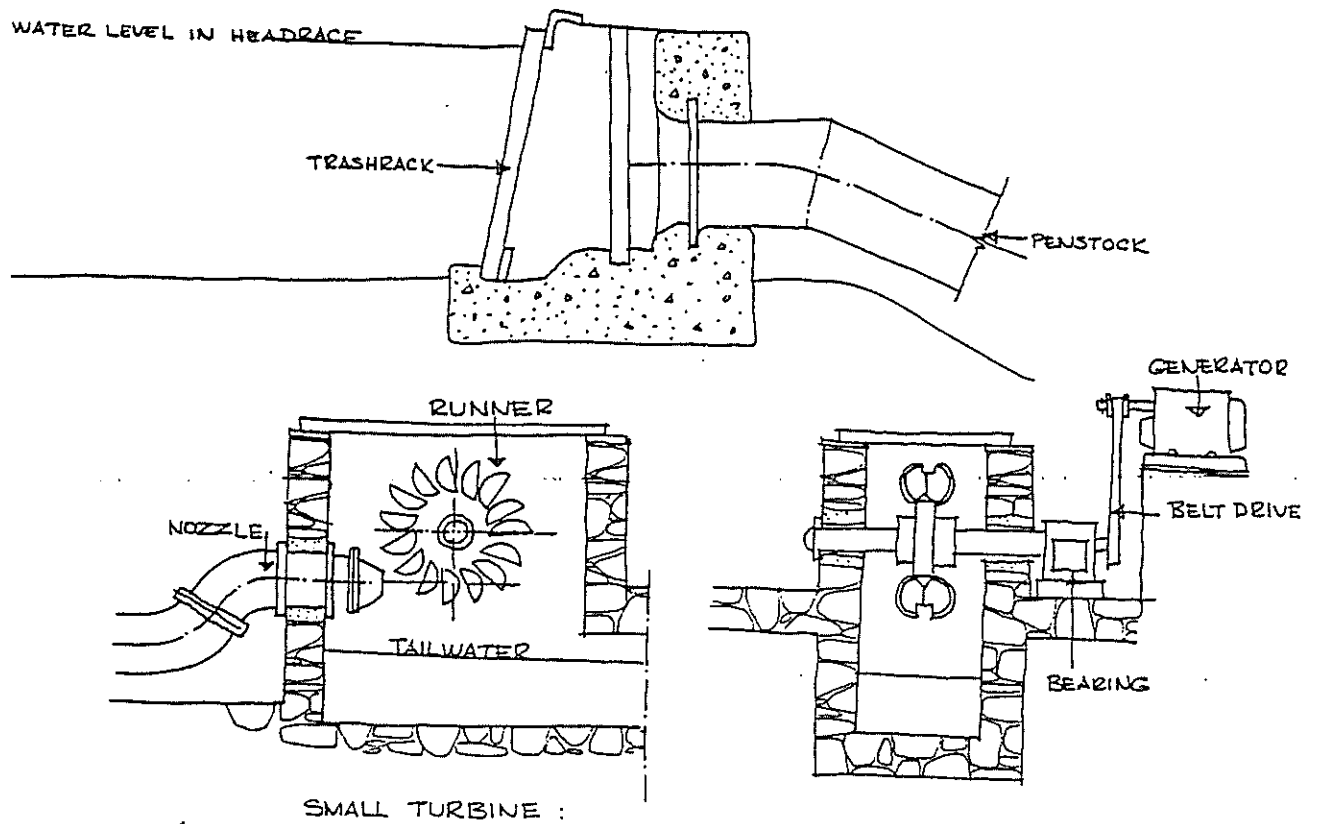
B_1 = width of nozzle (inches)

B_2 = width of runner (inches)



Arrangement of Michell (Banki) Turbine





Wood Energy: Wood is the oldest and most common fuel on earth. The world is now faced with a firewood shortage. Wood is used as fuel in stoves, which are more efficient than open fires.

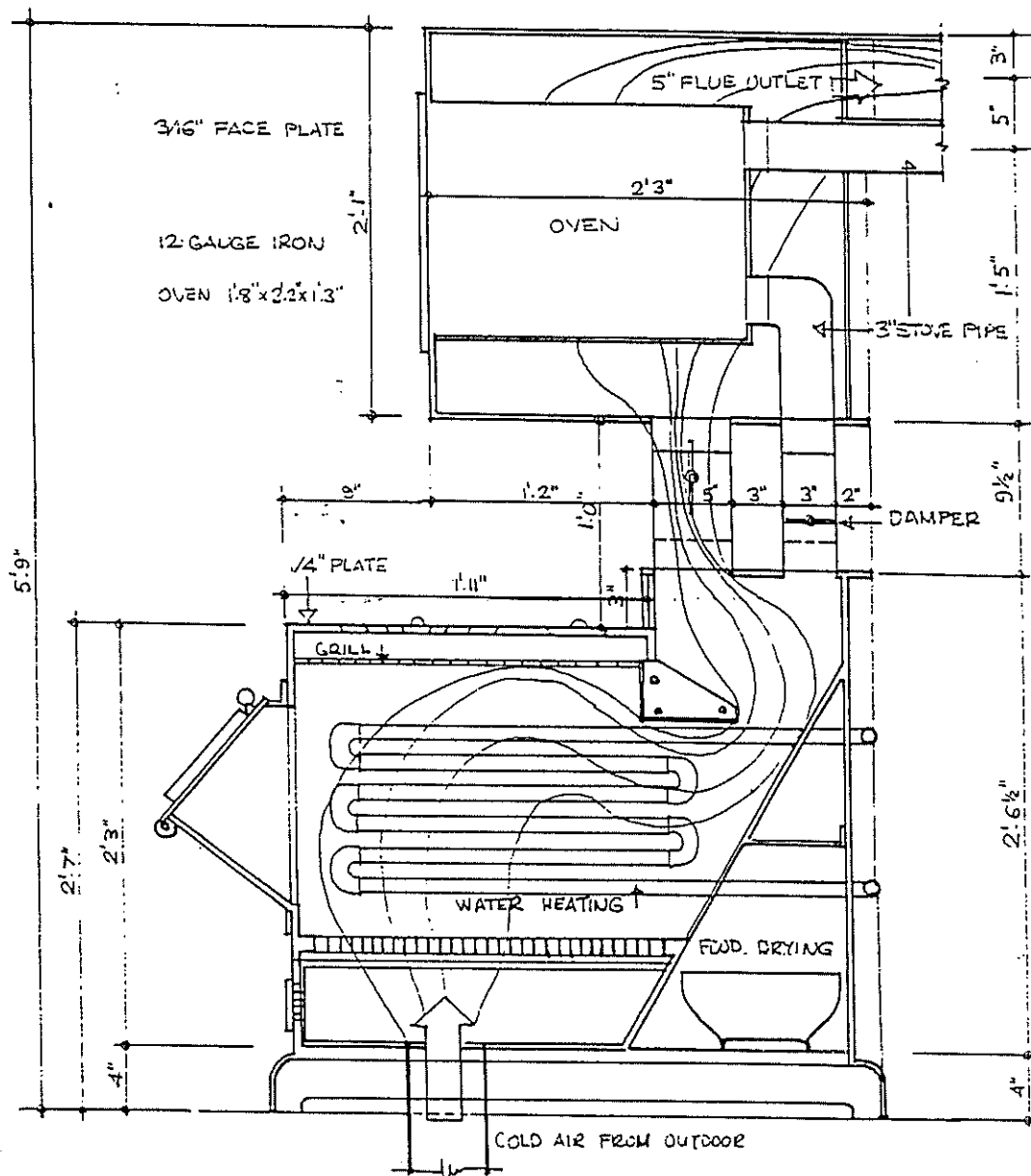
The stove designs are built to use sawdust or rice hulls as fuels, but they do not burn easily. These designs create a constant flow of oxygen next to the outer burning surface of the compressed rice hulls or sawdust.

Stoves also provide hot water: A coil of metal pipe placed inside the stovepipe will heat water as it circulates.

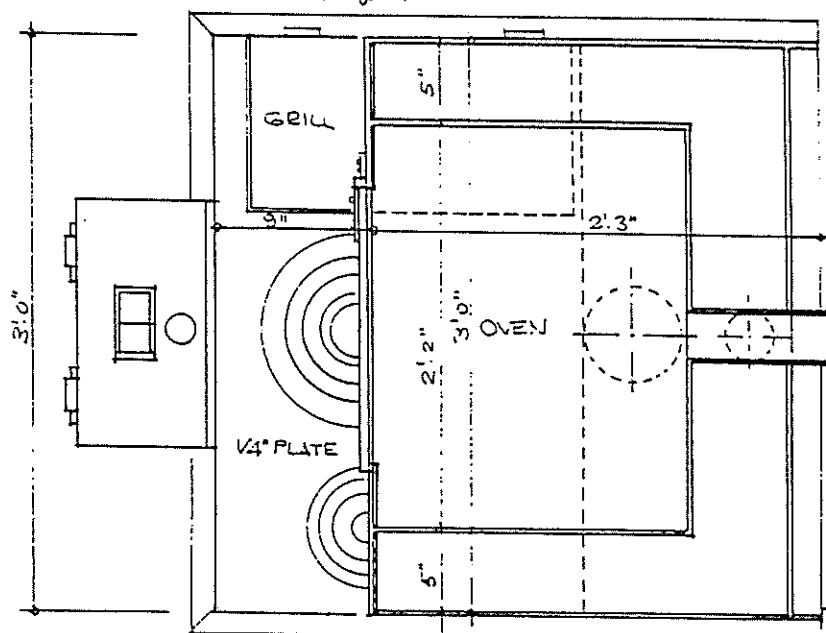
Wood stoves in village houses should be able to serve in different functions, geared to economy as well as comfort. Outside of heating and cooking, stoves should heat the domestic water of the house, and should smoke, dry, barbecue and bake different types of food.

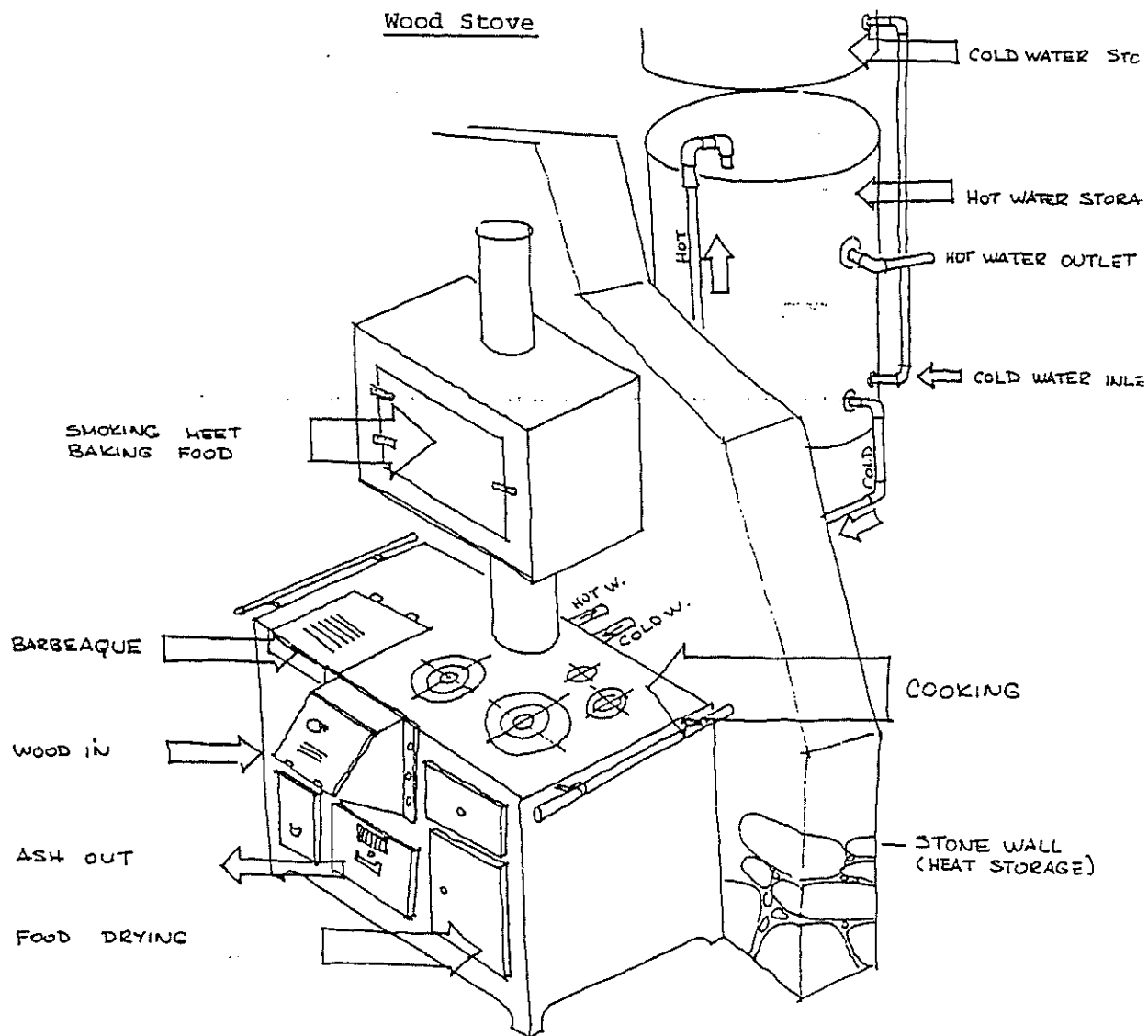
Heated water naturally thermosiphons into a hot water storage tank, which is placed behind the stove. In summer months the stove does not operate, and the garden fireplace takes on the cooking requirements of the house. (See illustration, next page.)

SECTION :
SCALE : 1" = 1'-0"



PLAN
SCALE : 1" = 1'-0"





Hydraulic ram: The hydraulic ram was invented 150 years ago. It is a simple system which uses the power from falling water and forces a small part of the water to a height above the source. The ram has two working parts; it can be pushed as far horizontally as desired, and in this case a bigger pipe is needed.

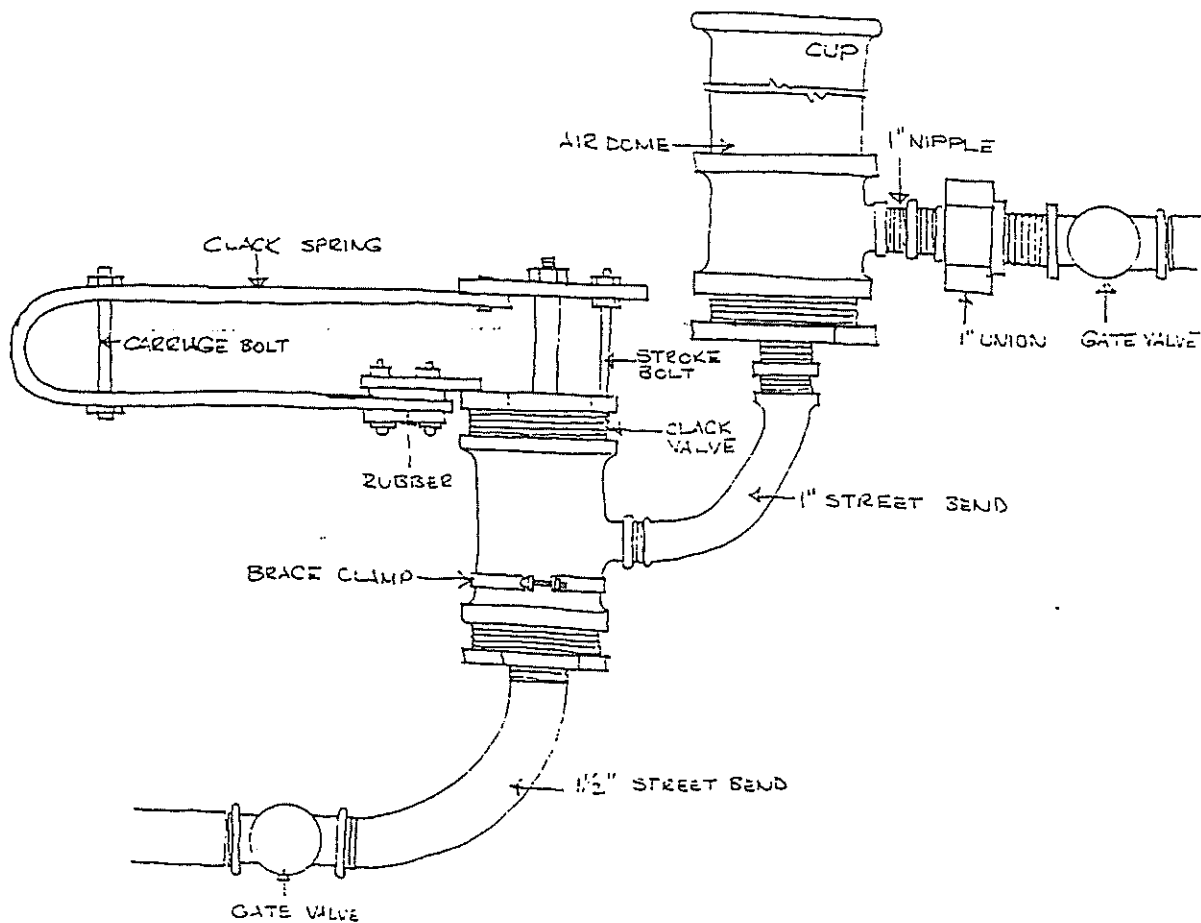
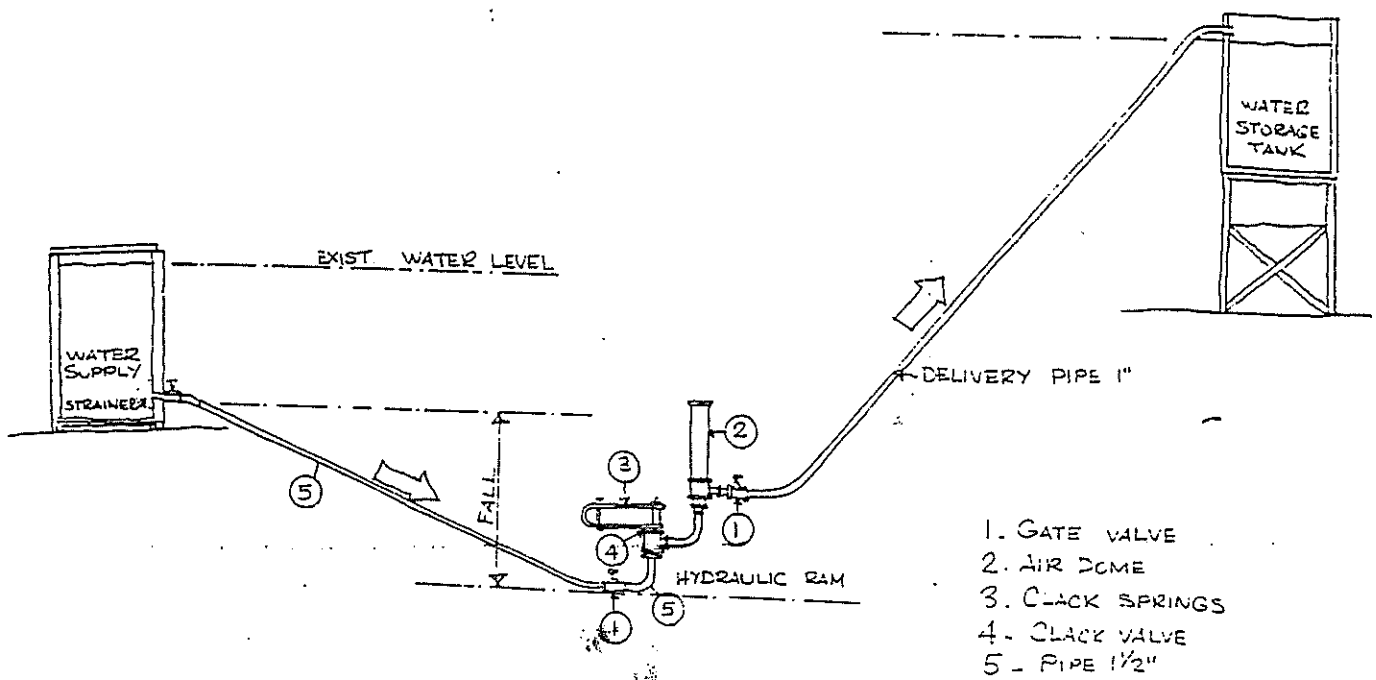
Two things are required for construction:

- enough water to make the ram work
- enough height of water to fall through the drive pipe

When the water runs down the pipe, it goes faster and faster until it forces the automatic valve to close suddenly. The weight of the moving water is stopped, creating high pressure, forcing some water into the air chamber, and compressing the air tremendously, until the energy of the moved water is exhausted. The compressing forces the water up the delivery pipe to the storage tank.

