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### Evaluation of the physical environment in Anatolian rural architecture

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#### Abstract

Anatolia, with its multicultural background and unique geography, is "the cradle" of many civilizations. It enables a variety of architectural design practices, due to diverse climate conditions from one region to another. Recently, a great intention is to generate architectural forms which provides health and comfort, less energy and harmony with human in the rural areas of Anatolia. There is a need to explore the properties of climate, material and building technology used in the traditional rural architecture in order to adapt into new architectural system. The identification of how physical environmental characteristics change in accordance with different climate regions and how traditional architecture aligned with the existing physical environment are specially important for the development of a method in this context. This study aims to resolve the characteristics of traditional architecture for the reassessment of rural area. Balıkesir is one of the provinces having a physical environment that can be utilized with the diversity of climate. In this study, therefore, Balıkesir is taken into account as it holds three types of climate. Different types of country houses in Balıkesir region are selected, modelled in 3D and analysed in terms of physical environment in regard to their own climate conditions. A comparison is also made between the obtained values of different climate regions. The results show that traditional rural architecture has many traits and features, that hardly found in today's contemporary residences.



#### Keywords

Anatolia, Environmental parameters, Rural architecture, Traditional architecture, Villages houses.



#### 1. Introduction

Rural areas are extremely rich in structural design. The structures in these areas make use of many elements, from belief systems to lifestyle preferences, from the climate data of the specific geography to the usage of traditional materials. Rural structures become integrated with the social and physical environment. Some architectural features embedded in rural structures carry great potential for improving today's standards in terms of the human, physical environment and comfort relation. In modern buildings, by the help of new materials, new technologies and new construction methods, many of the features of vernacular architectures can seem out of date. Nowadays, energy efficiency is an important area of concern so, studying vernacular architecture has still something new to explore. Especially solar passive features in the vernacular buildings are very difficult to quantify scientifically. However, by the help of thermal performance study, comfort temperatures evaluation etc., it is possible to calculate and explain the various solar passive features of the vernacular architecture that persist in different climatic regions. All over these specifications, the building sustainability aspects; such as economical, social and environmental, are also truly satisfied in the vernacular architectures (Singh, Mahapatra, & Atreya, 2011).

The vernacular environment is formed by the heritage as art, literature and music of its point of time. The loss of vernacular forms is not only a cultural loss, but also has an adverse and often irreversible effect on the way of life of the society concerned. When societies want to preserve parts of the vernacular environment and adapt them to conform to the more positive aspects of modern life, the "museum" result is not the best way to do it. To preserve the values of the community and upgrade facilities to comply with modern standards must be the chosen solution. The loss of cultural specific architectural forms and landscape has been substituted by modern planners and designers. They create objects which have began to dominate the open spaces and roads of modern

urban developments. This is a characteristic of the modern tradition and especially the deterioration and virtual disappearance of the public domain (Curran, 1983; Eben Saleh, 2000).

The natural harmony with climate, built form and people is the strength of vernacular architecture. However, the modern practice in architecture lacks conscious effort in using passive methods of controlling the indoor environment (Wang & Liu, 2002) (Cantin et al., 2010; Zhai & Previtali, 2010). Excessive use of modern materials irrespective of their efficiency at indoor environment has often resulted in high energy consumption, leading to many ecological and environmental problems (Kim, 2006). Also, energy intensive solutions are required in such buildings to attain comfort conditions in terms of cooling and ventilation (Dili, Naseer, & Varghese, 2010).

Although the living conditions of vernacular houses were poor in the past, the attempt to improve these conditions has led to the use of materials, which in fact produce an inferior building quality. Therefore, unfortunately, looking back on the last 30-year period in Anatolia, it is seen that the settlement pattern in rural areas has deteriorated because of actual structuring against the culture of the region, without considering local architectural features and the needs of local people. In trying to improve comfort, people were led to construct buildings which were not compatible with the contemporary buildings and which deteriorated the architectural texture (Vural, Vural, Engin, & Reşat Sümerkan, 2007).

