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VERNACULAR ARCHITECTURE AND ENVIRONMENTAL INFLUENCES: AN ANALYTIC AND A COMPARATIVE STUDY

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INTRODUCTION

Being part of the environmental system, human habitation--specifically housing--can be considered to have its own micro energy exchange. Within a system, unless it is a perfect closed system,(at least, theoretically),there will be an inflow and an outflow of energy. As long as there is an exchange of energy, there will be an energy-budget of the system where the difference between the incoming and outgoing energy will be used up in one way or the other. Our interest lies in the degree of utilization of the energy coming in and the success of man in converting this for his own benefit in the housing context without harming himself by disturbing the environmental system with which he is interacting. Our concern at this point is at a micro level when compared to the interactions occuring at suprasystems which include our subsystem. Nevertheless, man's use of resources and the utilization of the energy inflow is significant at this point for his "...role in the environment is becoming so enormous that his energetic capacity to hurt himself by upsetting the environmental system is increasing."[1]

We can write the general energy-budget equation,(Eq.1), as:

$$I_n = LE + H + G, \qquad (1)$$

where I_n is the net incoming radiation, LE is the latent heat flux, H is the sensible heat flux, and G is the amount of energy which is stored in the system. It is primarily the utilization of G, with which we concern ourselves. Its gain, its loss and the extra energy spent to replace its loss, are what we are interested in discovering.

It should not be assumed that environmental factors are the only determining issues in housing. Since man is part of a social system, which itself is in interaction with the environmental systems, we cannot isolate one from the other. "Nothing that happens...operates in isolation or fails to react in some degree on many activities."[2] 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 Rapoport's term, modifies it.[3]

1. H.T. ODUM, *Environment, Power, and Society*, New York: Wiley-Interscience, 1971, p.6.

2. C.D. FORDE, *Habitat, Economy and Society*, London: Methuen and Co.,1961, (1934), p. 470.

3. In his book, *House Form and Culture*, Englewood Cliffs, N.J.:Prentice-Hall, Inc., 1969, Amos 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. In turn, he argues, the climatic conditions, construction methods, materials available and the level of technology act as modifying forces (whereas the socio-cultural forces are defined as the primary forces).

Despite all the technological means for environmental control, man in the modern age has often built habitats that are inferior(in response to environmental influences) to those built by even the most primitive people in the earlier historical stages. Fitch and Branch find the primary reason for this in "...consistent underestimation of the environmental forces that play upon his buildings and cities, and consistent overestimation of his technological capacities."[4] With an understanding of the environmental influences and the utilization of them in a positive sense, such as harmony with the socio-cultural demands without allowing abstracted values to determine the design process, man can create habitats that are better than the ones today.

It is not our intention to look backward longingly to the past and romanticize it. Nor is it our contention to suggest that cultures of the past(and even at present some rural societies) were much more aware of the environmental influences and, therefore, tried to live with them in closer harmony or were able to cope with the situations more rationally than their descendant are doing today. Industrial civilization has provided us with a high command of machinery and the introduction of this has altered the socio-economic relations. Hence, the causes for a deficiency(if there is any) of the present cultures in dealing with some of the environmental problems must be sought with this fact in mind rather than studying the mere attitudes toward and awareness or understanding of the environmental influences by the cultures. However, this will be beyond the scope of our study at present.

Our study covers only two climatic zones--hot-arid and marine-cool. We will try to look at the evolution of housing in these areas and try to find the impact of environmental influences and the degree of freedom of choice it left to the inhabitants. Finally, a comparative analysis in the choice of materials and the utilization of the energy will be made.

ENVIRONMENTAL INFLUENCES AND THERMAL EFFECTS OF MATERIALS

Solar Radiation

Any building component which is at a different temperature from the surrounding space passes on energy to that space. It is also true that all building components, depending on their absorptivity, absorb different quantities of heat when their surfaces are exposed to solar radiation. Thus, solar radiation influences the indoor temperatures by directly heating the exposed surfaces of the enclosed spaces, by penetrating through the openings on the surfaces, and by heating the circumambient atmosphere.

While solar radiation is a favorable factor in cold weather, it is generally undesirable in warm days. Therefore,it becomes a design control problem to optimize the utilization of solar radiation in the built environment. Generally, there are three main controllable factors: absorptivity of the external surfaces(use of color is the main element); orientation of the building(use of heating impact on different surfaces and/or for different functioning spaces of the building); and shading of openings on surfaces(modification of heat flow to the indoor spaces). The latter two are also of prime importance in the ventilation problem which is closely related to the direction of the prevailing winds.

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[4] J.M. FITCH and D.P. BRANCH, Primitive Architecture and Climate , *Scientific American*, v. 205, n. 6, 1961, pp. 134-144. Elsewhere, Fitch treats the same problem in a broader scope. In his analysis of the present building process and in his comparison of the past and the present man-built environment, he looks at the problem in terms of economic relations where more comprehensive terms like "alineation", "economy of scarcity", and "economy of plenty" are incorporated into the architectural process. See J.M. FITCH, *Architecture and Aesthetics of Plenty*, New York: Columbia Un., 1961.

The intensity of solar radiation is dependent on three concepts: the direct intensity, the diffused radiation, and the reflected radiation. The total thermal effect of solar radiation can be expressed in the concept of the sol-air temperature. A thermal definition would be: "...the sol-air temperature for the surface of a given structural element is a theoretical external air temperature which, in the absence of radiant heat exchange, would produce the same thermal effects on the element as the existing combination of incident radiation and ambient air conditions."[5]

Due to complexities and some prior estimations, a simplified formula, (Eq.2), to compute the sol-air temperature has been employed here:

$$t_{sa} = t_a + \frac{aI}{h_o} \qquad (2)$$

where t_a is the outdoor air temperature, a is the absorptivity of the exposed surface, I is the intensity of the total solar radiation on the surface, and h_o is the overall external surface coefficient. (See TABLES I and III.)

Location	Yearly (kcal/cm^2/yr)	Daily (kcal/m^2/h) June	(kcal/m^2/h) December
Cent'l Turkey	150	270	63
Middle East	160	290	104
SW America	160	290	104
S of Sahara	160	230	210
Coastal Norway	75	188	20
B. Columbia	90	210	30
Chile	110	63	270
Tasmania	110	63	230

Table I Net Solar Radiation.
Sources: Landsberg, H.(1958); Lof, G.O.G., *et al.*(1966).