A small amount of water with plenty of fall will pump as much as a greater amount of water with a minimal fall. A hydraulic ram can be used when the flow of a spring of water flows with at least 91.5 cm (3 feet) fall in altitude. The source must have a flow of at least 11.4 liters (3 gallons) a minute. Water can be lifted about 7.6 meters (25 feet) for each 30.5 cm (12 inches) of fall in altitude. A common lift is 45 m (150 feet).

Once the ram is installed, there is little need for maintenance and no need for skilled labor. (See illustration, following page.)



Bio-power: Methane gas digester for fuel and fertilizer

It is possible to turn all natural raw materials to methane gas and sludge, to be stored in insulated, airtight containers called digesters. There are two kinds of digesters in use today:

1. Bath-load digester - filled immediately, sealed, and emptied when the raw material has stopped producing gas.
2. Continuous-load digester - Fed gradually and regularly, so that gas and fertilizer are continuously produced.

Continuous-load digesters are more efficient for village units, because of the availability of daily organic materials (plant wastes, animal manures and human wastes). The gas produced by digestion, known as bio-gas (70 percent methane - CH_4 - and 29 percent carbon dioxide - CO_2), can be used for lighting, cooking, heating and refrigeration (See "Family Size Non-Electric Refrigeration").

Sludge from a digester can be used in a wide variety of ways, in land, water, and pond cultures. In the field it serves a double purpose:

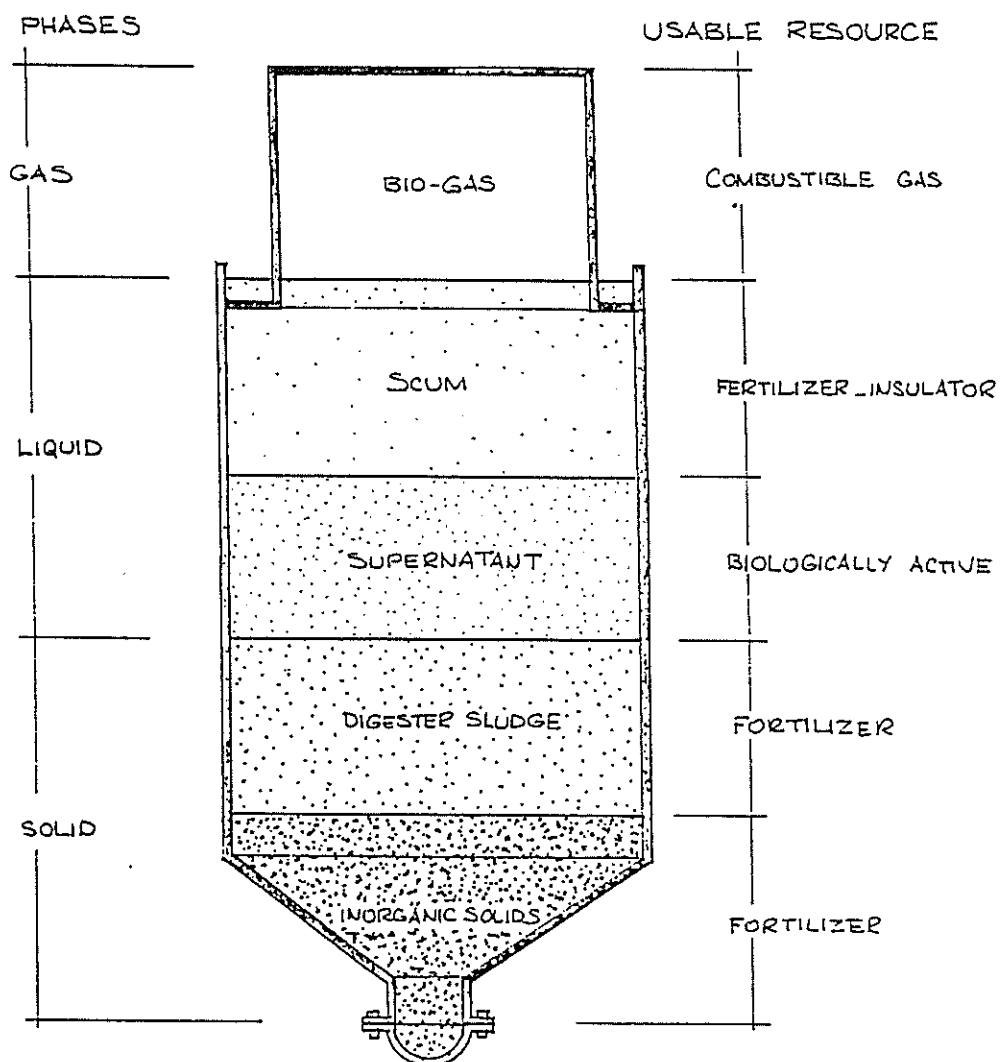
1. Sludge as a soil conditioner
2. Sludge as fertilizer

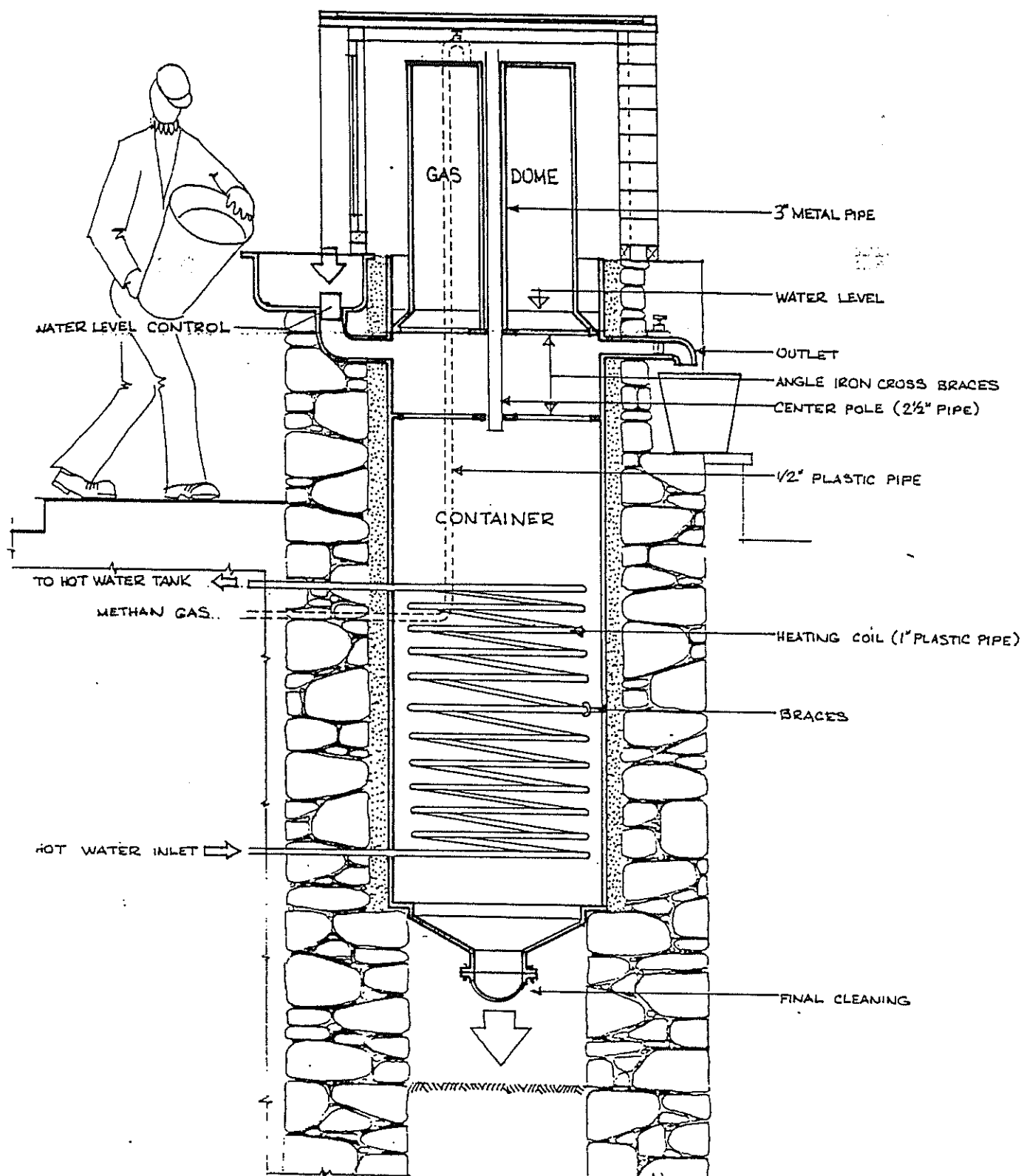
In the pond, sludge from the digester stimulates growth of algae, which are used as feed for fish raising.

Turkish villagers traditionally have used dried "cow patties" as a fuel, to provide sufficient heat for warmth and cooking. The

biggest disadvantage to burning cow patties is that afterwards there is no fertilizer to put on the land. Soil becomes infertile and hard, and this results in serious food shortages. I believe that rural house bio-gas digesters will be very helpful in producing fertilizer as much as bio-gas, but the cost involved to build the main tank (in cement and bricks) and the airtight cover might be considered high for farmers.

Layering of By-Products in Digester





Family Size Non-Electric Refrigerator

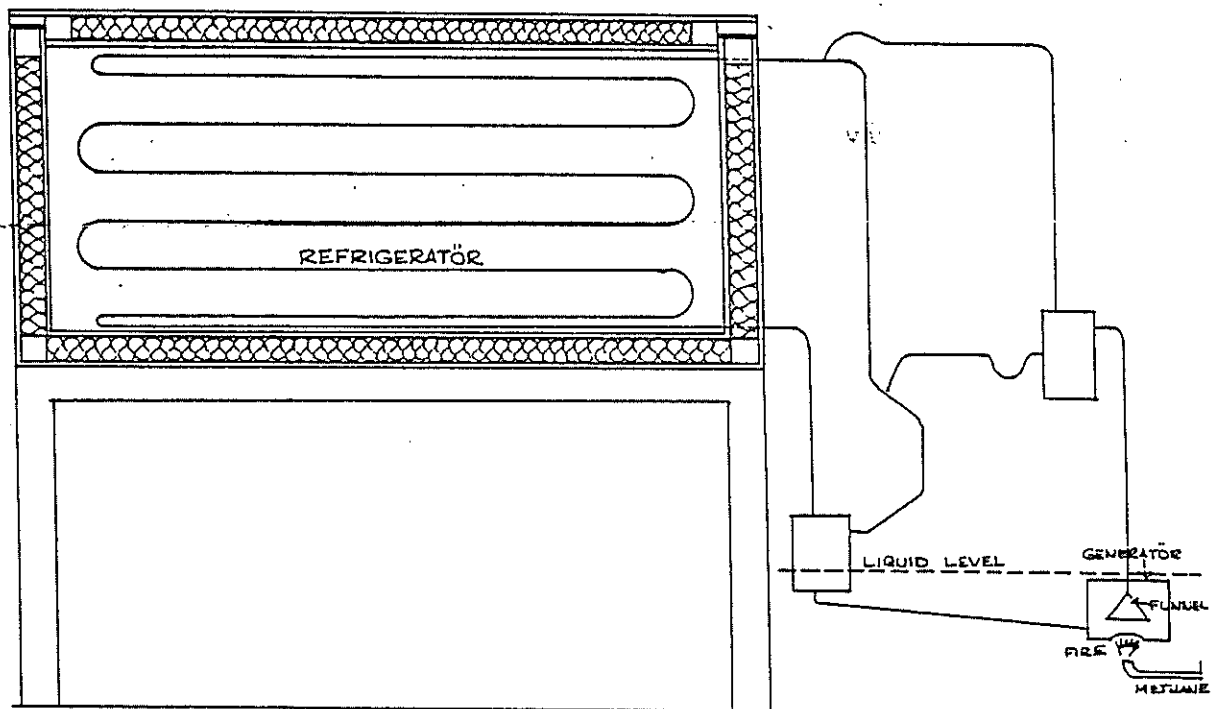
Like energy efficient wood stoves, non-electric refrigerators are ideal for village house units from a food preservation standpoint. They use an alcohol-water solution and cool by evaporation in a low-pressure cycle. The solution in the generator needs to be heated until alcohol vapors and water become separated. Villagers can produce their alcohol from fruit, and then they can use the methane.

From the bio-gas generator for heating the generator, alcohol vapors go into a condenser and then they are condensed back into a liquid. The liquid alcohol will flow down to the evaporator, where it is evaporated by the air passing over it. This is the place where cooling occurs (inside the refrigerator). The air flows back to the evaporator and the water-alcohol solution flows into a reservoir.

At the entry and exit of the coils to the insulated box, insulation is needed. The insulated box used for storing food can be built of wood or adobe bricks.

Enough alcohol-water solution should be placed in the system to fill the generator. When the burner starts to work, within a few minutes percolation should begin, and cooling will start shortly thereafter. The amount of cooling can be controlled by adjusting the amount of heat under the generator. More cooling can also be obtained by increasing the concentration of alcohol.

The system should be checked to see if the liquid level has dropped. If the system loses its cooling power, the liquid should be replaced with a fresh solution.



Sun Power

Solar energy is a low cost system used for home and water heating, cooking, water distillation, food and crop drying. For developing countries, the cost of material might make the collection expensive, but there are numerous ways to make a basic flat plate collector, especially if low pressure is used. These collectors would use metal rather than copper, and wire-tying of the pipe replaces pipes by using channels. The insulating material behind the collector plate can be a natural fiber, sawdust or

animal hairs. Solar cooking and crop drying are the most practical applications of this method. A solar cooker can be in a box with a reflector to direct the sun's energy inside (solar oven).

In the form of a high temperature flat plate, a collector produces steam or concentrates on parabolic dish reflection by focusing a large amount of the sun's energy onto a small area. It can be dangerous if used by a child.

Solar house: Systems and collector design -- In my interpretation, a solar house consists of a building designed to obtain its indoor temperatures by using the environment to which it belongs. Most of the houses built in the future will use environmental forces to heat or cool the interior. The cost of conventional fuels are rising, and their supply is becoming uncertain. This makes solar energy economically feasible as well as environmentally desirable.

Since solar houses are becoming an essential part of our lives, the professional and future users should be made aware of the differences between conventionally heated houses and solar heated houses.

There are four objectives which should be achieved in a solar house:

1. It should collect as much radiation as possible.
2. It should store the maximum amount of heat collected.

3. It should distribute the available heat in storage.
4. It should keep the available heat in the building by eliminating usual sources of heat.

The first three objectives can be achieved by (a) design, and (b) equipment used in building. The fourth objective can be achieved in design and construction of the building itself.

~~Collection of the heat:~~ The first goal of a solar building should be to collect as much radiation as possible. Heat collection occurs in collectors, which is where conversion of radiation to heat takes place. Collectors should be protected from convective, conductive and radiative cooling. Collectors consist of three parts:

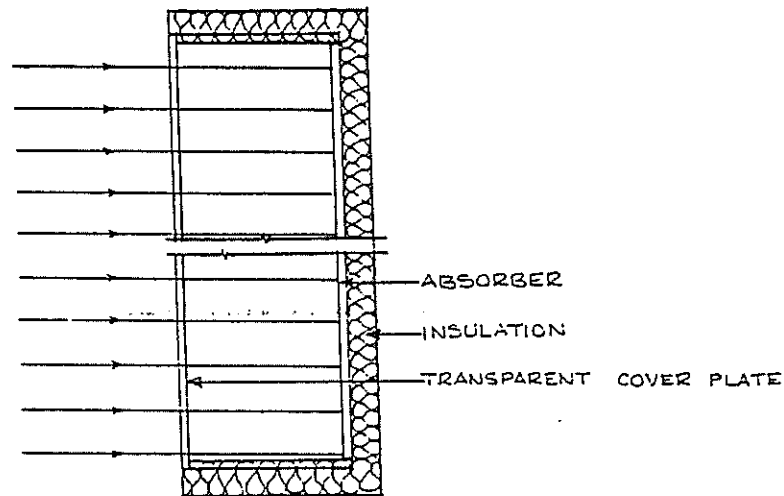
- a. Transparent cover plate
- b. Absorber
- c. Insulation

Glass or plastic is used predominantly today as a transparent cover plate. They both transmit ultraviolet radiation and absorb long-wave radiation.

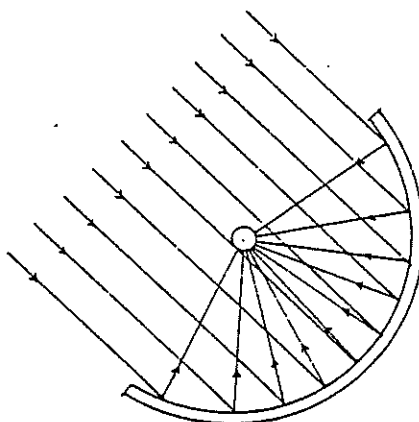
The absorber should have high solar absorbence, low emittance and high thermal conductivity. By painting the absorber in dark colors, the absorption of radiation is increased.

Insulation around the absorber is necessary to eliminate the heat losses of a collector. Animal hair, sawdust, or ready made insulation boards can be used. The amount of insulation should

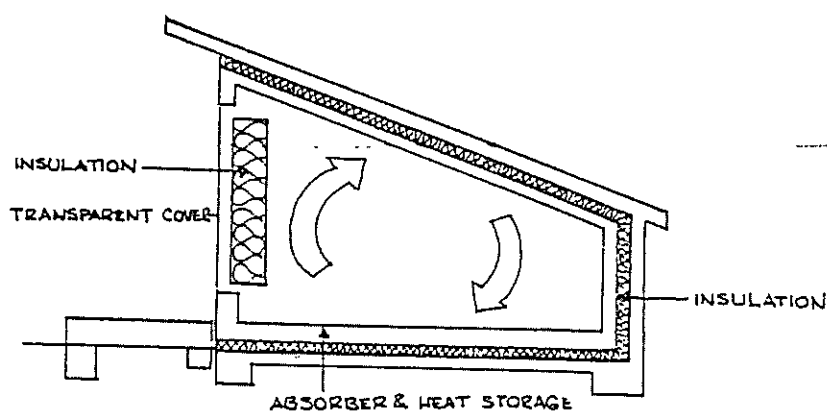
be calculated according to "U" values and temperature differences inside and outside the collectors.