The spread of urban living has a negative influence on the rural environment and therefore on rural housing. Today, the texture of rural settlements, the rich art and culture of rural structures are threatened by over consumption and mass production, products of modernity. The aim of this study is not only to evaluate the traditional architecture in relation to the physical environment but also to recognize and conserve those characteristics that are unique to the architecture of rural area, Balıkesir, exposed to three different climates.

The research focuses on the identifi-

cation of how physical environmental characteristics response to different climate conditions and how traditional architecture is aligned with the existing physical environment. This is important in order to develop a method for the adaptation of physical environment so that future works can get use of it.

#### 2. Method

The Department of Architecture and the Department of Urban and Regional Planning in Mimar Sinan Fine Arts University carried out a Project in 2010, with the Ministry of Public Works and Settlement, for the protection of rural areas and re-creation of life in Balıkesir. Although the Project comprises village planning, user surveys and assessment of regional chracteristics in a borad sense (Çorapçıoğlu et al., 2010), this paper presents only a part of it.

The study was conducted in the region of Balikesir located in Northwestern Anatolia, both Marmara Region and Agean Region. Balikesir is one of the provinces having a physical environment that can be utilized with the diversity of climate.

According to the Turkish Standard of Thermal Isolation in Buildings (TS825) there are 4 types of climate regions in Turkey. Balıkesir is one of two provinces that contains three of these four climate conditions. Therefore, the research takes the advantage of Balıkesir holding three types of climate and the physical environmental values are calculated for specific villages chosen according to their climate conditions. Figure 1 shows the location of Balıkesir in Turkey, on a satellite image.



Figure 1. The location of the Balıkesir in Anatolia.

#### 2.1. Objects and scope of the study

The project called "Extensification of Housing Compatible with Regional Texture and Architectural Features in Rural Areas" was initiated by evaluating the villages in the Province of Balıkesir (Çorapçıoğlu et al., 2010). Then detailed field survey and analysis were carried out to select villages for further investigation. This paper comprehends the analysis of houses in the villages selected, in terms of "Building Physics and Materials". The aim is to create opportunities for some architectural modifications and restorations to respond to the needs of today's, by preserving the current value of the villages.

In the study, multi-dimensional situation analysis and assessment were implemented, surveys with the villagers were performed, the village houses containing original and characteristic features were identified, measured and their plans were drawn.

In the scope of the study, a modeling and evaluation works took place in order for the technical analysis of the houses and all data were gathered in an evaluation chart. All technical analyses were performed under similar conditions. Typical meteorological year data in accordance with climate changes in the region were used.

The analyses in this study are concerned with the determination of the original values of village houses and the relations with climate changes. Correspondingly, the study is interested in the determination of the factors that form the basis for the protection orders and also architectural decisions for the new structures in the villages.

#### 2.2. Climate of Balıkesir

In Turkish Standard of Thermal Isolation in Buildings (TS825), in Turkey, there are four types of climate regions that characterized as degree-day regions. Balıkesir is in the second degree-day region. However, since the city of Balıkesir is spreaded to three climatic region, it is accepted that the Marmara coast is at the third degree-day region and the Aegean side of the city is at the first degree-day region as shown in Figure 2 (Turkish Standard, 2008b) (Çorapçıoğlu et al., 2010). The northern side of the city, parallel to the Marmara Coast, is under the influence of the Marmara climate type, which is mild and humid. Continental climate prevails in the city center and surroundings, which makes it mild and dry. The towns in the Aegean part of the city fall under a climate that is warm and humid.

In the field measurements, as a first step, all the villages and houses in Balıkesir region were visited to define most typical ones, which is valuable for further study Then, 13 villages in three different climate zones and totally 62 houses were confirmed to be considered in the study. All the data were collected by measuring the physical environmental characteristics of daylight, thermal comfort and energy use. In modeling the houses in 3D, Ecotect, sustainable design program was used as it enables the users to analyze the required environmental parameters.

The regions of Balıkesir were evaluated in regard to their average temperature. As it is seen in Table 1a, Region 1 (Aegean side) has the highest temperatures and Region 2 (Continental Climate) has the lowest throughout the year.