Humidity and Air Motion

Humidity is an essential item (it is actually the LE of the general energy-budget equation, (Eq.1), for the comfort of human beings, since it has a direct effect on the rate of heat loss of the body. Relative humidity is defined as the ratio of the amount of moisture in the ambient air and the amount of moisture that the same air can hold if saturated(or the ratio of ambient vapor pressure and the saturation vapor pressure at a temperature). Therefore, it is the combination of humidity and temperature that acts on the comfort level of the human body and thus regulates the rate of evaporation. The feeling of warmth and coolness is a joint function of temperature and humidity.

There is very little that can be done to control the humidity indoors except by mechanical means. Dehumidification, through air movement, is an important factor here. Humidity regulation is not the strongest item in winter except it should not be high enough to cause condensation; whereas during hot summer periods in dry regions low humidity and in humid regions high humidity can lead to very uncomfortable conditions. Requirements(on the velocity of the air) for evaporative cooling will set the boundaries of these thermal regions which determine the affect of humidity. The orientation of the

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[5] B. GIVONI, *Man, Climate, Architecture*, New York: Elsevier, 1969, p. 188.

building in regard to the prevailing wind and the position and size of the openings will determine the velocity of the air.

Primarily, air velocity will affect the convective heat exchange of the body and the evaporative capacity of the air. Consequently, the latter will determine the cooling efficiency of sweating. For instance, as the air velocity increases, the evaporative capacity will rise and as a result, within limits, will reduce the effect of high humidity. Air velocity will also reduce the effective air temperature as long as it is less than the skin temperature. When the air temperature is higher than the skin temperature, air velocity will cause a higher convective heat exchange, which will eventually warm up the body, but it will also increase the cooling efficiency by increasing the evaporative capacity of the air. (See TABLE II.)

Table II Possible Combinations of factors producing the same effective temperature of 27°C(80°F). DB and WB indicate DRY BULB andWET BULB Temperatures, respectively. Source: van Straaten, J.F. (1967).

DB Temp.		WB Temp.		RH	Rate of Air Movement	
°F	°C	°F	°C	%	ft/min	cm/sec
80	27	80	27	100	20	10
90	32	72	22	42	20	10
100	38	64	18	11	20	10
100	38	70	21	11	500	254

Time Constant(RC)

When air temperature and solar radiation are directly acting on the external surfaces, the *time constant*(RC) of the material placed an influential role on the nature of the relationship of internal and eqternal conditions. Comparison of this value for different materials shows clearly that the lower the *time constant*, the lower the minimum and the higher the maximum indoor temperatures. Thus with lower *time constant* the diurnal difference between minimum and maximum for the indoor temperature will be greater compared to a larger product of *heat-storing capacity*(C) and *thermal resistance*(R). In other words, the amplitude of internal temperatures depends on this value. (See TABLE IV.)

Table III Absorptivities and Emissivities of Surfaces. Source: Givoni, B. (169).

(In percentages)

	S. Wave Abs.	L. Wave Emis.
Whitewash	.12	.90
Gray color,light	.40	.90
Gray color, dark	.70	.90

Thermal Conductivity -Heat Storing Capacity Product(λC)

The quantity of heat stored in the building component depends a great deal on the density of the materials that make up that component. 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, especially when diurnal heating and cooling have to fluctuate considerably. Components with lower values of λC will be warmed quicker than those with higher values of λC, but they will also tend to cool faster when the heating system is turned off. That is, the value of λC will affect the *time-lag* between the indoor and outdoor maxima. (See TABLE IV.)

Table IV Thermophysical Properties of Materials and of the Components.

Material Properties:

Materials	ρ Density (kg/m^3)	c Sp. Heat (kcal/kg^{0}C)	λ Thermal Conductivity (kcal/m^{2}h^{0}C)	α Thermal Diffusivity (cm^2/h)	λc (λρc)
Adobe (Mud-brick)	1540	.18	.61	22	170
Wood (Timber)	500	.45	.17	7.6	38
Stone	1800	.20	1.18	33	425

Component Properties:

Materials	d Width (cm)	R Thermal Resistance (mh^{0}C/kcal)	K Thermal Conductance (kcal/m^{2}h^{0}C)	RC Time Constant (h)	δ Decrement Factor	ϕ Time Lag (h)
Adobe	35	.796	1.26	56.0	0.067	10.1
	50	1.046	.95	114.0	0.063	14.5
Timber	15	1.106	.86	29.5	.124	7.5
	20	1.406	.71	52.5	.121	9.9
Stone	30	.480	2.08	27.0	.056	7.2
	40	.564	1.77	48.5	.054	10.0

Time-Lag(ϕ) and Decrement Factor(δ)

When there are large fluctuations between diurnal maximum and minimum of external temperatures and solar radiation, the pattern of non-tempered indoor conditions will significantly depend on the components that enclose the indoors. Due to external factors, the components will pass on to the inside air only a portion of the heat stored. Thus, there will be a phase difference between the external daily pattern and the internal daily pattern, since it will take some time for the enclosing component to gain heat and to pass a portion of it on to the inside. This difference will cause a *time-lag*(ϕ) between the heat gain and time of maximum external surface temperature, and the heat loss to the inside air and the time of maximum internal surface temperature. In other words, there will be a phase delay, as well as reduced amplitudes of the maximum and minimum internal temperature variations, when this sinusoidal pattern is superimposed on the external heat load pattern.

The reduction in amplitudes can be expressed by the *decrement factor*(δ). This is the ratio between the amplitudes of the external surface temperatures and internal surface temperatures. Thus, the internal surface temperature follows a wave pattern of amplitude(θ_i) which is directly proportional to the *external amplitude* θ_e with the *decrement factor*(δ):

$$\theta_i = \delta\theta_e \tag{3}$$

The *time-lag* and the *decrement factor* for a fundamental wave ($\tau = 24$ hrs) can be calculated as:[6]

$$\phi = 1.38d\sqrt{\frac{1}{\alpha}} \quad ; \quad \delta = e^{-.362d\sqrt{\frac{\Pi}{\alpha\tau}}} \qquad (4),(5)$$

where d is the *thickness* of the material and α is the *thermal diffusivity* of the material which can be expressed as:

$$\alpha = \frac{\lambda}{\rho c} \qquad \text{(See TABLE IV.)} \tag{6}$$

		Temp.		RH	
Location	Year	July	Jan.	July	Jan.
		^{0}C		%	
SW America	1957	33	4.4	38	53
	1967	33	-4	33	40
	1970	35	-1	35	45
Cent'l Turkey	1957	29	-6	24	70
	1967	30	0	26	78
	1970	32	3	30	69
Coastal Norway	1957	14	3.6	85	80
	1967	13.9	1	81	83
	1970	13	0	76	80
B. Columbia	1957	15.9	-1	77	77
	1967	17.5	4.5	74	88
	1970	17.1	3	75	82

Observation Stations for the readings:

SW America - Albuquerque, Phoenix, Grand Junction
Central and SE Turkey - Malatya, Diyarbakır
Coastal Norway - Bergen
British Columbia - Van Couver

Table V Climatic Data for July and January in Hot-Arid and Marine-cool Regions.
Source: U.S. Dept. of Commerce/Weather Bureau.