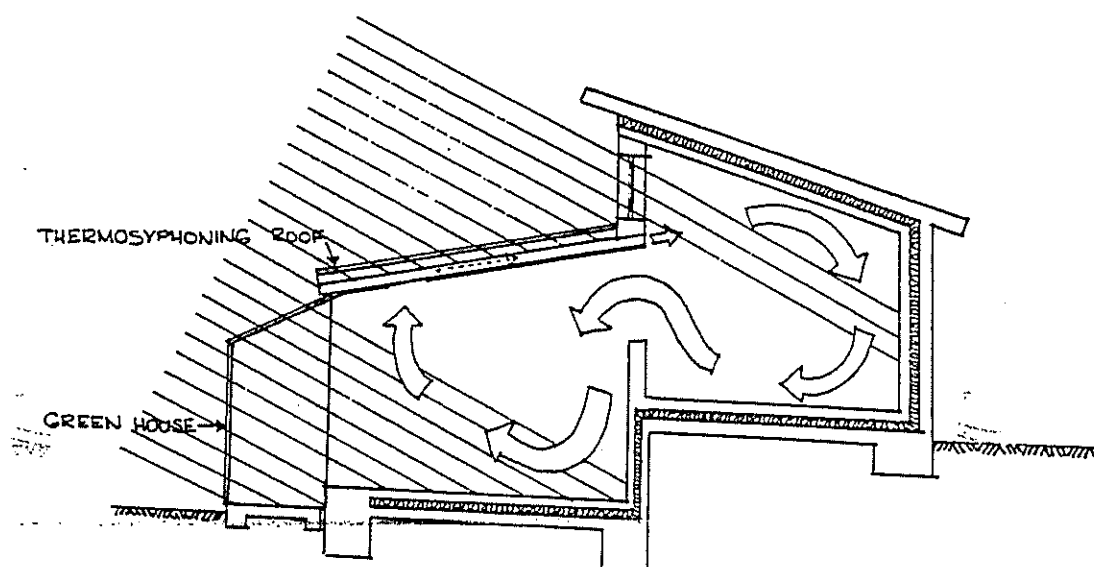
There are several types of collectors available to collect the sun's energy. Because of their low fabrication, maintenance and insulation costs and high efficiency, flat plate collectors are abundant in use. They are mostly factory produced, but they can also be built in a way that we call "do-it-yourself." There are several types of flat plate collectors known today: air-cooled flat plate collectors, open water flat plate collectors, liquid cooled flat plate collectors, etc. Another example concerning collectors is concentrating collectors, in which reflectors are used to increase radiation on a small absorption area. High cost needs, extra care, difficult maintenance of reflective surface are the disadvantages of concentrating collectors. As an advantage, they collect more than twice the amount, and the temperature can be generated by flat plate collectors.



Flat plate and concentrating collectors are separate elements of the building shell that can be applied on the roof, the walls or in the garden, far away from the building. It is also possible to design a house where the house itself works as a collector. Like a collector, the building consists of three parts with some differences. (Absorber acts also as heat storage.) The transparent cover should be protected with a movable insulation to reduce heat losses.



If we can eliminate the heat losses of a building shell during the sunless hours, this system which I call "house as a collector" can be the most efficient solution for our "future goal." Greenhouses and "thermosiphoning wall or roof and windows" are the alternatives of this system.



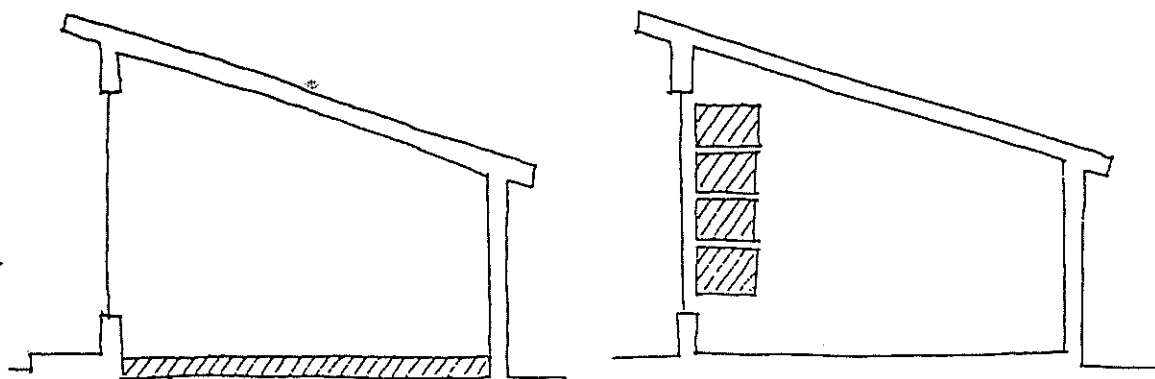
Storing of heat: The second goal of the solar house is that the building should store the maximum amount of heat collected. Storage is needed when radiation is not available or is in insufficient amounts. Storage can be a part of the absorber or it can occur away from the collector. It depends on how simple or complicated our distribution components are.

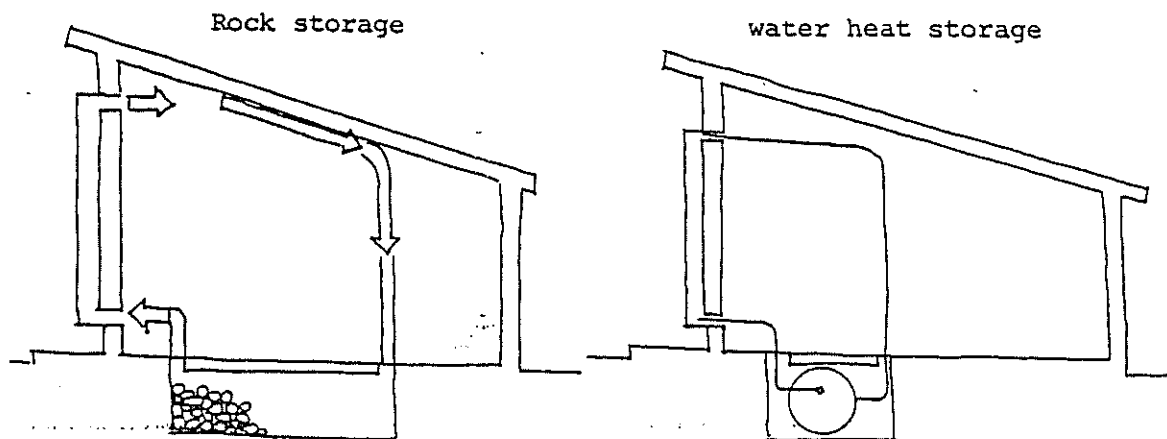
Inert substances which are largely used for heat storage are rock, water, stone, concrete, or adobe. Heat can also be stored by chemicals such as paraffin and salt hydrates.

Heat Storage Methods

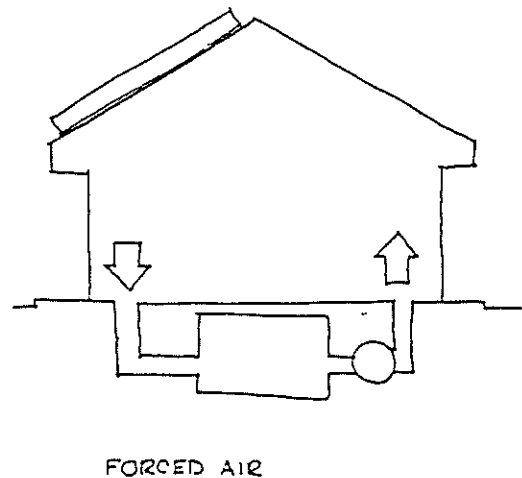
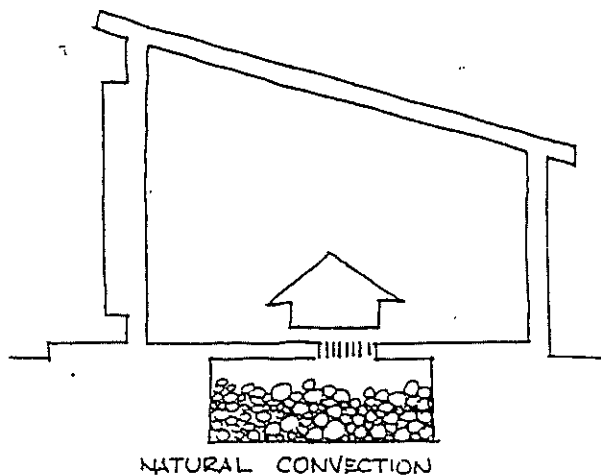
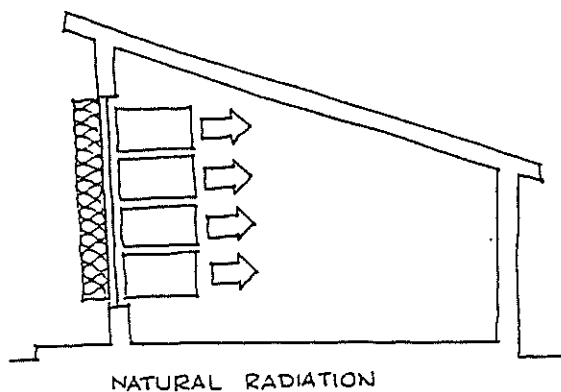
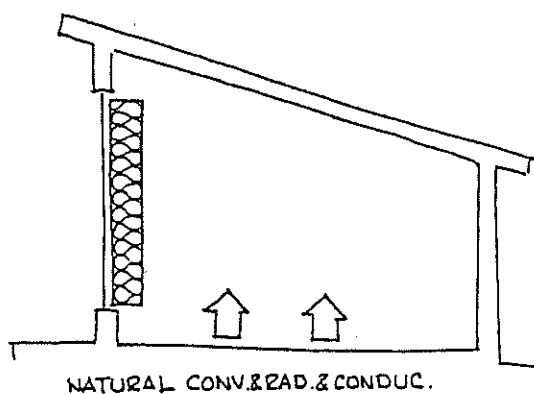
Exposed surfaces of interior shell

Heat storage in water tanks





Distribution of the heat: The job of distribution components is to carry thermal energy from the collector to the storage unit, and in some systems, to carry from the storage unit to the interior.



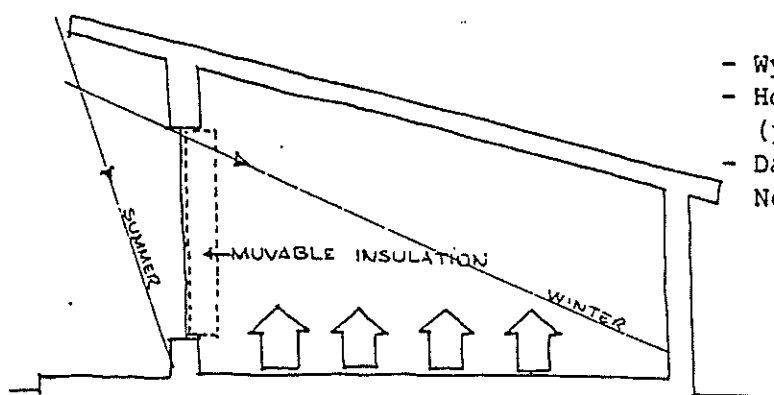
As we have seen from collection, storage, and distribution elements, some work naturally and some use force. This difference results from two different solar heating systems which are known as passive systems and active systems.

a) In passive systems, we use the conventional parts of the building to collect, store and distribute solar heat without using any other kind of energy sources.

b) In active systems, we use mechanical means such as pumps, fans, and automatic controls to collect, store and distribute the heat.

There are five main system types (passive or active) by which solar energy is used for heating purposes:

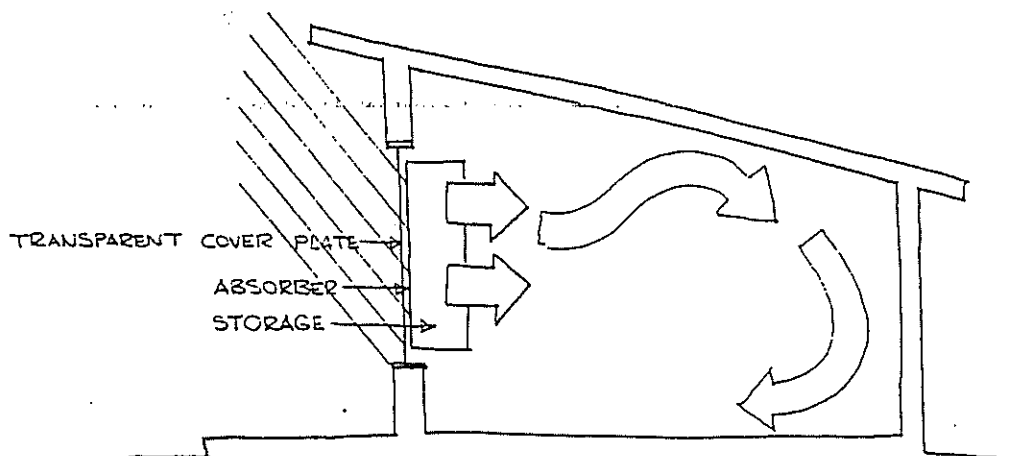
1. The use of windows as a collector is the most simple example of a passive system which can be used in almost every building. Windows oriented to the south and which are heavily insulated provide direct solar heating. Heat from the radiation is distributed by natural air movements inside the building. Interior surfaces of the building absorb the heat and act as heat storage.



Examples

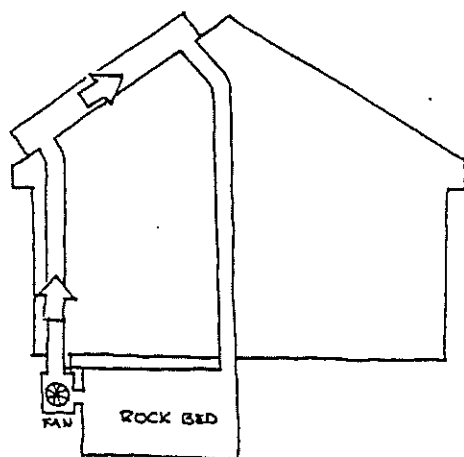
- Wyden residence, Chester, Ct., 1974
- House around garden greenhouse (joint venture)
- Dave Wright's house, Santa Fe, New Mexico, 1974

2. Collector and storage as one unit is the second example of a passive system. Radiation which passes through glass or plastic changes its form to the heat on the absorber (masonry wall or water containers). The absorber stores the heat and when the interior temperatures drop, it radiates stored energy towards the interior.

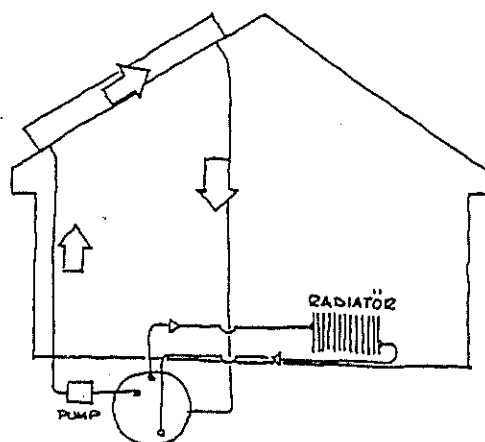


Examples: Michel-Trombe solar wall
 Tyrrell residence, Bedford, N.H. (1975)
 Drumwall system, Steve and Holly Bears residence (1972)
 Kolrauch residence, Princeton, N. J. (1976)
 The skytherm system house, Atascadero, Cal. (1973)

3. Active solar heating with collector, storage and distribution system: In this system, heat captured in collectors moves to the storage area by force (according to air or water system, fan or pump). Transfer of heat from the collector to storage, or distribution of heat from storage to the building interior, occurs using air ducts, water pipes or radiators.



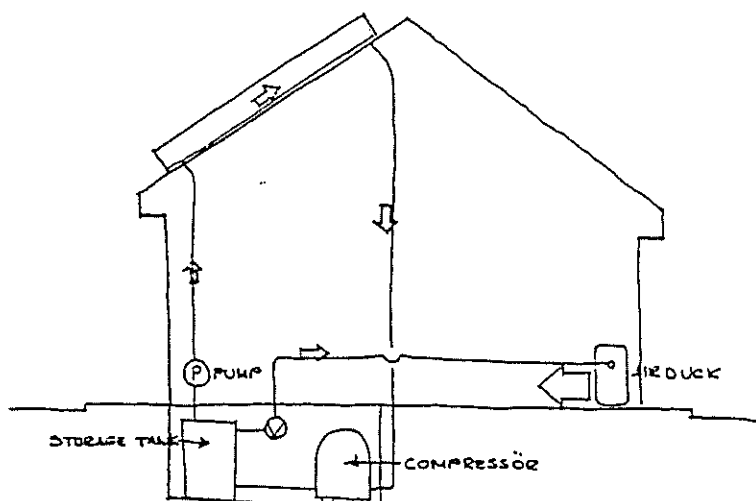
Active air system



Active water system

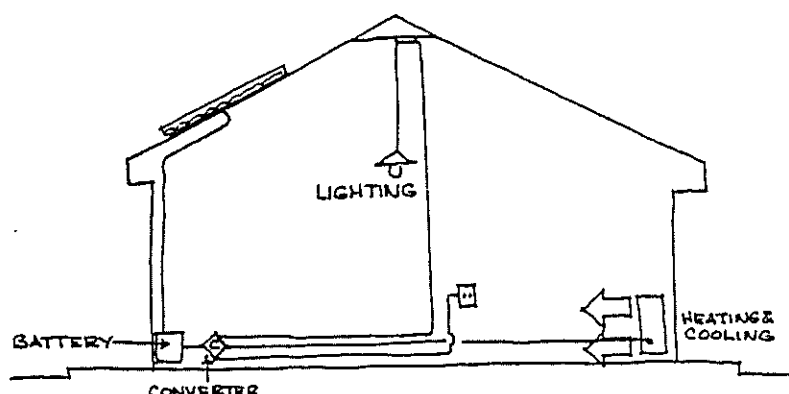
Examples: Barber residence, Guilford, Conn. (1975)
 Lof residence, Denver, Colorado (1975)
 Thomason residence, Calvert County, Md. (1976)

4. Active systems with special equipment: In this active air or water system, collection, transfer and storage of heat follows the same principle as system 3. However, heat in storage is used as a preheating source for mechanical heating equipment (like preheat a heat pump).



5. Photovoltaic solar cells: At the moment, because of economical reasons, solar cells are not practical for home energy needs. A continuous decrease in the cost will make solar cells widely applicable in the future.

Solar cells are used for electrical conversion. They create electricity when they are exposed to the sun. Power from the solar cells can be easily stored in batteries; and with an inverter, power can be used to satisfy home energy needs.



Which system will be more suitable for developing countries?