Figure 2. Three climate types prevailing in Balikesir.

*Table 1.* Meteorological characteristics and annual heating and cooling degree-hour values for three climate regions in Balikesir.



ITU A|Z • Vol 13 No 3 • November 2016 • Ü. Arpacıoğlu



Figure 3. Kireç Village: one of the rural settlement characteristics.



*Figure 4.* An example of functional analysis for one the selected villages.



*Figure 5.* An example of material analysis for one of the selected villages.

Average relative humidity values as given in Table 1b, by month are measured at 09.00 a.m. for the three regions of Balıkesir. In the comparison of three climate regions in terms of heating degree-hours, it is seen that the prevailing continental climate in Region 2 requires more heating load than the other regions. Region 1, on the other hand, is dominated by the Aegean climate type and the need for heating is the least in this area. Table 1c shows the annual heating degree-hour values for three climate regions. The values in Figure 3d show that, due to its warm and humid climate, the cooling load on Region 1 is much more than the other regions.

In hot-humid regions where the marine climate prevails, a fairly insulated building envelope will work. In order to lessen the effect of discomfort caused by high temperature and humidity, the indoors should be cross ventilated through at least two windows to the outdoor air reciprocatively

#### 2.3. Case study description

Province of Balıkesir is very rich in the types of Anatolian rural architectural styles. In the context of this study, 13 villages were defined to specify the architectural examples in three different climate and totally 62 houses in these villages were analyzed. Figure 3 shows one of those villages called "Kireç" in "Dursunbey" located in the east part of Balıkesir.

Each village is identified by landscape and texture and also structural, material and functional analyses were carried out for each of them. Figure 4 shows the functional analysis of one of the villages and Figure 5 describes the material analysis of the village.

Furthermore, houses in the villages were investigated. As an example, two houses, with their plans and views, presented in Figure 6.

In the analysis of 62 houses, a regional typological distribution was fulfilled as shown in Figure 7. Plan typologies were formed and conceptual



Figure 6. Example of village houses analyzed (Çorapçıoğlu et al., 2010).

formation of new buildings were made. The survey carried out in the rural areas of the Balıkesir, shows that almost all houses have rooms connected with halls. However, the connection forms, hall shapes and location varies. Halls can be open to the outside or closed, located to the front, side or interior, in T-shapes, L-shapes or I-shapes, according to the planning of the houses and needs (Çorapçıoğlu et al., 2010) (Çorapçıoğlu K. Aysel N., Görgülü C., Kolbay D., Seçkin P., Ünsal E., 2008).

It is observed that "e" type plan mostly used in Region 2, where mild and dry climate prevails, "d" and "f" type plan mostly used in Region 3, where mild and humid climate prevails, "g" and "h" type plan mostly used in Region 1, where warm and humid climate prevails. Houses with "a", "b" or "c" plan type are seen in different climate regions.

The houses, located in different climate regions of Balıkesir, with different construction techniques and materials were also compared in terms of thermal comfort and conservation, daylight and energy use. Figure 8 shows four houses from different villages and built with different construction tech-



**Figure 7.** Plan Typologies: plan with hall (a) Without hall (b) Plan with hall front (c) Plan with hall shaped L (d) Plan with hall side (e) Plan with hall interior (f) Plan with hall shaped T(g) Plan with hall seperated (h) Plan with hall half (Çorapçıoğlu et al., 2010).

In order to evaluate the energy efficiencies of houses, energy quantities were calculated taking Into account the minimum and maximum indoor temperatures needed for comfort criteria of indoors in rural areas. It is assumed that when the temperatures fall below 18°C, the houses need to be heated and when the temperatures rise above 26°C



Figure 8. Vernacular house types in Balikesir.

the houses need to be cooled, between the hours of 07:00 and 24:00 in the day.

### 3. Evaluation of structural differences resulting from material conditions

In addition to the socio-cultural setup, economy, material and technological availability, climate is also one of the main factors that greatly influence building architecture and its sustainability. Since climate varies from place to place, favorable architectural solutions for the built environment are also region specific which reflects their needs and socio-cultural values of the region people (Engin, Vural, Vural, & Sumerkan, 2007). The buildings that are constructed using locally available materials show a greater respect for the existing environment and also take into account the constraints imposed by the climate. Vernacular architecture sets an example of harmony between dwellings, dwellers and the physical environment (Singh, Mahapatra, & Atreya, 2009).