Optimum Shape due to Heat Exchange

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. Although the radiation effect through openings on surfaces is negligible in the case of the structures studied here, due to their having no openings or very small openings, the thermal impacts of temperature and radiation on the indoor air partially depend on the form of the building. Quantitatively, this can be computed by the heat flow method as suggested by Olgyay.[7]

The optimum form can be expressed as:

$$\frac{c_1}{c_2} = \frac{y}{x}, \tag{7}$$

where c_1 and c_2 are the *heat effects* on the side x and side y

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[6] B. GIVONI, *Man, Climate, Architecture*, New York: Elsevier, 1969, p. 132.

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of an area respectively. A modifying factor, which Olgyay calls "the criterion of elasticity,"[8] must be applied however, depending on the intensity of summer and winter in the particular region. For example, the summer stresses in the hot-arid regions are nearly eight times larger than the winter ones: therefore, the summer index may be adopted despite a different index for the winter. On the other hand, if the stresses are not that different between summer and winter conditions, an average index or an index closer to that of the more tense season may be adopted.

Olgyay's studies show that the optimum for all climatic conditions lies in a form which is oriented to the east-west direction in its major axis.[9] The optimum for hot-arid regions is 1:1.3 with an elasticity of 1:1.6 and for marine-cool it is 1:1.2 with an elasticity of 1:1.4. These are from our calculations and they agree that Olgyay's results rather closely.

EVOLUTION OF HOUSING IN MARINE-COOL AND HOT-ARID REGIONS

From the very early primitive architecture to the vernacular, to the industrialised architecture in housing, man tried to find solutions with which to adapt to and survive within a given environmental situtation. The environmental influences on his sheltering and their modifying effects on the type, shape, material and even on the means of erecting these shelters have played as important a historical role as the socio-cultural potentialities of man.[10] From the savage food-gatherers to the more advanced cultivators, we see the tremendous effort by man to search for the right micro-environment where he can be comfortable away from the physical disturbances. "It is a tool which frees man for other activities by creating an environment which suits him, protecting him from the undesirable effects of his surroundings."[11]

As man left the shelter of nature (i.e.,cave, tree trunks, large rocks, etc.), *his search for an adaptable shelter* and house led him to different solutions under different conditions. The evolution of the built environment is the product of his patient and sensible search through the centuries. Provided that the built form reflects his socio-cultural influences in certain ways, the environmental influence on his solutions is not at all minimum. This is apparent in his consistency and in his maintaining a suitable environment where he found comfort.

Basically, we can talk of the evolution of his built-environment in two categories:

1. Subterranean and/or Semi-subterranean Shelter;
2. Built dwelling.

Subterranean and/or Semi-subterranean Shelter

In both hot-arid regions marine-cool regions the cave was the first shelter.[12] As man found means to create and build more suitable surroundings, a step forward in his search took him to the subterranean and/or semi-subterranean shelters. This consisted mainly of an earth hut dug into the hillside or large holes dug underground and covered with earth on top. (See Fig. 1). More sophisticated examples of these are still in existence in some parts of these particular climatic zones.[13]

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8. V.OLGYAY, *Design with Climate*, Princeton, N.J.: Princeton Un., 1963, p. 88.

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10. There has been a strong inclination to explain historical and cultural phenomena through the physical environmental forces. For example, see: E.HUNTINGTON, *Civilization and Climate*, (3rd. Ed.), New Haven: Yale Un., 1924,; E.C. SEMPLE, *Influences of Geographic Environment*, New York: Russell and Russell, 1968, (1911), (esp. pp. 1-73, 473-520, 557-637). The advantage of the "environmental determinist" point of view lies in providing data for empirical phenomena from which a straight forward analysis can be carried to postulate that human behavior and development of man's artifacts are determined(and/or can be predicted) by reference to some set of casual laws. This approach represents an *oversimplified perspective of the* ecological relationship. The empirical phenomena, presented for the purpose of analysis, may not be acknowledged as being independent of the other cultural influences as they may appear. The complexities of a dialectical framework that exists in the man-environment relationship are not consistent with the misleading simpicity of positivistic empiricism and the neat schematic straight-forwardness of philosophical formalism. For an elaboration of the subject, see: M.R. TURAN, "Environmental Stress: An Ecological Approach with Social Reference to Housing", Unpublished Ph. D. dissertation, Columbia Un., 1974,(esp. pp. 1-45, 101-128). A more extensive treatment of the subject can, also, be found in: H. SPROUT and H. SPROUT, *The Ecological Perspective on Human Affairs*, Princeton, N.J.: Princeton Un., 1969, p. 85.

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13. B. RUDOFSKY, *Architecture Without Architects*, Garden City, N.Y.: Doubleday and Co., 1964, no.s 16,48. *Needless to say, almost all of this type* of housing that exists today are in the rural areas. "Economy of Scarcity", which was mentioned earlier, is one of the major characteristics of this type of construction where participation of the inhabitants in the actual construction is one of the key elements in this process. Although a similar type of participation takes place in the *squatter settlements* on the outskirts of larger cities(especially true in Latin America, Northern Africa, Middle East and Far East), the socio-economic factors- the industrially produced materials, technological level, and the economic relations initiated by the changed distribution of wealth and products- make the conditions very different. Hence, this difference in the given circumstances results in entirely dissimilar products(housing) where there can be discrepancies which may not exist in the rural areas.