Without hesitation, we can say that passive systems are more suitable for developing countries, for the following reasons:

1. low cost in construction
2. easy to understand regarding building and operating
3. trouble-free operation
4. easy and low cost maintenance
5. system can be built using a variety of building materials

From an efficiency point of view, active systems have a higher degree of effectiveness than passive systems. But their high cost, difficulty of operation and maintenance, need for high technical skills and construction materials, as well as their need for the other types of energy to operate the system, make passive systems more applicable to developing countries.

The following chart is a comparative study between passive and active systems.

Active System (water)	Active System (air)	Passive System	
400°F	300°F	200°F	maximum temperature
yes	yes	no	need of space for heat distribution
small	small	large	need for heat exchange area
high	high	low	cost of the system
yes	yes	no	maximum care must be taken of the system
yes	no	no	possible freeze and leakage damage
no	yes	yes	possible rust problems
yes	no	no	possible dust problems
yes	yes	no	possible collector operation problems
no	no	no	limited climatic applicability
yes	yes	no	function of the collector is only one
no	no	yes	possible disruption of low sunbeams
no	no	yes	design problems for occupant privacy
no	no	yes	large nighttime heat losses from collector
yes	yes	no	need for other types of energy to make system work
no	no	yes	solar energy system is apart from construction
no	no	yes	need to protect housegoods against sun bleaching and drying

Active System (water)	Active System (air)	Passive System	
no	no	yes	interior masonry surfaces work as heat storage
no	no	yes	simple to build
yes	yes	no	system requires moving parts
yes	yes	no	difficult maintenance
yes	yes	no	need for high skill and construction materials

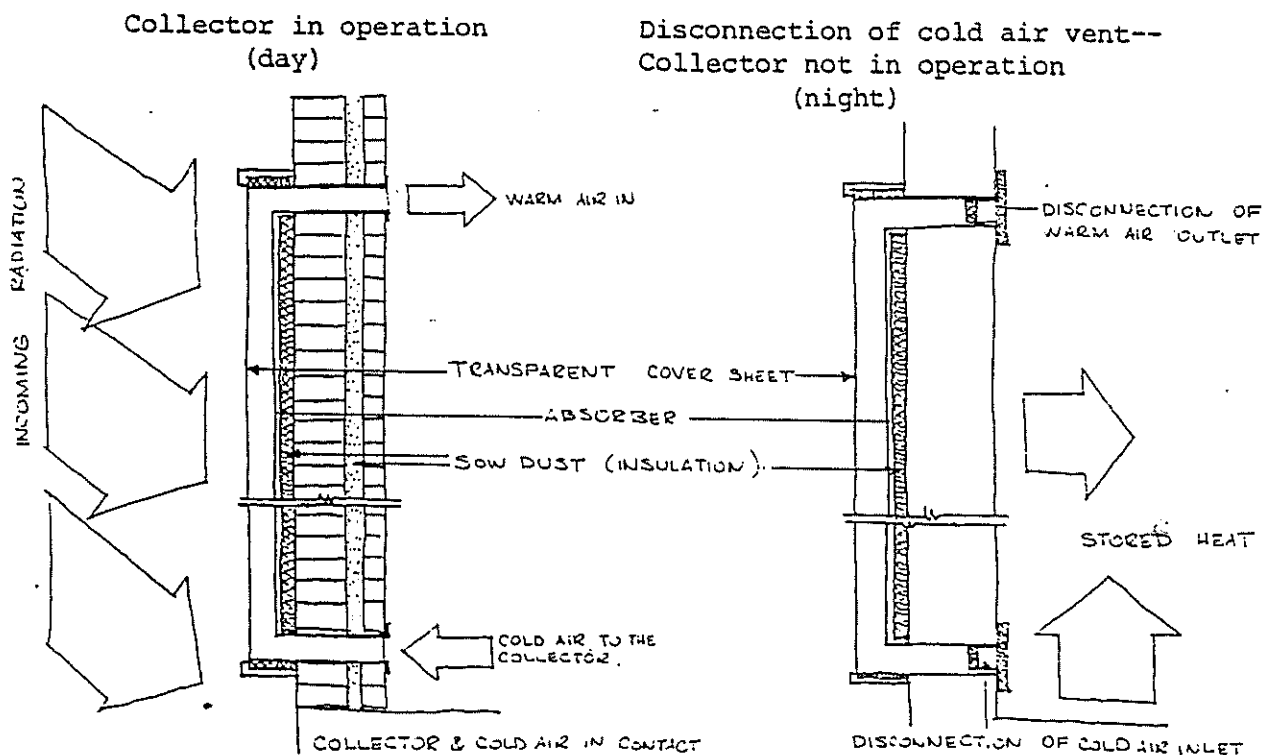
When we say passive systems are more suitable for developing countries, we do not mean that our design should necessarily be one of the designs discussed above. Since we are in a learning period, the aim of architects or engineers should always be to eliminate previous mistakes. If we take an overall look at passive systems, we will find that there are many questions on existing systems which need solutions. For example:

1. Windows as solar collectors, and greenhouses: Great heat losses through the south window should be eliminated. This can be done in two ways: (a) double or triple glazing (which does not exist in most of the developing countries, or the high cost of glass doesn't permit villagers to insulate the openings of their buildings with another layer of glass); (b) heavy indoor or outdoor insulation (which is impractical and not economically feasible).

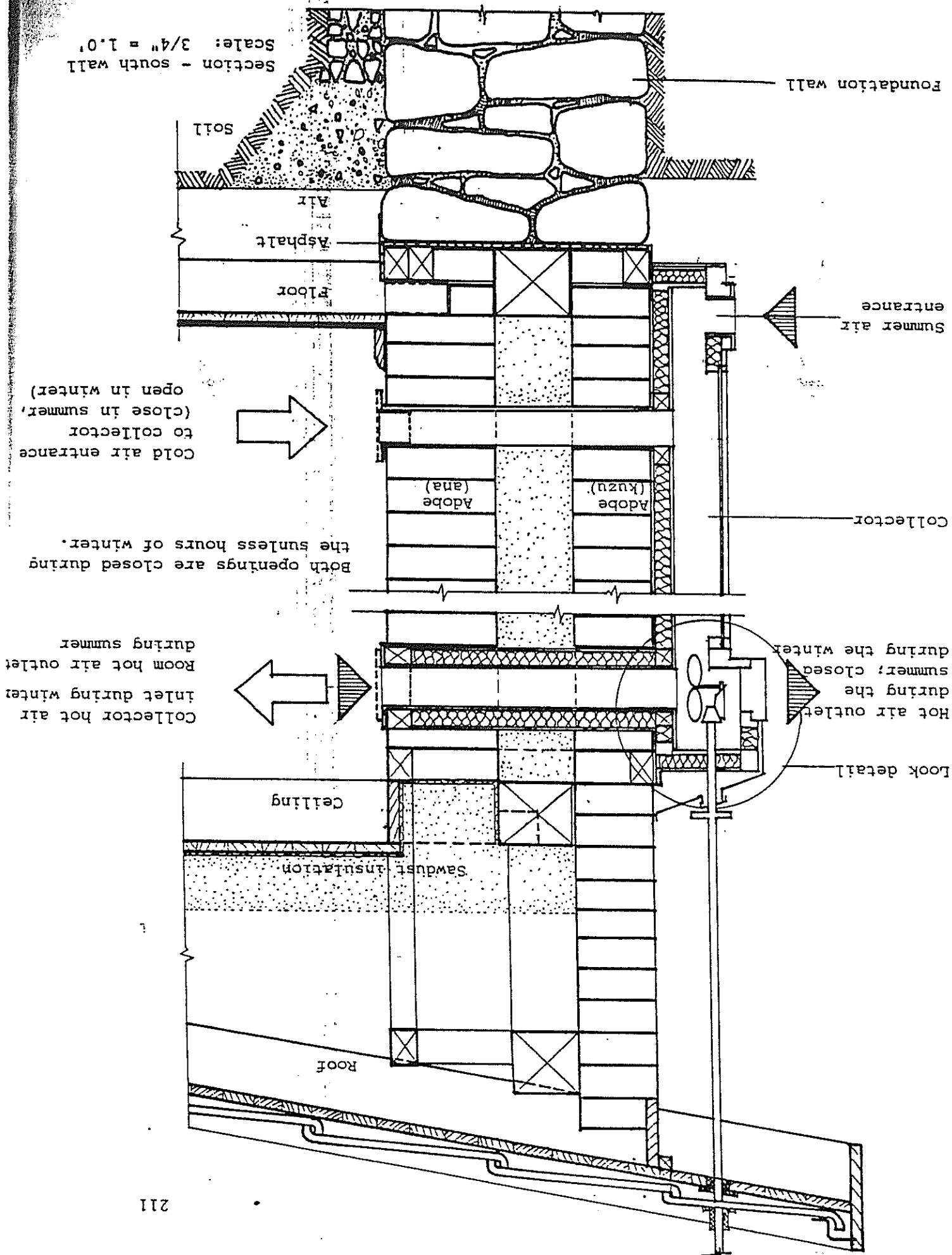
2. Roof ponds and thermosiphoning roofs: In this system the roof itself is in question. Difficult roof details needed for extra roof insulation, maintenance difficulties, and cost makes this system undesirable.

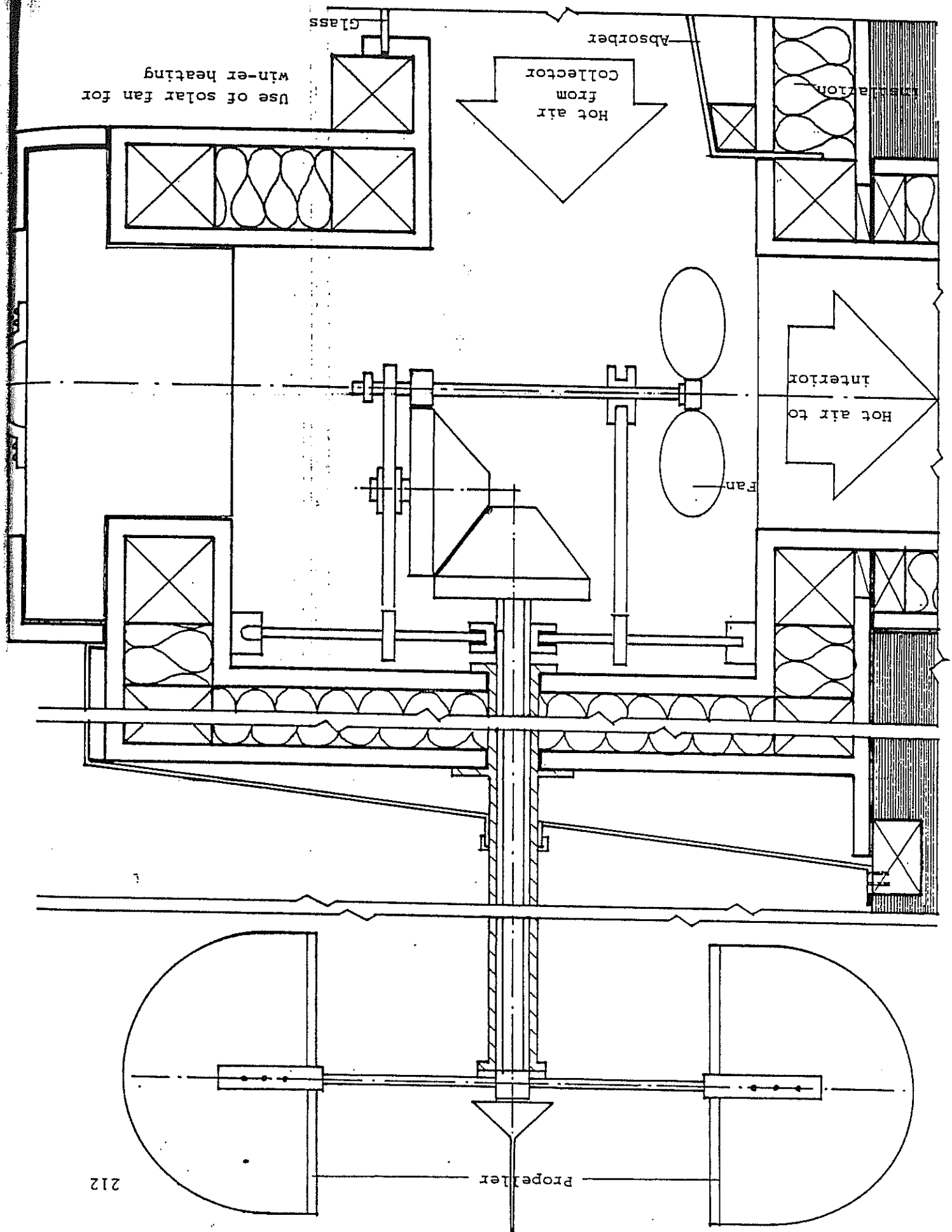
3. Thermosiphoning wall: This is the most suitable system for developing countries. It is simple, no care is needed, and it works naturally. The only extra cost is the frame and plastic cover. However, this system can also have its problems. First, the wall behind the glass acts as a heat absorber as well as for heat storage. When the outdoor temperature is lower than the indoor temperature, most of the heat in storage radiates to the outside of the house, and this causes the system to work with very low efficiency. The second disadvantage of this system is that the absorber and the storage wall between the transparent cover sheet and the interior becomes a visual barrier. This system separates part of the garden (south) from the interior of the building. A third disadvantage of the system is the high cost of the glazed area which usually covers all the southern face of the building, and it should be done in the construction stage. In most village construction, the limited money available for the building runs out before work begins on the roof. They will not usually be able to afford a building with a heating system which will double the cost of the house. A system should be applicable to the building envelope during or after construction, according to the wealth of the owner. The system also should be applicable to already existing rural construction with minimum labor and cost. All those necessary needs encouraged me to develop a "thermosiphoning collector" for the use of developing countries.

A thermosiphoning collector consists of a metallic absorbing plate which is painted black to increase its absorption of radiation. Behind the absorber, three inches of sawdust is used as insulation to minimize heat losses from the plate. The front part of the collector is covered with a transparent sheet to trap heat. The captured heat is removed from the absorber which is heated as it passes, and there is no heat storage inside the collector. Heated air passes naturally into the dwelling. Masonry parts of the interior capture heat and act as heat storage. During sunless hours, disconnecting the cold air inlet and the warm air outlet with the interior results in zero heat loss through the collector, and there is no need for insulation. During hot summer days, the same collector works for cooling and natural ventilation. Another function of this collector is the improvement in value of the wall because of the three inches of insulation behind the absorber.



Section - south wall
Scale: 3/4" = 1.0'





Propeller

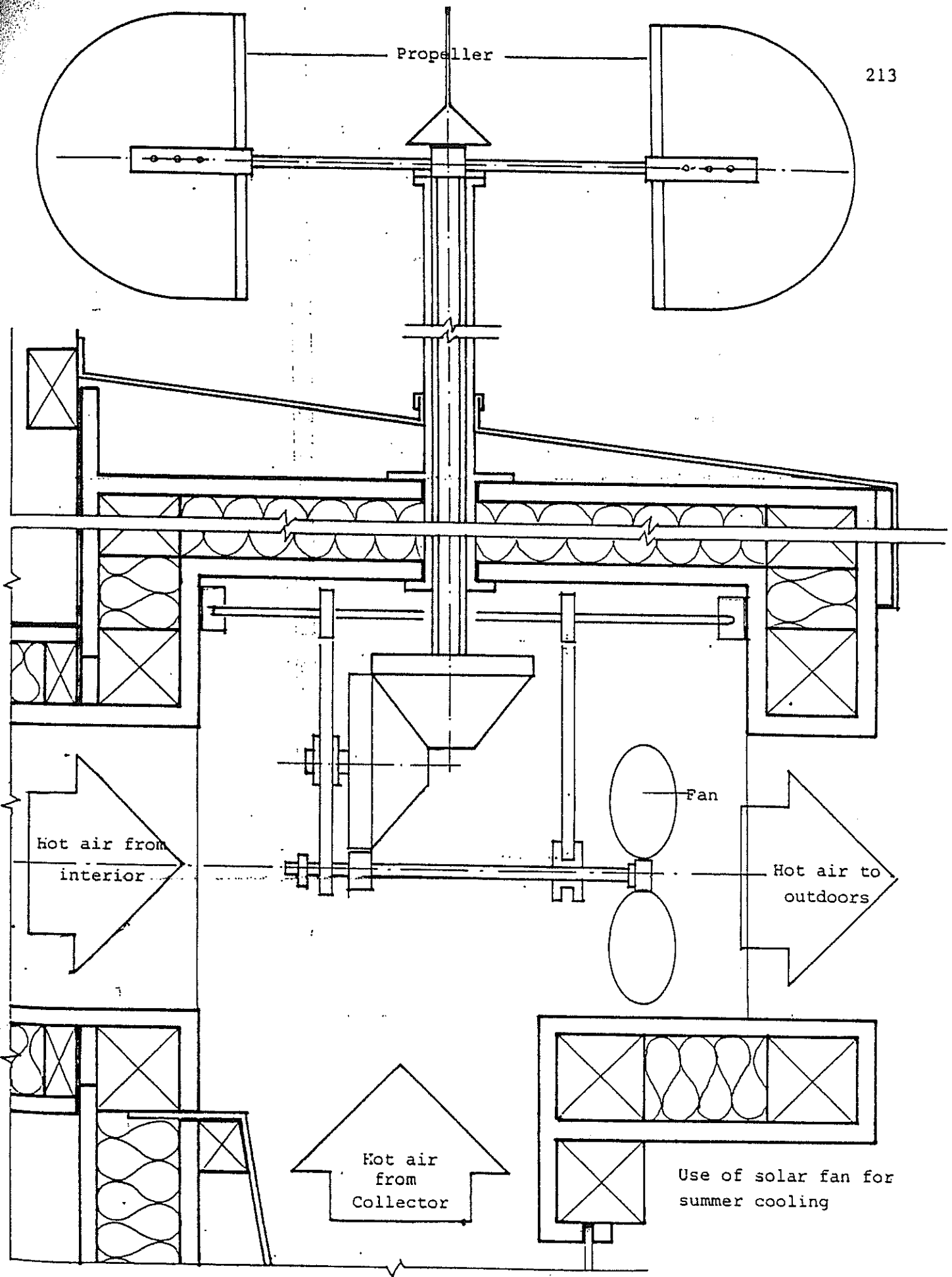
Fan

Hot air from
interior

Hot air to
outdoors

Hot air
from
Collector

Use of solar fan for
summer cooling



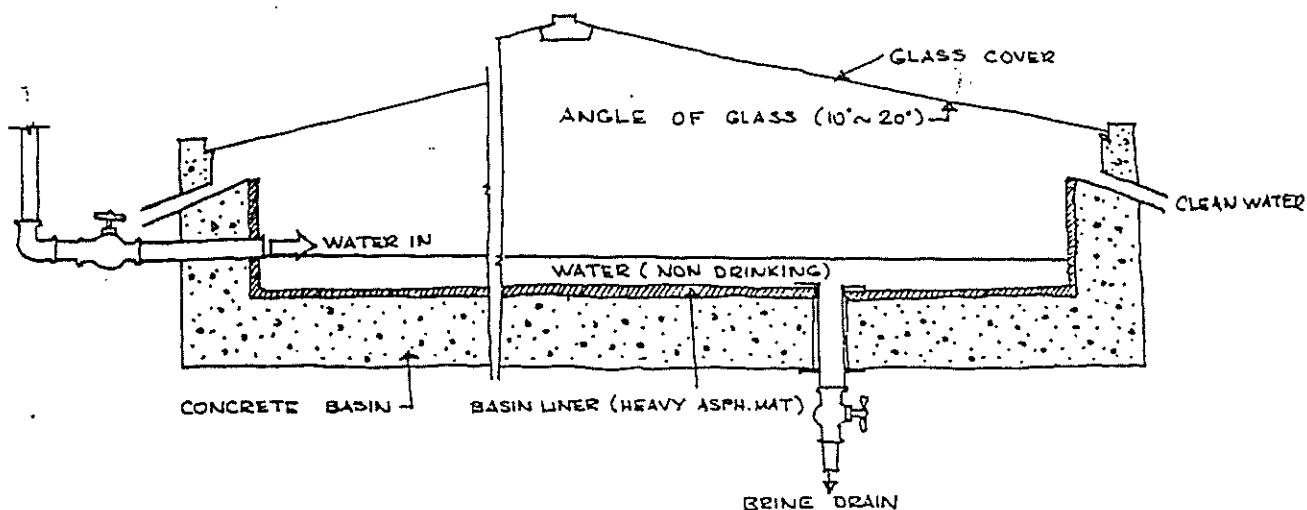
Solar Distillation

Solar distillation is used for producing clean or fresh water from polluted water of the sea. It can be built with simple construction materials and rarely gives any maintenance problems.