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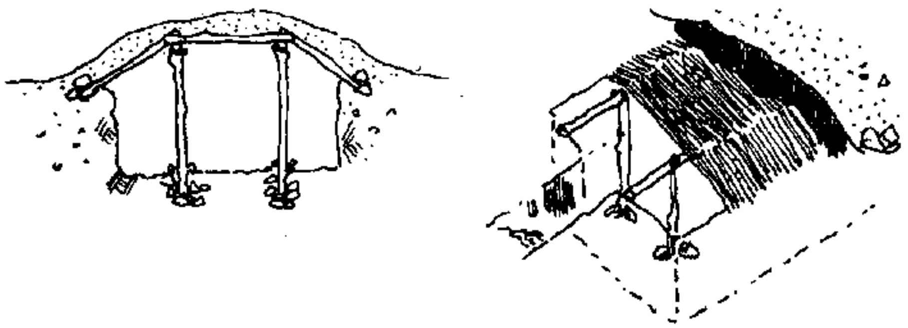

Fig. 1 (After Morgan, L.H.,1965, p. 106).

The use of these dwellings even in our present era is not entirely due to the socio-cultural factors but also to the comfort they provide under hot-arid climatic conditions. The favorable conditions of ground can be seen in Fig. 2.

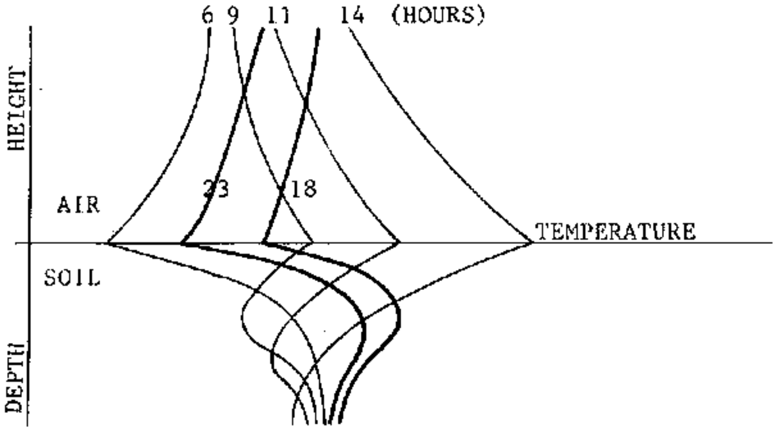

Fig. 2 Generalized Sol-Air Temp. profiles (tautochrones) near the soil surface at intervals during a diurnal period. (Source: Lowry, W.P.,1969, p. 36).

Approximately ten million people still live in these underground homes carved out of loess in the provinces of Honan, Kansu, Shansi and Shensi in Northern China.[14]

Another example of semi-subterranean shelters is the one still used by the peasants in the Middle-Eastern countries of Iran, Iraq, Syria and Turkey.

Another version of this type of shelter is the troglodyte village which gave seclusion and shelter to its inhabitants. The natural forms, which are the result of volcanic actions and weathering, have sheltered people from very early times. In the Göreme valley(Cappadocia) in Turkey, intensive erosion has given shape to an unusual and fantastic landscape which consists of pumice stone that has been worn into deep clefts and eventually formed into isolated cones about 10-20 m. high. (See Fig. 3). For the earlier pagan communities and for the early monastic settlements of Christianity in the 5th Century, carving into these cones and finding comfort and shelter behind the natural thick walls of perfect thermophysical properties was an important as finding undisturbed seclusion.

Subterranean house architecture has not been as durable in the marine-cool regions as it was in hot-arid regions. The principal reason for this is precipitation. The ground water is at a much higher level in the marine-cool regions than it is in the hot-arid regions. Also, the topography and geological factors are elements that work against this type of shelter and make it unsuitable for marine-cool regions. A new solution

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[14] B. RUDOFSKY, *Architecture Without Architects*, Garden City, N.Y.: Doubleday and Co., 1964, no. 18.

Fig. 3

emerged out of the environmental exigencies in these areas. The post and beam system covered with earth was not only an answer to the environmental forces but to the needs of social structure which was mainly a communal living later transformed into extended families.[15]

Built Dwelling/Marine-Cool

Made of low, sloping earth, with stone walls and a turf roof on birch bark, supported by the posts and beams, enclosed by the earth skin, these dwellings were seldom divided inside.[16] The cold climate in winter required heating which was done by an open hearth in the middle of the floor. Thus, the only openings for air ventilation in these dwellings which had dimensions of 5-7 m by 15-20 m were the entrance on one short side and one or two smoke openings on the roof. Despite its deficiency in ventilation, it must have provided a rather comfortable living condition during the cold winter months. Although its major axis ran along an east-west direction to utilize the solar radiation as much as possible, it must have been somewhat cooler than a comfortable temperature indoors in the summer. This is, of course, due to the high storage capacity of the earth and stone that were used as the enclosing skin. (See Fig.4).

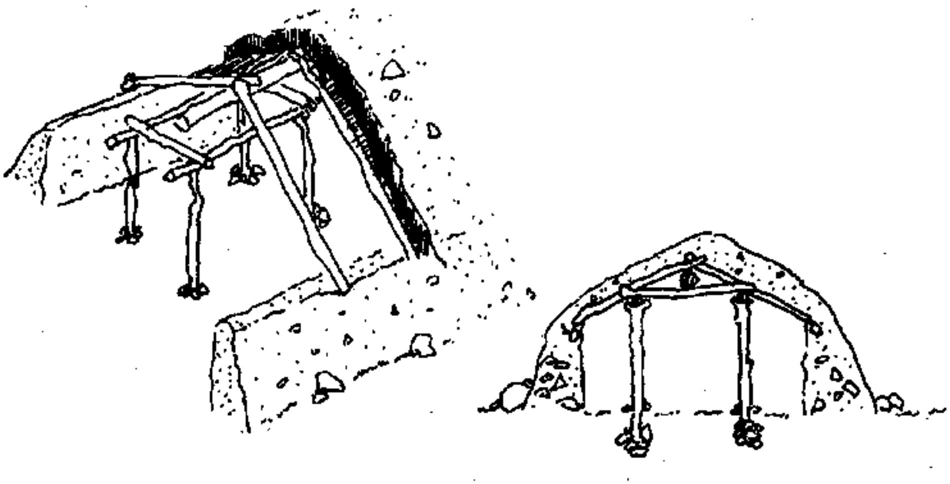

Fig. 4 (After Alneas, E., et al.,1950, p. 10).

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[15] L.H. MORGAN, *Houses and House-Life of the American Aborigines*, Chicago, 1965(1881); J.LLOYD, "The Norwegian Laftehus", in P. Oliver(ed.), *Shelter and Society*, New York: Praeger, 1969, pp. 33-48.

[16] E. ALNAES, *et al.*, *Norwegian Architecture Throughout the Ages*, Oslo: Aschehang and Co., 1950, p. 10.

Contrary to the hot-arid regions, solar radiation and warmer temperature are welcome in the summer in marine-cool regions where the maximum daily outdoor temperatures seldom exceed 20°C. The first signs of the type of wood construction which was to follow the posts and beams enclosed by earth dates back to A.D.300 in Norway.[17] A very similar type of construction was also used by the Nootka and Kwakiutl people on the northwest coast of Noth America.[18] Due to its abundance in these areas, wood, with its thermophysical properties which were more suitable for this climate--at least during the summer months--became the main construction material. As knowledge and technical means(tools were stone, shell and bone) developed, plus the advantage of working with soft woods with long, parallel grains, it was easy for these fishing people to work with this material and give form to their dwellings according to the environmental factors and their sociocultural necessities. A massive framework which lasted for generations could house numbers of families in the style of communal living. The framework was enclosed by wall planks which could be dismantled and used as a deck on a pair of canoes during the summer migrations and which also provided the material for temporary summer dwellings which were lighter than the winter ones.

The roof was covered with curved sections, concave and convex planks laid alternatively, to provide drainage and waterproofing. Both the outer shell of planking and the roof planks could be renovated when necessary. An earthen bank, faced with planking, ran along the inner walls with the dimensions of 15-20 m by 15-30 m.[19] Bedding and storage for each family were laid out on these banks.[20] These earthen banks not only served the several activities within the dwelling but also must have acted as good insulating devices against the cool, windy winters. The heating was provided by open hearths in the center. (See Fig. 5).

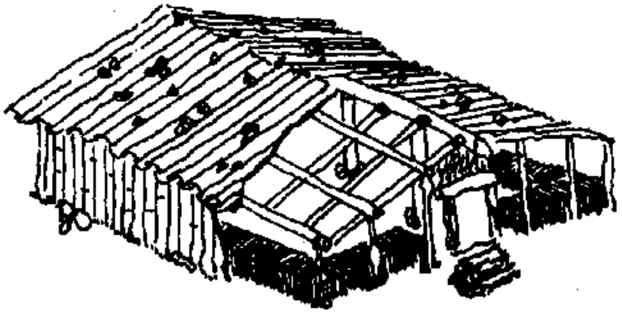

Fig. 5 (After Forde, C.D., 1934, p. 75).

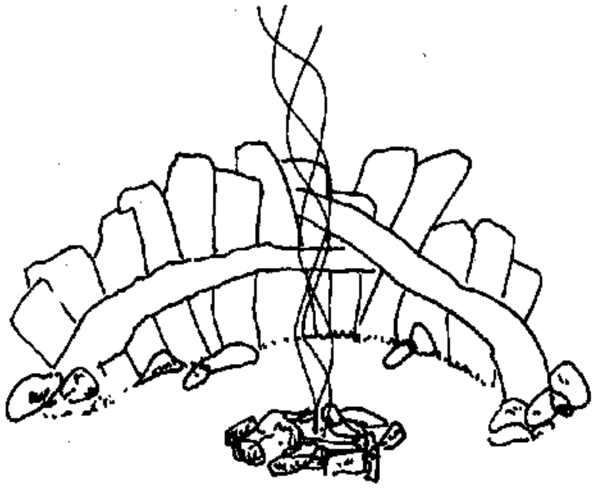

Fig. 6 (Adapted from Forde, C.D., 1934, p.98).

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[17] J. LLOYD, The Norwegian Laftehus, in P. Oliver(ed.), *Shelter and Society*, New York: Praeger, 1969, p. 37.

[18] C.D. FORDE, *Habitat, Economy and Society*, London: Methuen and Co., 1961, (1934), pp. 69-100.

[19] L. H. MORGAN, *Houses and House-Life of the American Aborigines*, Chicago: Un. of Chicago, 1965(1881), pp.115-116.

[20] C.D. FORDE, *Habitat, Economy and Society*, London: Methuen and Co.,1961 (1934), p. 75.

Although very similar climatic conditions exist on the island of Tasmania, south-east of Australia, a great cultural contrast shows itself both in the use of resources and the means for shelter.[21] The shelter of Tasmanians is nothing more than a low, unroofed wind-break made of sheets of bark or boughs. (See Fig. 6). The same arrangement happens to be true for the aborigines of Australia living in hot regions, who do not have either the concept of a wall nor the notion of subterranean sheltering which is quite common among people living in other regions of hot-arid zones.

This contrast between two cultures under similar environmental influences show us that "...the recognition of a close relation between economy and settlement must not be taken to imply that the permanence and elaboration of habitation will depend inevitably on the resources of the natural environment."[22] Although an adaptation process is necessary and a modification of culture is needed in relation to physical conditions, this apparently cannot occur without discoveries, inventions, and infiltration. Culture itself is not static; it is adaptable and modifiable. But without either diffusion or innovation, and with the restrictions set by social patterns and norms on the utilization of certain resources or on adaptations to physical environment, it can be rather stagnant and defy changes.

Those people who had advanced to the level of stave construction in the marine-cool regions did go one step forward in developing even more suitable dwellings a few centuries later. Although the first timber-log construction, according to archeological evidences, goes back to A.D. 300 in Scandinavia, as mentioned earlier, it was not utilized in housing except as a burial chamber. Stave construction, which had a primitive beginning in the coastal regions, was developed side by side with boat building. Timber-log construction, or the jointed timber construction, was being utilized in the high plateaus of the herding people. Therefore, it can be said that the two construction systems developed independently of each other. Whether the introduction of timber-log for housing was a cultural diffusion from the Mediterranean regions to the North is an unanswered question.

Although several ingenious measures were taken to adapt the stave construction to harsh environmental factors by the Vikings and the people of early Saga time, there still was more to accomplish to find a more satisfactory environment. to keep the moisture out, they made the floors with packed clay, mixed with animal hair, and they even sometimes used layers of burnt stones, 20 cm thick.[23] Measures like this and like the earthen bank around the inner walls was not sufficient to maintain a better energy expenditure. Cold winter months required considerable heating since the walls were not able to store heat.

The timber-log construction, or the "laft" construction, (See Fig. 7), although more laborious and a slower process, was constructed to offer a more suitable internal environment-especially in winter when the thermal stresses are more intense than in the summer months. Logs are placed one upon another with ends cut for dove-tailing(See Fig. 8). After the roof is completed, the structure is set to wait about a year for settlement of walls which causes tighter connections. For wind proofing, Norwegians used moss or woolen cloths of red, blue and green in between the horizontal joints.[24] The colors

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21. C.D. FORDE, *Habitat, Economy and Society*, London: Methuen and Co., 1961. (1934), p. 95.