Being based on a time-variable energy source, solar distillation provides a variable output. Summer production can be three or four times more than winter production. For this reason, when long and cloudy days occur, construction of a water boiler becomes necessary. (See illustration.)

The most common type of solar still, which is the most advanced stages of development and application, is the basin-type still. A water surface of limited size is covered with a transparent cover for solar radiation. This cover serves three major purposes:

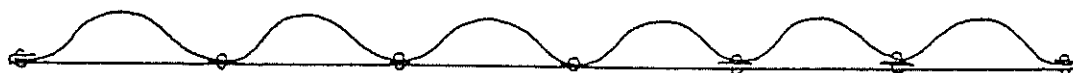
1. It prevents escape of humid air above the water surfaces;
2. It furnishes a cool surface upon which part of the humidity can condense;
3. It serves as a radiation shield and reduces heat loss.



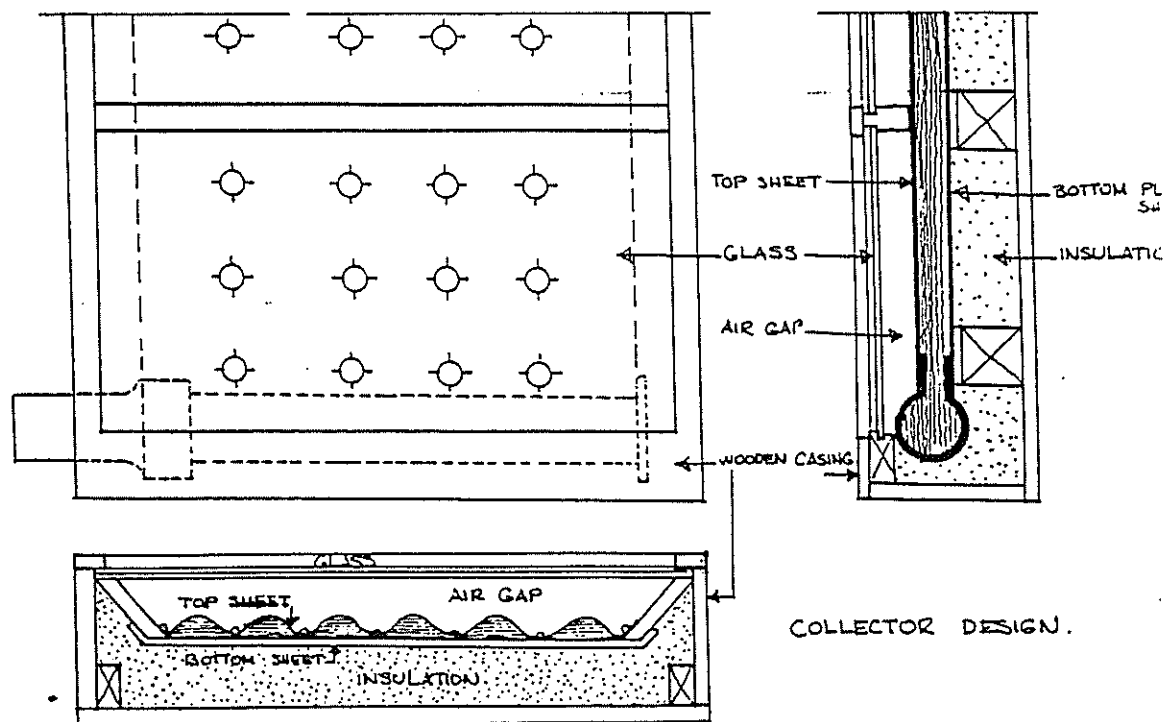
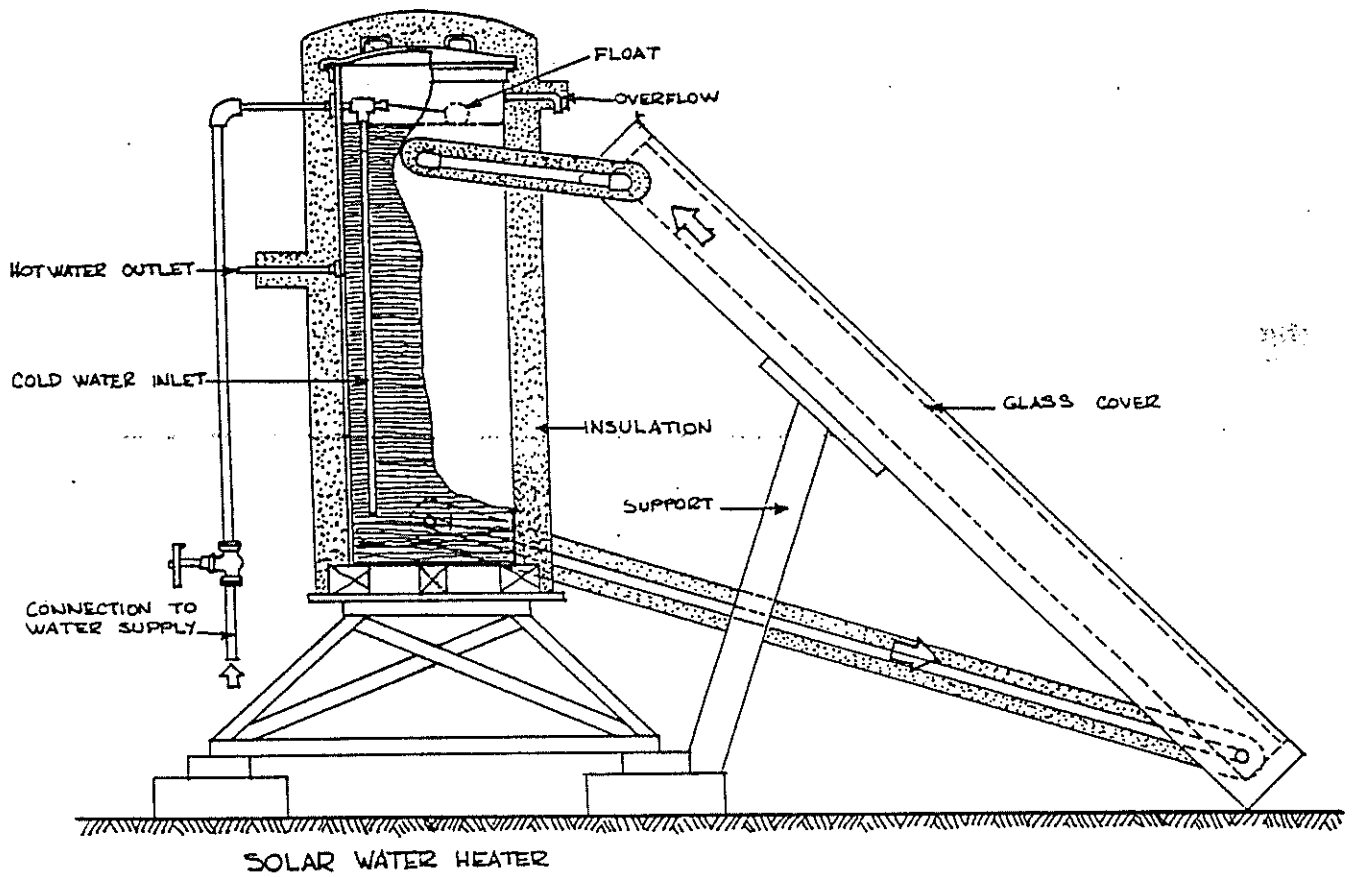
Solar Water Heaters

Because of their low price and lack of attention, flat plate collectors are the most useful types for solar water heating. Solar water heaters supply hot water for domestic requirements such as bath and kitchen use, etc. In the most common types of flat plate collectors, the heat transfer is effected by water flowing through copper pipes in contact with a blackened copper absorber plate. The surface facing the sun has one or more layers of glass plates a little above the absorber surface, while the underside and the edges are protected with insulation to prevent undue heat losses. This method has an important disadvantage which reduces the efficiency. It contains a highly limited area of contact between the circular pipes and the flat surface of the region of contact that all the heat exchange between the flowing water and the collector plate takes place.

Because of this reason, the use of galvanized iron corrugated sheets (which are available almost everywhere in Turkey and used mostly for roofing) yields a more efficient solution. A sandwich shape is formed with a corrugated sheet backed with a plain sheet of the same gauge. The edges along the length are hammered together with an overlap and then sealed with soft solder as shown in the following diagram:



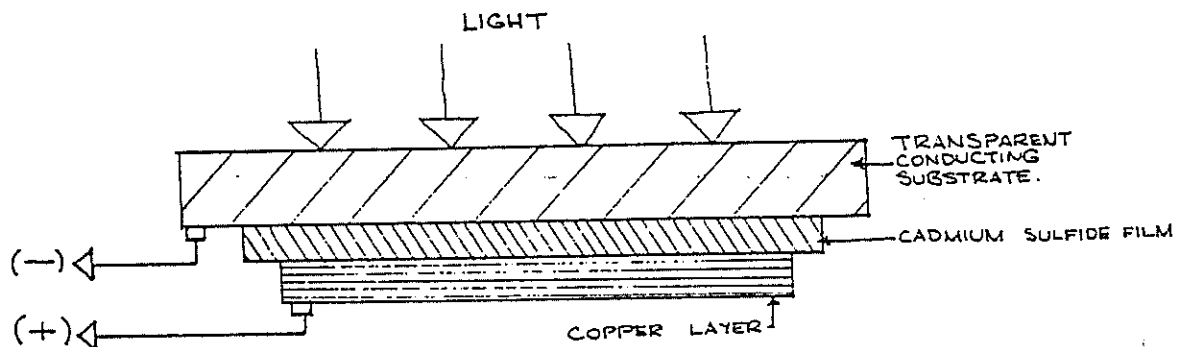
The complete set-up of the single solar water heater unit is shown in the following drawings.



Low-Cost Photovoltaic Conversion of Solar Energy:

Photovoltaic solar energy conversion is the mechanism for obtaining electrical power directly from solar radiation, which is abundantly available. Solar cells will have a large application in developing countries. Present day devices are too expensive. The major reason for this is the need to make single crystals. Solar cells that are made from raw materials will be inexpensive. A cost of U. S. \$1 to \$10 per square foot of a ten percent efficient solar cell would probably bring the cost into the range of economic feasibility for home use in developed countries. In developing countries, this application would be mostly devoted to the distribution of power to small appliances (radio, television, irons, etc.).

A section of the cell is illustrated in the following figure:



Photovoltaic cells have been improved so that 14 percent conversion efficiency can be obtained.

CHAPTER V

HANDBOOK FOR THE USE OF ARCHITECTS AND VILLAGERS

Turkish Village House Design Parameters for Designers and Architects

Basic Program

- Plot Planning
 - general objectives
 - site conditions
 - service and facilities
 - access
 - yard dimensions
 - landscape and building
 - daylight and fresh air
- Building Planning
 - general objectives
 - general housing type requirements
 - space
 - general house layout requirements
 - space activities
 - program and space relationship
 - separate spaces of building and activities
 - orientation
 - closets
 - ceiling heights

- light and ventilation
- access
- construction
- individual water supply and sewage disposal systems
- septic tank

Turkish village houses have differed from place to place and from time to time, according to influences as diverse as the climate, character of the lands where they occurred, and community patterns or technical proficiency of the people who built them. Even within a limited regional area, local styles of buildings may show differences. The idea of home in a Turkish village comes from the basic needs of the villager, which include:

- shelter - From the elements and occasionally from enemies which is a fundamental necessity of man. Only by shelter can man adapt to his environment.
- storage - This is the second basic necessity for village man; only by storing his personal belongings and his food can he survive.
- privacy - Increasing density of the population in any society such as a Turkish village or village house becomes the reason for new problems. The need for independence and freedom is one which only privacy can provide.

In village buildings, the form generally reflects the surrounding physical conditions, climate, materials obtained locally, the relationship of these materials, construction systems, controlled interior environment, and ease of mobility for both the people and the building materials. In the architectural field, the influence of Europeanization can be observed at different levels in the architecture

of Turkish cities. Since we had to live like Europeans, Turkish architects copied their homes from European designs. Climate, construction systems and materials, culture and traditions were completely neglected. After fifty years of this practice, some Turkish architects became aware of the problems they are faced with today.

Following the trend of taking Europe as a model for their cities, today Turkish villages are following the city's example, unaware of the danger that can result. Today, because of new transportation and communication facilities, Turkish villagers are in more frequent contact with the cities than previously. Knowledge has reached the point where it is ready to be transferred from the city to the villages, and village shelter is ready to accept this change. This will work in two ways:

1. Application of machine made construction materials to the village house;

2. Application of "city architecture" to the villages.

As Vitruvius says: "When you become aware that you are on the wrong road, it is necessary and essential to return to the essence (first principles)."

The general objectives of Turkish house design should result from the study of village architecture, which is used as a basis and tool by architects. This is the reason I would like to conclude the last part of my work with design parameters which can be developed by architects and formed into an architectural design.

Plot Planning

The general objective are to provide for:

- a) Convenient access to and around the dwelling;
- b) Adequate natural light and ventilation of rooms and spaces;
- c) Reasonable privacy for each living unit;
- d) Utilization of the plot for cleaning, laundry drying, landscaping, and outdoor living;
- e) Adequate areas to assure a safe and sanitary installation when individual water supply and sewage disposal systems are involved.

1. Site conditions: The property should be free of hazards which may affect the health and safety of the occupants. These hazards may be subsidence, flood, erosion or other factors.

2. Service and facilities: Each living unit should be able to be used and maintained individually without trespassing on adjoining properties.

Each living unit should contain provisions for each of the following:

- a) Continuous supply of safe, potable water;
- b) Sanitary facilities and a safe method of sewage disposal;
- c) Adequate heating for healthful and comfortable living conditions.

3. Access to the living unit: A means of access to each living unit and to the garden should be provided without passing through any other living unit.

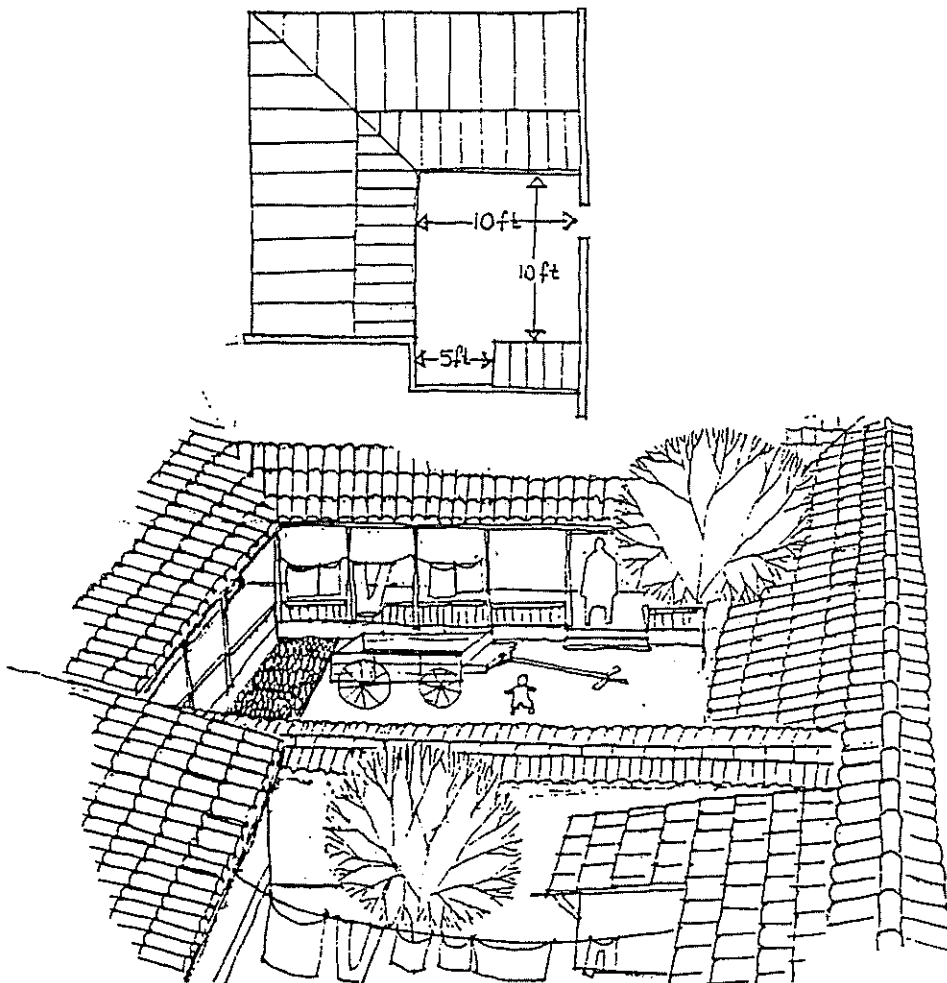
4. Yard dimensions: Free design without regulations is basic to the character of village men.

Since the ultimate end of the village house is an inner courtyard, architects should take into consideration minimum dimensions to provide for healthy and comfortable living conditions.

Minimum area of the inner court: 100 sq. ft.

9.29 square meters.

Minimum dimensions of the inner court: 10 ft. X 10 ft (3 m.)



5. Landscape and building: In villages, a great amount of garden space and freedom in the living area of the houses is desirable. Architects should have a knowledge of the relation between the house, landscape orientation and sunpath diagrams, which differ from region to region.

In low density development the density control in itself will normally ensure adequate daylight and fresh air. Architects should always remember that a good working rule for daylight is that there should be no continuous external obstruction that would increase the angle of obstruction at ground floor sill level to more than 18 degrees.

The assimilation of the buildings into the landscape can only be achieved by skillful planning in relation to the contours. This is accomplished by adequate and proper planting of suitable trees, careful attention to the shape as well as to the color and texture of the buildings themselves.

Building Planning

General objectives

To provide for healthy environment with complete living facilities arranged and equipped to provide suitable and desirable living conditions, commensurate with the type and quality of the property under consideration.

Each living unit should have at least two habitable rooms, one of which should be a bedroom-bathroom combination, the other an efficiency type living unit.

Each living unit should be provided with space necessary for suitable living, sleeping, cooking and dining accommodations, adequate storage, laundry and sanitary facilities. The space should be planned to permit placement of furniture and essential equipment.

The plan of a village house will be largely determined by the habits and customs of the inhabitants of the area and the services that can be provided. Architects should make their own studies regarding habits, customs and lifestyles for different regions.

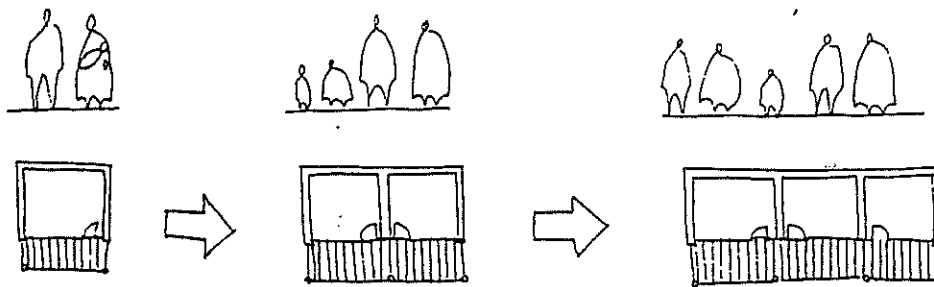
General housing type requirements

-Turkish village people need a home which will closely resemble a private atrium or a private separate house.

-The designer should provide housing which has some degree of individuality and regional identity.

-At the design stage, the designer should give strong attention to the need for privacy, customs and traditions.

-The house has to have a plan related to future family growth and the family life cycle stage. In the event of expansion, the family has to be able to grow in their existing space.



-The architect's aim should be to improve building designs and methods and reduce the cost involved.

-Economies in terms of time, building cost, maintenance and future expenses (like heating costs) have to be considered before the designing stage.

Space: Families need sufficient space to allow for a change of activities within the same amount of space.

-All spaces in the house should have a purpose and should be related to ongoing activities.

-Organization and arrangement of the interior furnishing should answer the needs of the desired activities.

-Families need sufficient accoustical insulation and visual separation to allow incompatible activities to occur simultaneously.

General House Layout Requirements:

-Family members need to be able to circulate around individual interior spaces without disturbing the privacy of the other members of the family.

-Families need a layout in which the common activity space is visually and accoustically separated from others areas of the

house. This is necessary for the individual to rest, sleep, study and attend to his personal care.

-Residents should have a clear visual access to the garden and its entrance.

-The villager should have a house layout characterized by the following hall/common activity space relationship:

1. Hall/room relationship
2. Hall/garden relationship
3. Hall/kitchen and toilet relationship
4. Hall/garden entrance relationship

Space activities:

Hall: Summer - Living and dining, cooking and special activities (meetings, marriage ceremonies)

Winter - Clothes drying space

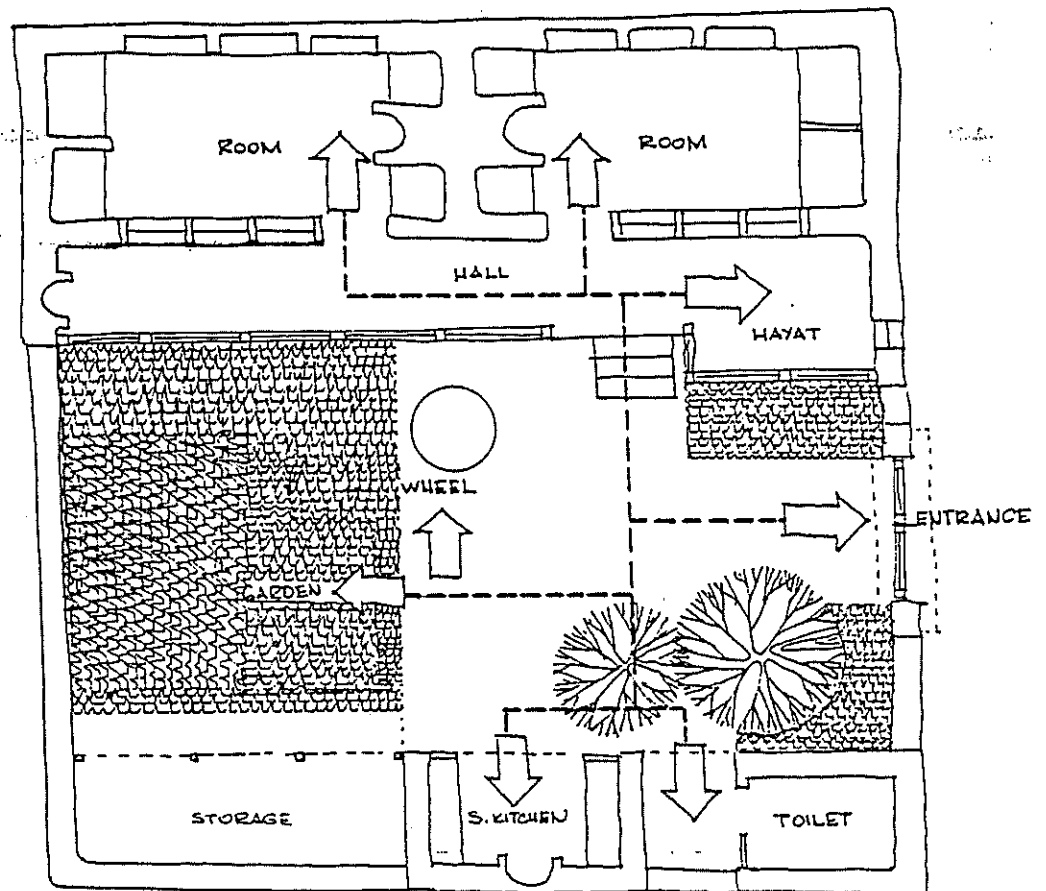
Room: Summer and winter - living and dining, cooking, sleeping, bath, study and play

Garden: Summer - Clothing drying, planting, leisure, food drying, playing, and storage

Kitchen: Summer - cooking, laundry and clothing care.

Here the designer should pay particular attention to the influences of climate, as well as the relationship between activities and space.

Space Relationship Diagram
(in existing village houses)



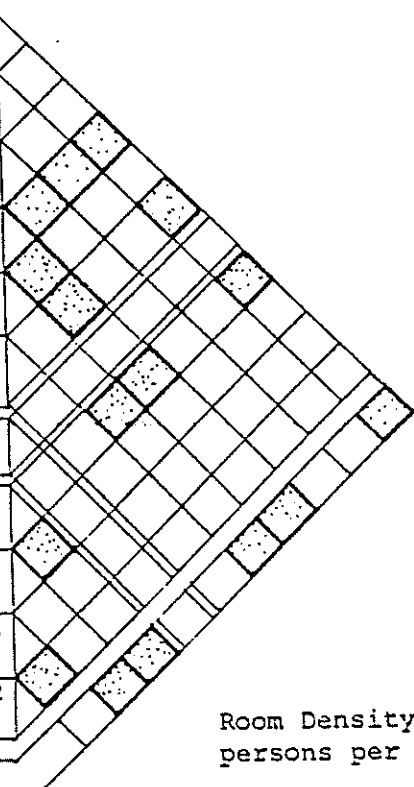
1. Hall/room
2. Hall/garden
3. Hall/kitchen and toilet
4. Hall/garden entrance

Program and Space Relationship

Family group - couple plus two

Rooms - two

Space Description	Gross Floor Area	Recommended Relationship
BASIC SPACES	55 m ²	
cook	3 m ²	
room 1	18 m ²	
room 2	18 m ²	
hall	11 m ²	
toilet	2 m ²	
storage	3 m ²	
OPTIONAL SPACES	56 m ²	
entrance patio	16 m ²	
stable	25 m ²	
tool storage	5 m ²	
work space	10 m ²	
OUTDOOR SPACE		



Room Density: min. 2
persons per room

Max. 9 m² per person.

Gross floor area includes 5 percent for circulation and 10 percent
for structure. (Roof covered structure 65 m².)

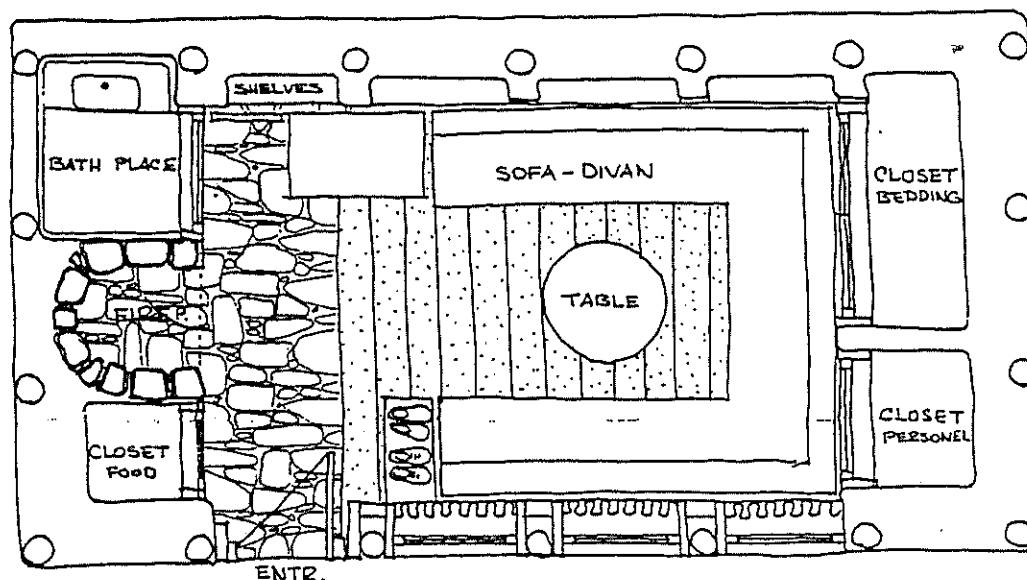
Separate building spaces:

General: Measurements are based upon dimensions between the finished floor surface and the rough ceiling surface, and between rough wall or rough partition surfaces.

The area occupied by a fireplace or closet will not be included in determining the required room area.

Rooms: All rooms should be simple and convenient in shape. There should only be one separate access to each of the principal rooms from a common hall.

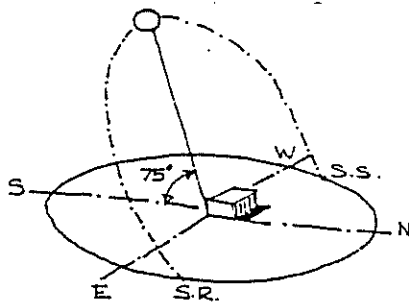
Existing room plan:



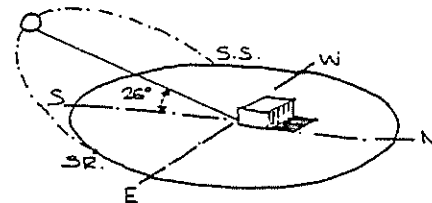
Different activity diagrams should be developed for the various regions of Turkey, depending on the needs of the villagers. Turkish rooms should have great flexibility for the various activities which take place throughout the day. Every room in a dwelling should make provision for at least nine hours of sunlight a day, especially during sunny winter days.

Orientation of the house hall and rooms:

The sun has an extended arc and is high overhead at noon in the summer time. In the winter, it has a much reduced arc and is lower in the sky at noon. The house needs protection from this overhead summer sun, but in the winter the object is to capture all the sunshine possible.



Summer (June) 40° N.



Winter (December) 40° N.

Closets

Room closets: Each room should have at least one closet for bedding and one for personal belongings.

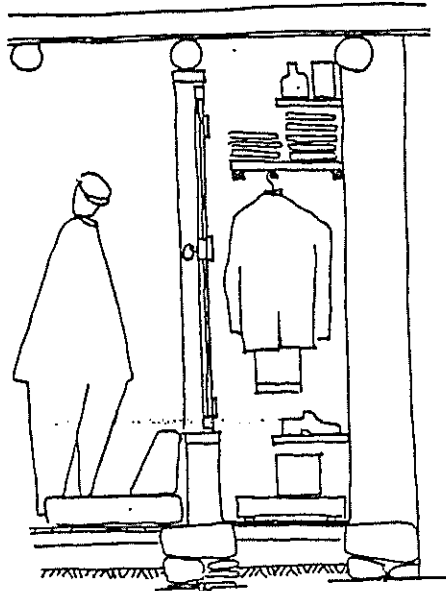
Closet for personal belongings:

Min. depth: 0.65M clear for required area.

Min. width - 1M.

Height: floor to ceiling

- The minimum is adequate to permit 1.5M (around 5 feet) of clear hanging space for at least the required width.
- Lower shelf should not be closer to the floor than 0.5M (1.65 feet)
- At least one-half the closet floor depth should be flat.



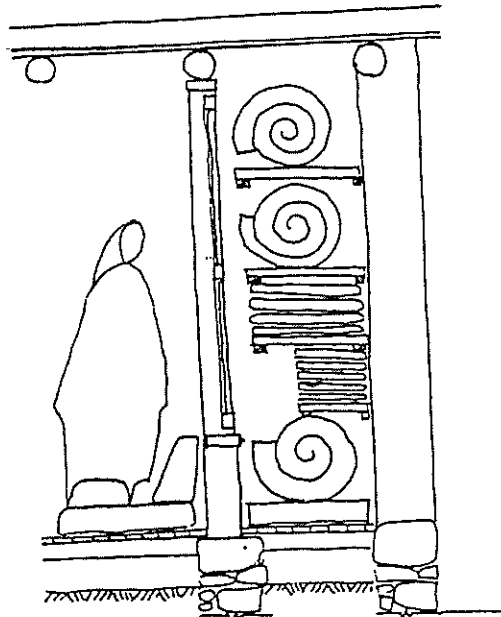
Linen closet:

Min. depth: 0.65M

Min. width: 1M

Height: floor to ceiling

No hanging space is required. There are only flat shelves with a minimum clearance of 0.5M.



Food storage: Each kitchen and each section of the rooms in which cooking occurs should have accessible storage space for food and utensils, as well as space for these activities and equipment to perform their intended functions. It should be well ventilated and on the cold side of the house, but still easily accessible from the kitchen. Storage rooms should be spacious in the event that the delivery of commodities is infrequent.

-Outside storage should be large enough to accommodate garden produce and garden equipment.

-In all closets and storage rooms, natural ventilation openings through the external wall should be covered with rustless wire mesh panels at both high and low levels.

-A full-sized single unit closet should be provided for dry goods, and a similar size unit for brooms and cleaning materials should be close to the kitchen.

Ceiling heights

Rooms and hall: 2.50M maximum

Bathrooms, toilet compartments, basement and stables, etc.: Average height 2.30 M (7.5 feet)

Light and ventilation

The objective is to provide a healthy environment within the dwelling and situated to provide an acceptable degree of comfort. Natural light, when required, should be provided by means of windows and glazed doors. The area of the glazed material should be

sufficient to transmit an amount of light equal to that transmitted by the required area of clear glass.

Natural ventilation, when required, should be provided through windows that can be opened, exterior doors, or other suitable openings in the exterior walls.

In habitable rooms:

- Natural light should be provided in a "total glass area, not less than 10 percent of the floor area of the room or space."

- To provide natural ventilation, the "net area should not be less than 4 percent of floor area of the room or space." Openings which open into a hall (using the Turkish example) where the depth exceeds 4 feet (1.25M) should be increased in area to 10 percent per foot (around 30cm) for depths over 1.25M.

Openings which open into a hall may be included in the required ventilation area, provided the required area is obtained in both the exterior wall and hall.

Kitchens: Natural and artificial light should be provided by natural means in amounts required for habitable rooms.

Bathrooms and toilets:

- provide natural and artificial light.
- provide natural ventilation. The minimum area required for natural ventilating opening is 3 square feet ($0.27M^2$).

Basements: Natural, artificial light and natural ventilation should be provided. When the basement area is divided into separate spaces, natural light and ventilation should be provided for each space.

Access

The objective is to provide openings adequate in size to admit furniture and equipment to all spaces and to permit inspection for repair and maintenance.

Garden doors: 2 (80cm X 2.10 cm) [2(2.6 feet X 6.5)]

Room doors: (75cm X 2.10) (2.5 feet X 6.5 feet)

Toilet and closet doors: (65 cm X 2M) (2.1 feet X 6.5 feet)

Privacy

The objective is to provide a degree of privacy commensurate with desirable living conditions, obtainable by proper location of exterior and interior openings in relation to exterior or interior conditions and the interior arrangements of living spaces.

Construction materials

Should be installed in such a manner and quality to assure that the dwelling will provide:

- a) adequate structural strength
- b) adequate resistance to weather and moisture
- c) reasonable durability and economy of maintenance.

The greatest care is needed to select suitable materials for the building shell. The best design and layout can easily be spoiled by garish and uncompromising material which destroys the unity and charm of the village.

Construction

Every dwelling should provide:

- a) adequate structural strength and rigidity
- b) adequate protection from corrosion, decay, insects, etc.
- c) necessary resistance to the elements
- d) reasonable durability and economy of maintenance
- e) acceptable quality of workmanship.

Earthquake provisions: When earthquake design is required, the structure and all its component parts should be designed to resist horizontal forces resulting from pressure.

The minimum lateral force at each floor or roof level should be assumed to be a static force equal to 10 percent of the dead load at or above the floor or roof structures less than 35 feet (10.5M) in height.

Parapet walls should be designed to resist a lateral force equal to 100 percent of their weight.

Individual water supply and sewage disposal systems

The objective is to provide each living unit with:

- a) a continuous and sufficient supply of potable water
- b) a water-carried sewage system adequate to dispose of all domestic wastes in a manner which will not create a nuisance or endanger the public health.

To provide an individual water supply system requires:

- a) an adequate supply of safe and palatable water;

- b) reasonable, durable and economic maintenance and operation;
- c) located and constructed to avoid contamination by any existing sewage;
- d) disposal system.

Wells should be located at least 3m (10 feet) from property lines.

Minimum distances for well location (in feet and M):

<u>Source of pollution</u>	<u>Minimum distance</u>	
septic tank	50 feet	15 M
absorption field	100 feet	30 M
sewer lines with permanent watertight joints	10 feet	3 M
dry well	50 feet	15 M

Septic tank

Design should provide adequate volume for settling, sludge, scum storage and access for cleaning.