22. C.D. FORDE, *Habitat, Economy and Society*, London: Methuen and Co.,1961 (1934), p. 374.

23. G. KAVLI, *Norwegian Architecture Past and Present*, Oslo: Dreyfers Forlay, 1958, p. 26.

24. G. KAVLI, *Norwegian Architecture Past and Present*, Oslo: Dreyfers Forlay, 1958, p. 23.

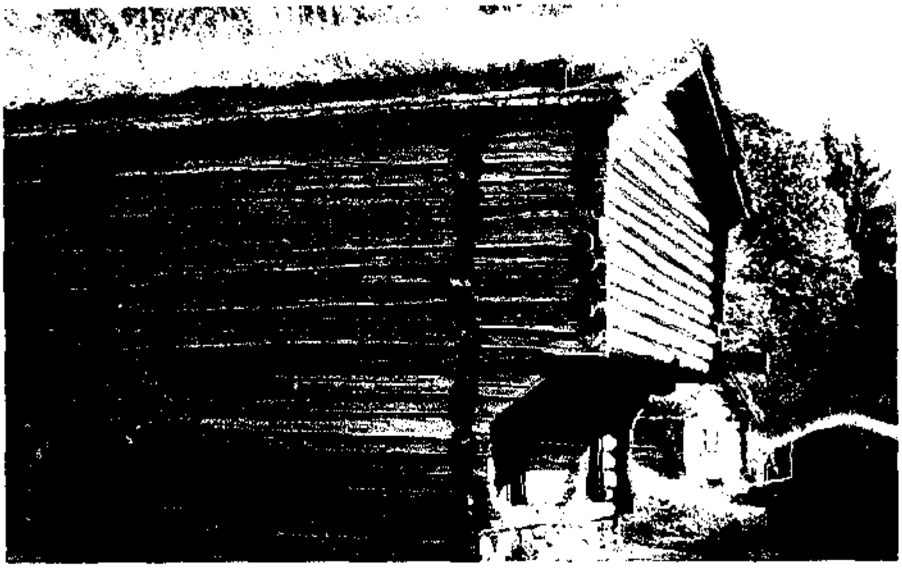


Fig. 7

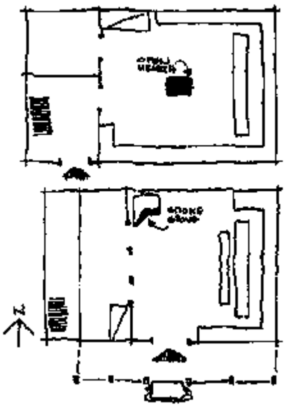
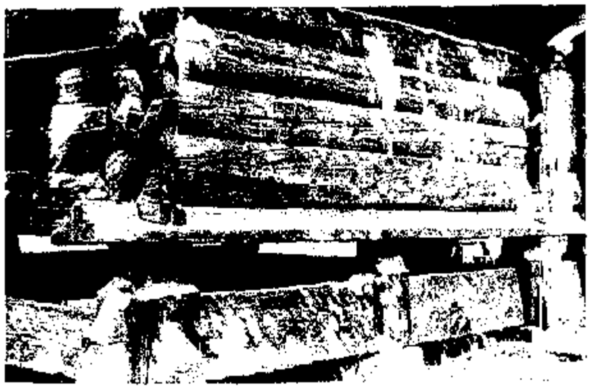


Fig. 8 (After Kavli, G., 1958, p. 27).



used in this chinking process, together with the color of the wood itself, have a rather large absorptivity which is of great help in receiving and absorbing the incident radiation.

At first, heating was done by an elevated open hearth.[25] In the 12th Century a different heating system was introduced.[26] The "smoke stove", a closed box of stone, independent of the main structure, was placed in the north corner of the dividing wall of the small rooms of the tripartite plan.(See Fig.9). This way a lot of heat could be stored in the stone and could be radiated at night to keep a comfortable temperature. It had no chimney. It was not until about 1500 that the regular chimney was introduced in the Scandinavian peninsula.[27]

Elevated store houses(See Fig. 10) were used as sleeping quarters in summer months.[28] Later, this form was partially adapted as the regular construction for a complete dwelling unit, especially in areas where more precipitation occurred--mainly to prevent moisture from penetrating up from the ground. Its drawbacks--cold winds under the floors--are obvious therefore, subsequently, as they progressed to two story dwellings, they built the first story walls with stone. (See Fig. 11).

Built Dwelling/Hot-Arid

The predominant house type in hot-arid regions is one made of mud. Different variations of it various reinforcements can

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[25] J. LLOYD, The Norwegian Laftehus, in P. Oliver(ed.), *Shelter and Society*, New York: Praeger, 1969, p.39.

[26] G. KAVLI, *Norwegian Architecture Past and Present*, Oslo: Dreyfers Forlay, 1958, p. 27.

[27] J. LLOYD, The Norwegian Laftehus, in P. Oliver(ed.), *Shelter and Society*, Praeger, 1969, p. 44.

[28] G. KAVLI, *Norwegian Architecture Past and Present*, Oslo: Dreyfers Forlay, 1958, p. 28.

Fig. 9

Fig. 10

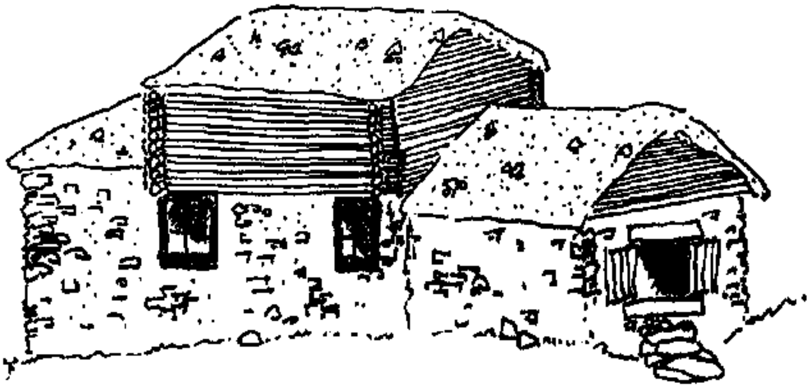

Fig. 11 (Adapted from Alneas, E., *et al.*,1950, p. 96).

still be seen in use today. The beginning of this type of construction obviously preceded a developed civilization. From archeological evidence we see that the initial introduction of rectangular brick houses, which were to follow the wattle and daub huts,[29] was made around 4000 B.C. in Mesopotamia.[30] Progress continued with great adobe structures, adobe brick making, sun-dried bricks, oven-baked bricks, dry-wall stone masonry, and stone and adobe wall construction. These types of material in these particular regions seem to be the natural response to conditions of specific environmental factors. There are exceptions, of course, like the aborigines of Australia, as mentioned earlier, and the Yuma Indians of south-west America.[31]

Stone, despite its favorable thermophysical properties of arid lands, was rather late to appear as a material. But its development was rapid, and the consequences were rather unusual forms that enclosed lofty spaces which provided comfortable conditions against the thermal stresses of summer particularly. "Beehive" houses of Harran, Turkey(See Fig. 12) are not only suitable for summer conditions but quite resistant to diurnal and seasonal changes in temperatures. "Trulli", a peasant house in southern Apulia in Italy, where the intensity of summer sun is as great as in arid zones, has a very similar conic cupola built of annular layers of stone. Rudofsky points out the fact that this is an archaic form of an early megalithic period, dating back to 2000 B.C.[32]

Still, the most commonly used type of built dwelling in these regions is one of mud and straw combination, baked in the sun. The high heat capacity of this material, with extended time-lag, provides the most suitable living conditions under the existing environmental factors. The heat stored in the heavy walls during the day radiates itself at night when, due to the high fluctuations in the diurnal sinusoidal cycle, the air temperature is lower. To minimize the effect of solar radiation all the openings are small.

The material used in the walls is generally wet earth with sufficient clay content for impermeability, sometimes mixed with straw(for reinforcement). There is no standard size adobe; they may vary from 25 by 25 by 10 cm to 25 by 50 by 10 cm. Mortar of mud is used for cohesion and sealing. Then, both

Fig. 12

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29. G.F. CARTER, *Man and the Life*, New York: Holt, Rinehart and Winston, 1968 (1964), p. 84.

30. E.A.W. BUDGE, *Babylonian Life and History*, London: The Religious Tract Society, 1925(1884).

31. G.F. CARTER, *Man and the Life*, New York: Holt, Rinehart and Winston, 1968, (1964), p. 91.

32. B. RUDOFSKY, *Architecture Without Architects*, Garden City, N.Y.: Doubleday and Co., 1964, no. 49.

inside and outside are plastered with daub and straw. Thus, the thickness of a wall may vary from 30 cm to 100 cm depending on the load it is going to carry. Different specimens of masonry have been used depending on the availability of local materials. This extends to not using mortar for cohesion purposes but instead using small stones to fill the intervals between the beds of stone used for masonry.[33]

Roofs are usually built on closely set poles resting on the load bearing walls. A layer of thatch is topped with a thick layer of tamped earth mixed with pulverized clay. Since roofs are used for various activities during the day, as well as for sleeping purposes at night in certain instances, they are flat. Deficiency in ventilation is a problem. This may not have been a poor design choice, considering the other benefits they received with small openings. Also, most of the daily activities take place outdoors. This is certainly true for the Middle-Eastern people.

The humble crofts of the Middle East minimize the exposed surface areas by building one croft adjacent to other crofts. (See Fig. 13). Generally, the first floors are used for sheltering the animals. This has its advantage in the cold winter periods, since the heat produced by the animals provides an extra source of heating for the living and sleeping quarters. Normally, a light gray color, outside surfaces sometimes are white-washed to increase the reflection of the incident radiation which is very strong in the summer time.

The striking edifices of the south-west American Indians(See Fig. 14), a compact geometrical form which minimizes the exposed surfaces with the maximum volumetric spaces, are sensible solutions which adapt to the environment and provide the space needed for socio-cultural influences. Striking similarities in the buildings and their arrangements in two different cultures--that of Indians in Taos, N.M. of SW America and of the Turkish settlements in Mardin and Birecik of SE Turkey-- can be seen in Figures 15 and 16. Climatic characteristics of both places are very much alike. Their rather accurately designed and expandable clusters are almost always open to the south or southeast, in order to maximize the energy received which is the heavy walls stored and received when it is needed.

Fig. 13

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[33] L.H. MORGAN, *Houses and House-Life of the American Aborigines*, Chicago: Un. of Chicago, 1965 (1881), p. 173.

Fig. 14

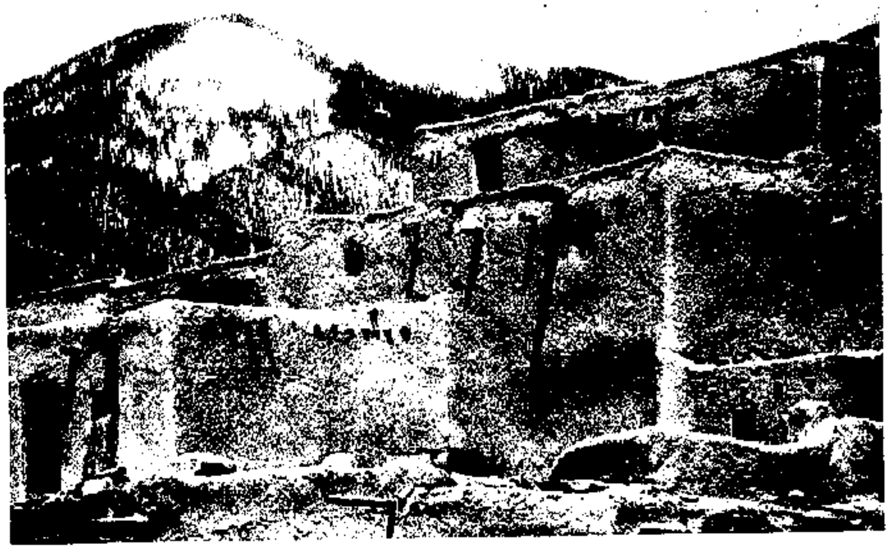

Fig. 15

Fig. 16

Although great similarities exist in people's responses to environmental factors under the same conditions, individual differences and cultural divergences help shape the variable forms within a context of sensible solutions. "It is necessary to distinguish negative conditions that are limiting factors at all stages of culture, and which demand special efforts and unusual costs if they are to be overcome(such are, for instance difficulties of terrain, climatic restrictions on particular plants and animals), from those which acquire positive significance only in connection with specific cultural achievements."[34]

ANALYSIS

For the given environmental conditions and the thermophysical properties of the materials used in the construction of the building under consideration, and with the inference from the values obtained from decrement factors, we are now able to calculate theoretical indoor temperatures. This, of course, excludes the factor of an artificial heating system in the building, and also excludes the heat produced by the inhabitants of the building.