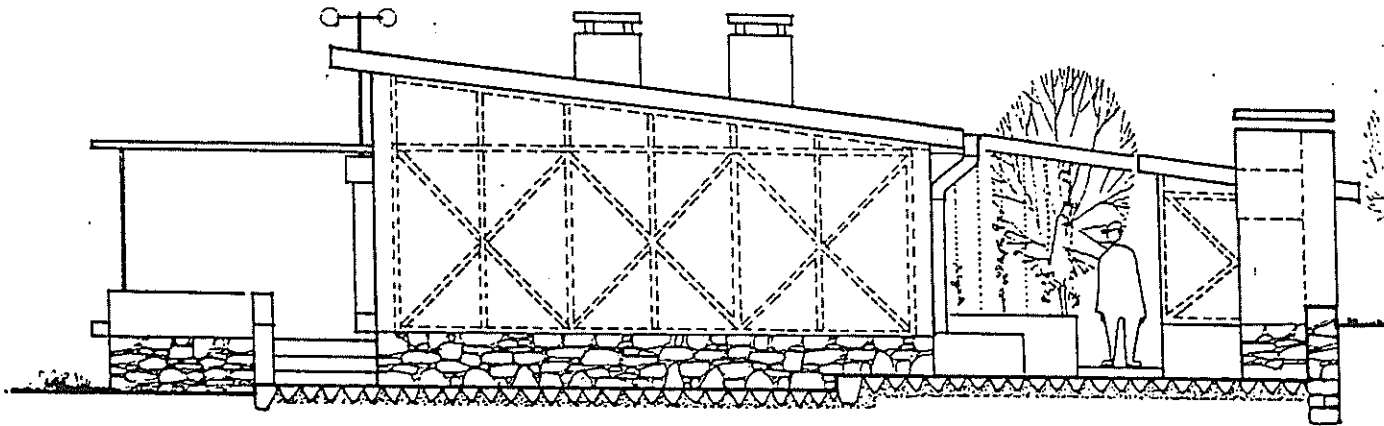
Minimum distances for septic tank:

- from well to septic tank: 50 feet (15 M)
- from foundation wall to septic tank: 5 feet (1.5 M)
- from water lines to septic tank: 10 feet (3 M)
- from dry well to septic tank: 6 feet (around 1.5 M)

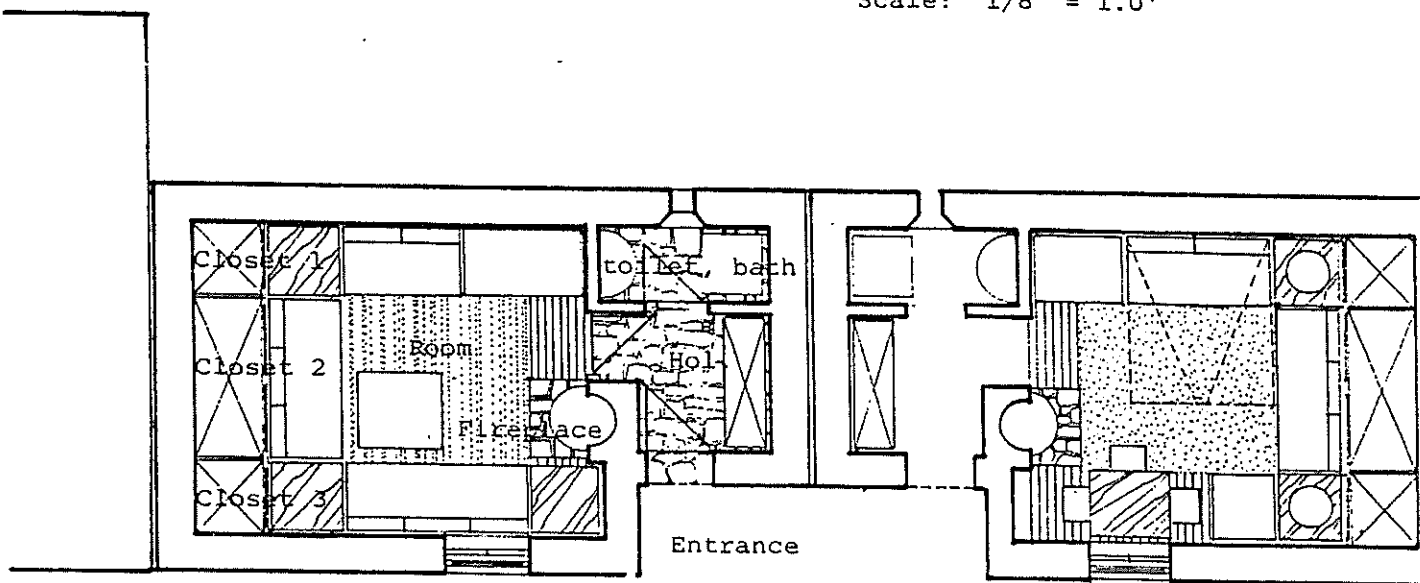
Minimum capacities for septic tanks:

- number of people: 2 = 750 min. liquid capacity (gallons)
- 3 = 900 gallons
- 4 = 1000 gallons

For each additional person, add 250 gallons.

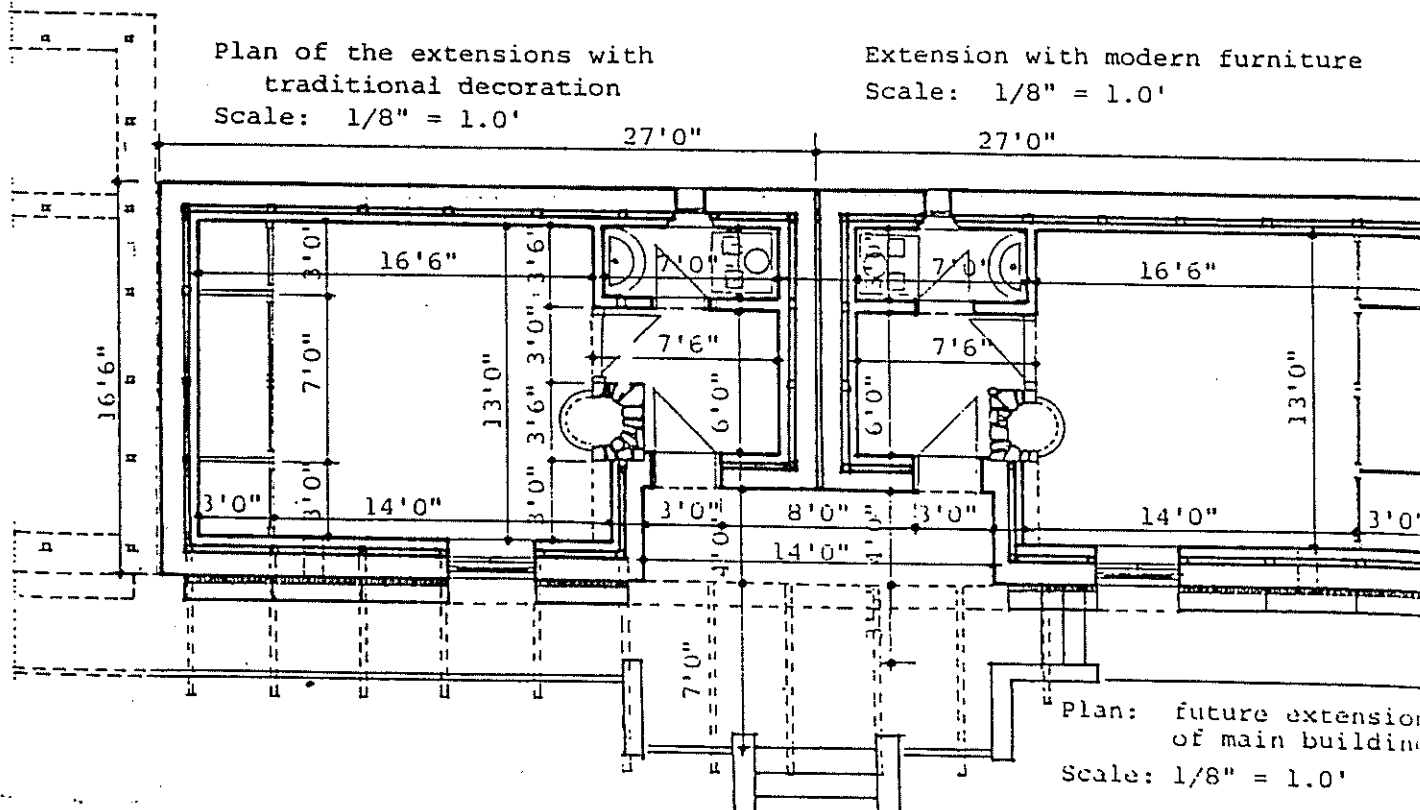


Elevation - main building - east
Scale: $1/8" = 1.0'$



Plan of the extensions with
traditional decoration
Scale: $1/8" = 1.0'$

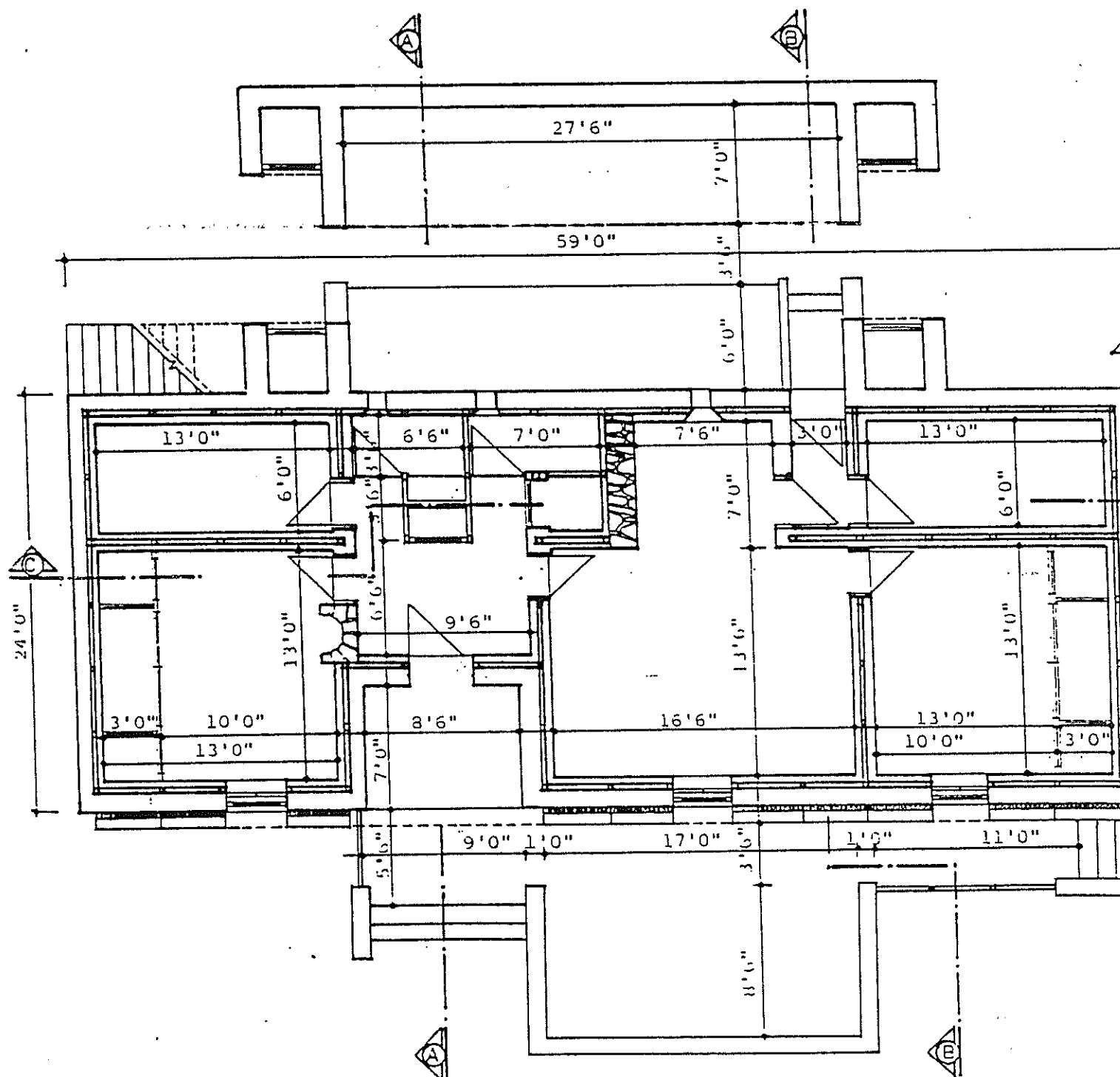
Extension with modern furniture
Scale: $1/8" = 1.0'$





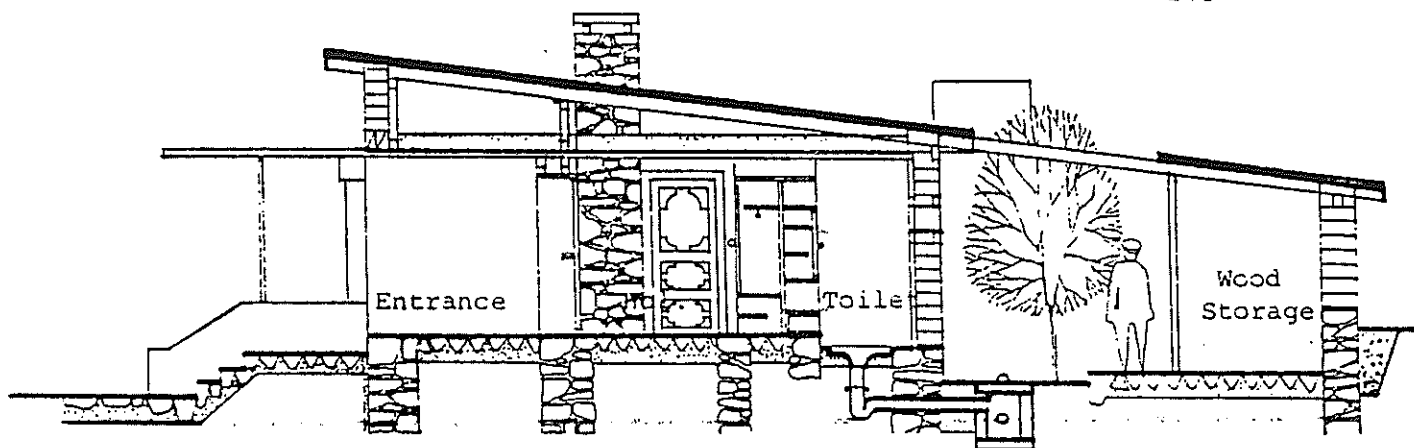
1994

1984

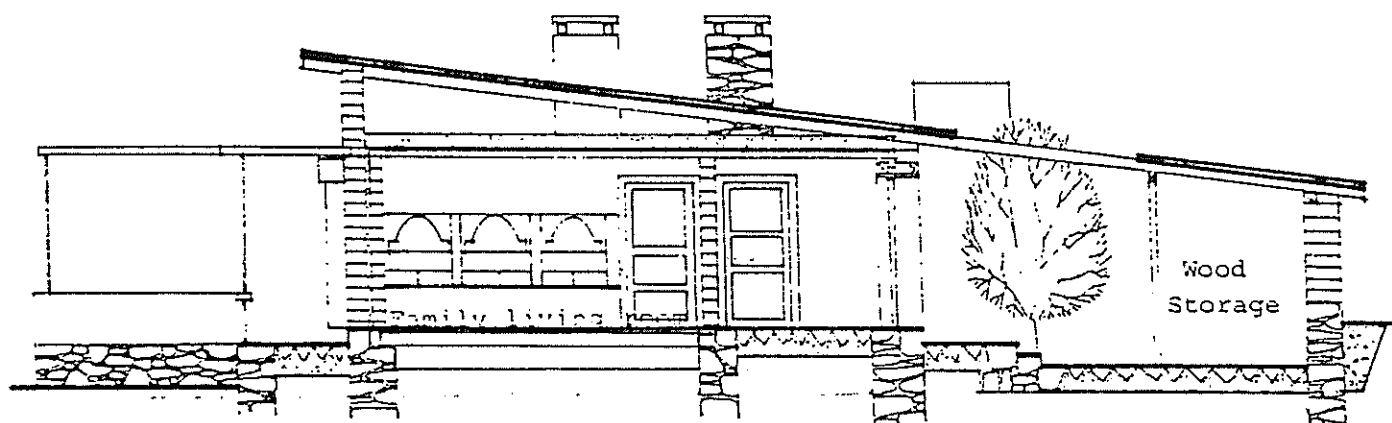


Plan: Main building

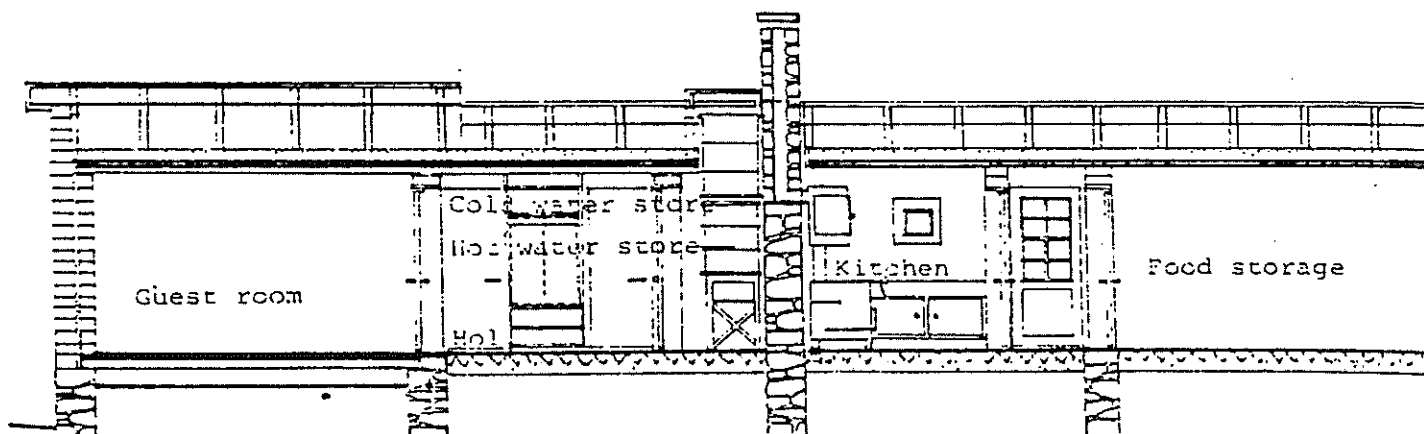
Scale: 1/8" = 1.0'



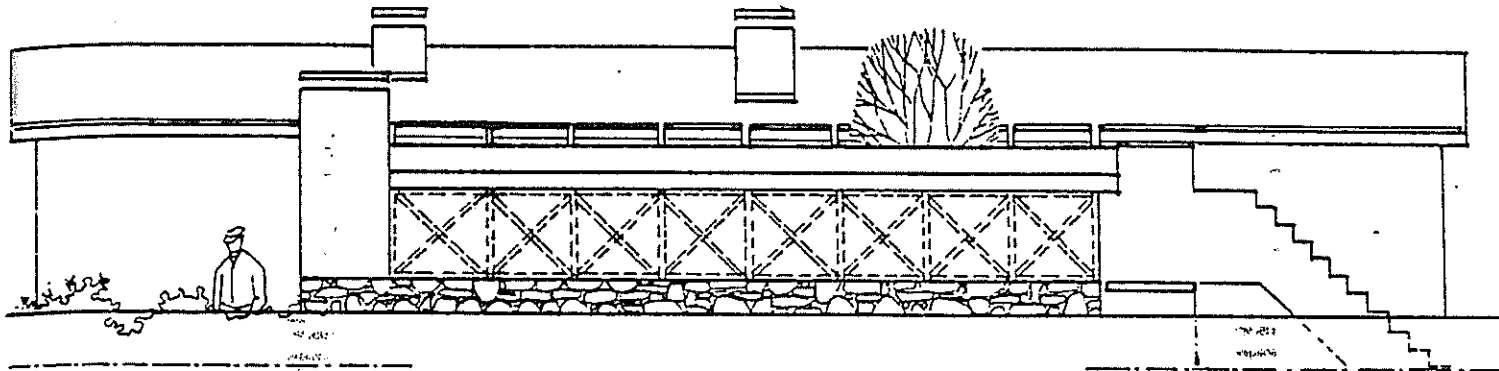
Section A
Scale: 1/8" = 1.0'



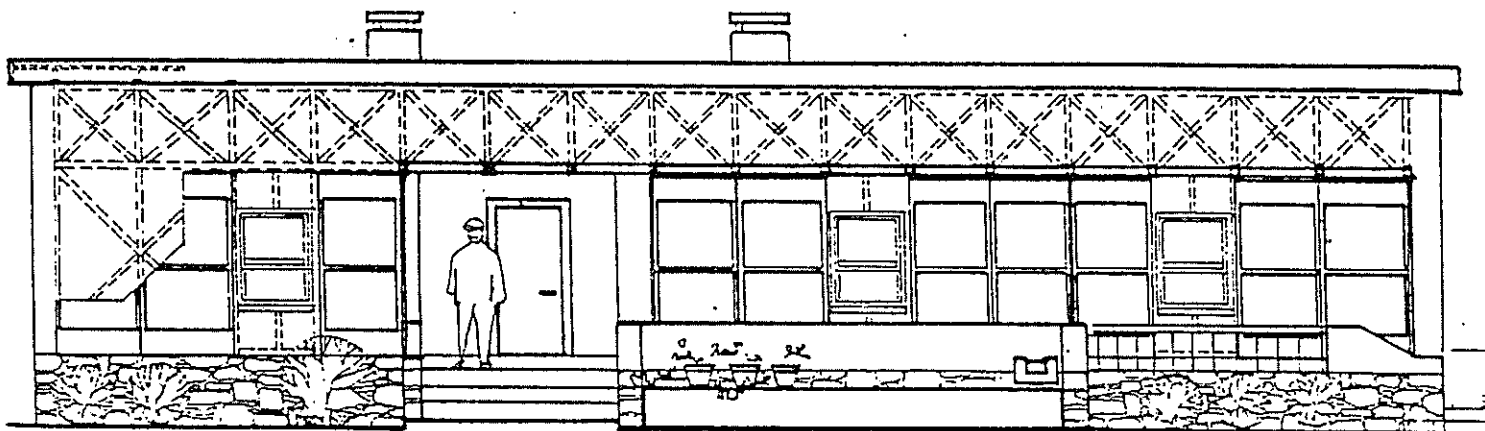
Section B
Scale: 1/8" = 1.0'



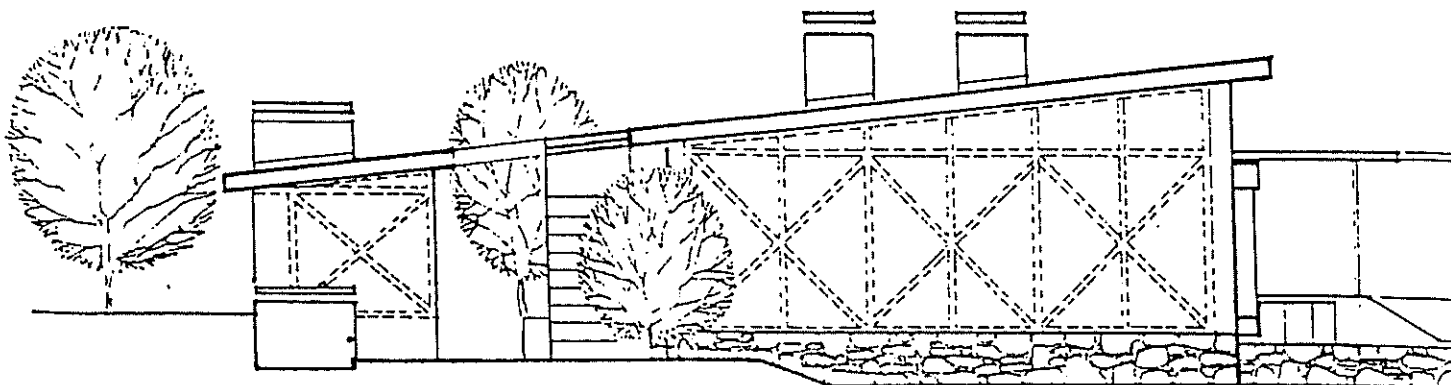
Section C
Scale: 1/2" = 1.0'



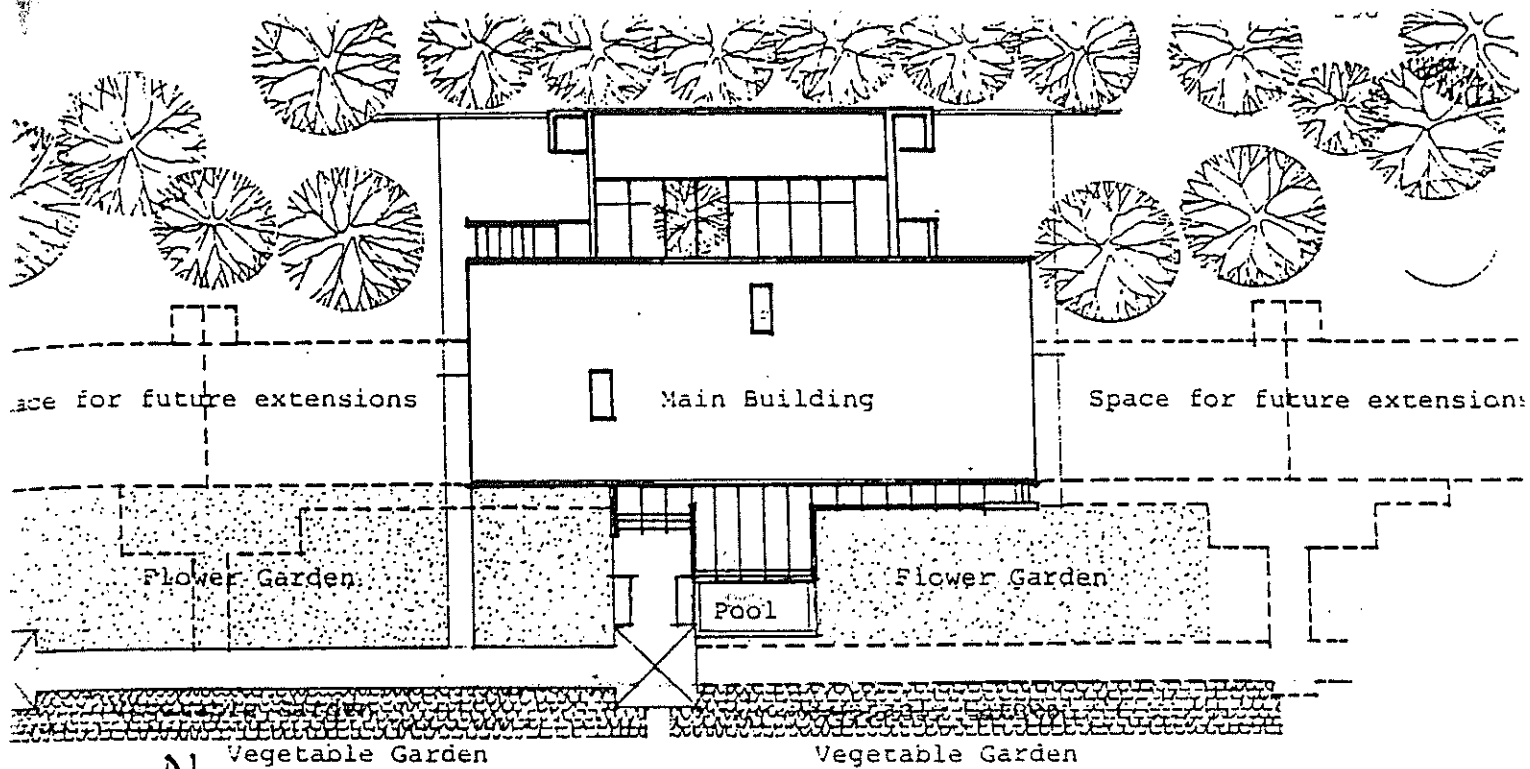
Elevation - Main building - north
Scale: $1/8" = 1.0'$



Elevation - main building - south
Scale: $1/8" = 1.0'$

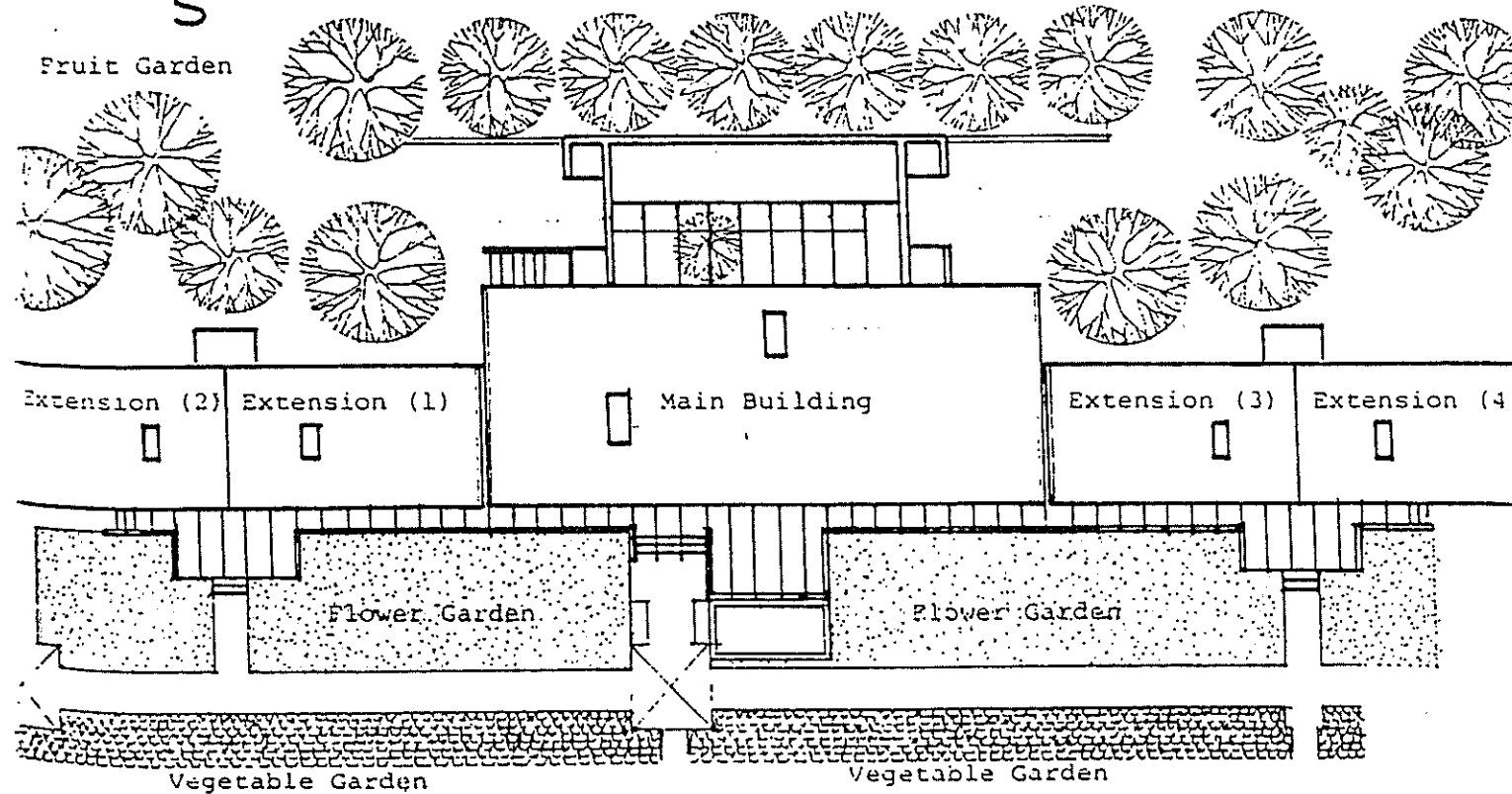
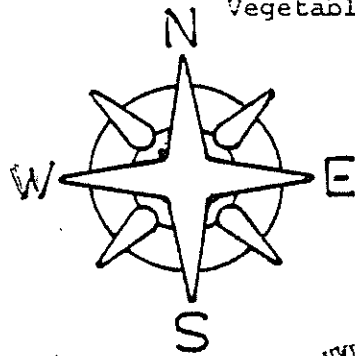


Elevation - main building - west
Scale: $1/8" = 1.0'$



Site Plan: Main Building before extensions

Scale: 0 5 10 15



Site Plan: Main Building after Extensions

Scale: 0 5 10 15

CONCLUSIONS

The Concept

The project provides new solutions to the improvement of dwelling conditions in rural areas. Based on the knowledge and present traditions and culture, its aim is to use local skills and materials as well as existing sources of energy (sun, wind and biomass) in order to provide a house which can be built by villagers and be operated at low costs. Attention has been focused on the economy of energy (a) by eliminating oil consumption, replaced by an alternative source of energy, and (b) by increasing energy conservation and reducing heat losses.

The various thermal balances required for the house are obtained from local sources of energy--heating by solar energy and wood, cooking by woodstove, and refrigeration by biogas (methane). The design concept, the constructional options and the equipment selected concur to put modern techniques at the service of the traditional lifestyle of village inhabitants at affordable costs.

First Phase

It is proposed to build a prototype of this house for experimental purposes in a village of Turkey, after a comprehensive assessment of possible sites. Several governmental agencies may cooperate to implement the project -- the Ministry of Agriculture, the Ministry of Energy, the Ministry of Forests, and the Solar Energy Research Center.

(d) Solar energy: heat produced per day,
month and year

Sunshine houses

Temperature measurements

(e) Water: consumption, temperature

(f) Electricity: consumption

Appropriate sensors and recording instruments will be installed in the house to perform the tests. In addition, a social study will be undertaken on the attitude of villagers regarding the house construction as well as the behavior of the family living in the house. Close contacts will be maintained with villagers during the project and the follow-up period.

Second Phase

Using the data collected during the experiment conducted in the first phase of the project, the design will be improved to take into account the results of the tests and of the social study.

The second phase of the project will consist of the construction of pilot rural houses on a regional basis. Four regions will be considered: (1) the Black Sea (Northern part); (2) the Eastern part of Turkey; (3) the Southern part; (4) the Western part. It is proposed to build five pilot houses in each of these regions.

The revised design -- as improved after phase I -- will be adapted to the local conditions prevailing in each of the regions, to assure uniformity and foster appropriateness. A comprehensive testing and training program will also be included in this phase of the project.

Third Phase

The third phase of the project will consist in examining the results of phase II and considering the potentials for extending the project to other rural areas of Turkey. There are now 50,000 villages in Turkey. Studies will be undertaken to build up a program of improved dwellings in these villages, taking into account the data collected in phase I and II of the project.

Phase Four

Phase IV of the project will aim at studying the potentials for disseminating the information related to the project in other developing countries with a view to exploring possible applications and adaptation on an international scale. Technical assistance programs might be undertaken by the government, with the assistance of the United Nations, to describe the experiments undertaken in Turkey, assess their results, and suggest possible adaptations and projects in other developing countries. This phase would be based upon the recommendations of the United Nations Conference on "Technical Cooperation among Developing Countries" (TCDC, Buenos Aires, September 1978). This phase would provide an opportunity for Turkey to export its technical know-how and also some of the equipment developed while performing the first three phases of the project. It would be of particular benefit to the 1.5 million villages in the world which are facing problems often similar to those of the Turkish villages.

BIBLIOGRAPHY

AIA Research Corporation for the U. S. Department of Housing and Urban Development. Solar Dwelling Design Concepts. Washington, D. C., May 1976.

Anderson, Bruce, with Riordan, M. The Solar Home Book; Heating, Cooling and Designing with the Sun. Published by Cheshire Books, 1976.

Ashrae Handbook of Fundamentals. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. New York, 1972.

Ashrae Handbook. Energy Estimating Methods, Section 4, Chapter 43. 620.6AM 396. 1976.

Ashrae Handbook. Solar Energy Utilization for Heating and Cooling. Chapter 59. 1974.

Billington, N. S. Building Physics: Heat. New York: Pergamon Press, 1967.

Bullen, D. C. Solar Design.

Center of Construction Industry in Turkey. Information of Building Industries Production and Materials. Istanbul.

Duffy and Beckman. Solar Energy Thermal Processes.

EFL Literature. Energy Conservation and the Building Shell.

Energy Research and Development Administration, Division of Solar Energy. Passive Solar Heating and Cooling. May 18-19, 1976, University of Mexico, Albuquerque, New Mexico.

Gabel, Medard, with the World Game Workshop. A Global Energy Strategy for Spaceship Earth. 1975.

Givoni, B. Man, Climate and Architecture. NA 2541 658. New York, 1969.

Hoffman, M. E., and Givoni, B. Proposal of a Method for Calculation of External Surface Temperature. January 1973.

Holden, T. S. Calculation of Incident Radiation Temperature upon Building Surfaces. April 1961.

Knowles, R., and Kreith, F. Solar Heating and Cooling - Engineering, Practical Design and Economics. 1975 Hemisphere Publishing Corporation.

Ministry of Public Works. Climatological Data of Turkey. Ankara.

National Research Council - Canada. Science Dimension. 1976/5.

Olgyay. Design with Climate. Princeton, New Jersey, 1963.

Olgyay. Solar Control and Shading Devices. A 729 09 261.

Prime Ministry, State Planning Organization. Five Year Development Plan of Turkey, 1973 - 1977. Published in 1973.

Shepard, M. L., Chaddock, J. B., Cocks, F. H., Harman, C. M. Introduction to Energy Technology. Ann Arbor: 1976.

Steadman, P. Energy, Environment and Building. Cambridge Press, 1975.

Symposium on "Energy production and thermal effects." September 10-11, 1973. Energy Production and Thermal Effects, Ann Arbor.

Thirring, H. Energy for Man. Indiana Press, 1958.

Total Environmental Action. Solar Energy Home Design in 4 Climates. TEA, 1975.

United Nations. Research in Non-Conventional and Non-Polluting Sources of Energy. November 1, 1975. 3/AC/XXI/CRP.5/add I and add II.

United Nations. New Sources of Energy: Proceedings of the U.N. Conference on New Sources of Energy. Rome, 21-31 August 1961.

- Volume 4. Solar Energy I
- Volume 5. Solar Energy II
- Volume 7. Solar Energy III
- Volume 7. Wind Power

Uzgun, Ismet. Turkey's Underground Fossil Fuels. Istanbul, January 1974.

Van Riper, J. Man's Physical World. McGraw Hill Book Co., 1962.

Van Straten. Thermal Performance of Buildings. TH 72225 V 35.

Watson, D. Designing and Building a Solar House. 1977.

Williams, R. Solar Energy Technology and Applications. Ann Arbor, 1975.

Workshop on alternative energy strategies: Energy, Global Prospects 1985 - 2000. MIT, 1977.

PERIODICALS

Building Manual: Control the Climate your House Lives in. Fall-Winter 1974-1975.

Architectural Design Climate Control. Correac, C. Volume 39, August 1969.

Journal of Architectural Education. "Energy and Architecture." February 1977.

History of Turkish Village Houses.

Architectural Records. Climate Control by Building Design. Richards, S. J.

Architectural Records Climate Balanced House Design. Olgyay. Volume 133. Mid-May 1963.

International Journal of Biometeorology. Bioclimatic Orientation Method for Buildings. July 1967.

MIT Journal of the Faculty of Architecture. Anatolian Turkish Gardens. Gonul A. Evyapan. Spring 1975, #1.