The difference between maxima and minima of external and internal temperatures is important in the selection of the material to be used. The difference between maximum external temperature and indoor temperature is a major factor to be considered, especially in hot-arid regions where there is a noticeable diurnal difference in temperature from day to night. Nevertheless, the difference between indoor minimum and outdoor air temperatures is an important parameter in humid regions with warm and still nights. This parameter becomes especially significant for the coastal regions where daytime conditions, in contrast to the nights, are windy and of moderate temperatures.

The analysis and results are presented in tables and graphs. The thermophysical properties of materials mentioned in section two are summarized in TABLE IV. Diurnal temperature fluctuations of outdoor and indoor air, of external and internal surfaces for adobe and timber-log constructions for hot-arid and marine-cool regions, respectively are shown in Figure 17. For these

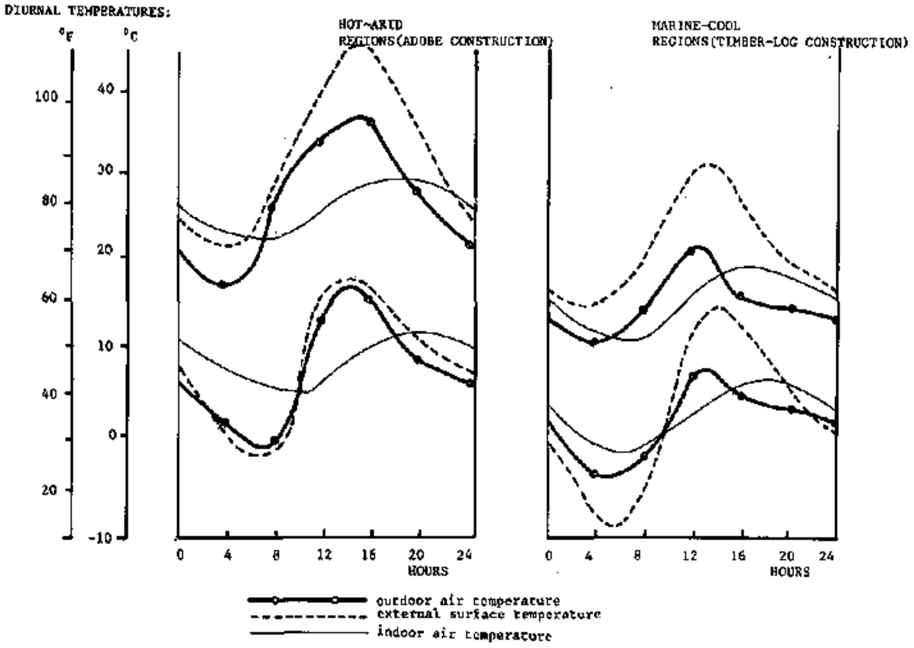

Fig. 17

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[34] C.D. FORDE, *Habitat, Economy and Society*, London: Methuen and Co.,1961 (1934), p. 463.

calculations, an average of 40 cm wall thickness for adobe construction, and 20 cm for timber-log construction was assumed.

The heat required to raise winter indoor temperatures to a comfortable level of 20°C was calculated for the two different zones. An average of 5 by 6 by 3 m room size for the hot-arid regions and 8 by 10 by 3 m room size for the marine-cool regions were assumed. Heat loss due to imperfections, especially in timber-log constructions, is included in these calculations. Two different materials commonly used at present required to raise the winter temperatures to 20°C under the same environmental influences. These are summarized in TABLE VI. TABLE V shows the observed readings of temperatures and relative humidities taken at different times and at different locations.

Table VI Energy Expenditure for Heating.

			Hourly Heat Required to raise the Temperature to 20°C (kcal/h)	
	Thickness (cm)	Conductance ($kcal/m^2h^0C$)	HOT-ARID REGIONS	MARINE-COOL REGIONS
ADOBE	40	1.00	2438	
TIMBER	20	.71		5608
BRICK	22	1.96	2768	6898
CONCRETE	20	2.85	4268	12028

YÖRESEL MİMARLIK VE ÇEVRESEL ETKİ: ÇÖZÜMSEL VE KARŞILAŞTIRMALI BİR ÇALIŞMA

ÖZET

Yerleşmeleri, hatta barınak ya da konutları çevresel dizgenin bir altdizgesi olarak onayan bir varsayım sonucu tek tek yapılardaki enerji dengesini çözümleyebiliriz. Bu çalışma, genel "enerji-bütçesi" denklemini ($I_n = LE + H + G$) oluşturan veriler içinde yapı gereçlerinin ısı biriktirme/saklama yeteneklerini (G), ve yöresel mimarlıkta bu enerjiyi kullanma ve yararlanmada ki evrimi, değişik iklimsel özellikleri olan iki bölgeyi örnek alarak, ortaya koymayı amaç edinmiştir. Değişik toplum ve kültürlerin yöresel mimarlıklarını karşılaştırarak, çevresel etmenlerine,konutların oluşumunda ve evrimindeki etkililiğini incelerken seçilen değişik iki iklim bölgesi, kuru-sıcak ve nemli-serin bölgelerdir. Yöresel mimarlıktaki evrime yalnızca çevresel-gerekircilik (environmental determinism) anlayışı ile yaklaşmaktaki sakınca ve eksiklik, karmaşık olan insan-çevre ilişkilerini, karşılıklı süregiden etki ve tepkileri, yalnızca mekanik bir düzeyde ele almak olur ki, bu da gerek çevrenin gerekse de insanın doğasına karşıdır. Bunun yanı sıra salt soyut

düzeyde bir takım değerlerin ve yargıların tasarım sürecine etken olmasının olumsuz ve yıpratıcı sonuçları özellikle günümüzde belirgindir. İnsan-doğa ilişkisinin daha iyi anlaşılması ve toplumsal-kültürel gereksinmeler ile uyumlu yürümesi, insan yapılarına bugünkünden daha olumlu ve gerçek bir anlam kazandırabilir. İncelenen değişik iki iklim bölgesinde yöresel veriler ve gereçler değerlendirilerek, birey yapılar için enerji dengesinin karşılaştırmalı bir çözümlemesi yapılmıştır.

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