It is a known fact that traditional rural architecture is shaped under the

**Table 2.** (a) Ratio of material usage for constructing walls in Balıkesir, (b) Average wall thickness of Balıkesir's climate regions, according to material used in construction (c) Average aspect ratio of facades for three climate regions of Balıkesir (d) Average aspect ratios of facades according to the wall material for three climate regions of Balıkesir.



Evaluation of the physical environment in Anatolian rural architecture

influence of environmental factors and material resources. This study illustrates the changes in the design-environment relationship and in structural details of the space, resulting from differences in climate conditions.

Walls may be the most important structural element for village houses in rural areas. The wall material and technology is not only an indicator of the construction's identity but also an important factor affecting the indoor environmental quality. Research indicates that three different wall materials are being used in three regions of Balıkesir. Stone is usually used in masonry walls as load bearing material, whereas bricks are most frequently used as filling material. Adobe is used for both masonry construction and noggin. Adobe materials feature two advantages: they are permeable to water vapor and their mechanical behavior is similar to that of earthen walls, which makes them more compatible with earthen walls than cement based coatings, which are waterproof and overly stiff (Lanas & Alvarez-Galindo, 2003). The mechanical compatibility can be estimated based on the difference between Young's moduli of the wall and plaster (Hamard, Morel, Salgado, Marcom, & Meunier, 2013).

Bricks and adobe as filling have been found in wooden constructions. However, in today's measures for some physical environment values, a space that is surrounded with this type of filling materials is quite inadequate. This is the main reason for the difference in the estimated physical environment values of walls made with different construction techniques.

The results of the analysis of houses in three climate regions in Balıkesir show that Region 1 stands out with almost equal usage of stone and adobe. More frequent usage of stone material in Region 2 may be attributed to the mountainous terrains in the area. Region 3 has various structures. It is seen that brick is used in this region as packing material within a wooden carrier system. Table 2a gives the ratios of preferred construction techniques owing to available material.

The average wall thickness of stone and adobe material is quite similar to each other in Region 1, while there is a big difference in Region 2 and Region 3. This difference results from the use of different techniques. In Region 1, mainly masonry wall material is used while in Regions 2 and 3 both masonry and noggin (studwork) materials used. Table 2b illustrates the relationship between average wall thickness and materials used for constructing walls, for three regions.

In Region 2 and Region 3, the facade aspect ratios of village houses that are made of stone and adobe are close to each other. Lower aspect ratios for Region 1 may be attributed to changes in construction techniques due to the region's hot and humid climate. Average aspect ratio of facades for three climate regions are shown in Table 2c and the differences in aspect ratios according to construction techniques and climate regions are shown in Table 2d.

### 4. Evaluating the effects of physical environment to the space in traditional architecture

Vernacular architecture is shaped by locally available materials in a functional style devised to meet the needs of common people in their time and place. Most of the vernacular architecture responds to the regional climate and these structures were modified and evolved over time through feedback mechanisms that already exist in the system, to reflect the environmental, cultural and historical context in which they exist (Albatici, 2009) (Lau, Lam, & Yang, 2007). The vernacular building construction techniques and specifications are more based on



*Figure 9.* An example of three-dimensional model of a village house.



*Figure 10.* An example daylight analysis in radiance by ecotect software.

knowledge achieved by trial and error rather than conventional practices and these techniques are more often transferred by traditions and handed down through the generations (Rakoto-Joseph, Garde, David, Adelard, & Randriamanantany, 2009). These solutions represent the perfect balance between economic, cultural, social needs, natural built environment and limited technical resources (Zhai & Previtali, 2010) (Dili, Naseer, & Zacharia Varghese, 2010) (Tassiopoulou, Grindley, & Probert, 1996).

In the physical environmental analysis the houses were modeled in 3D by using a software of Ecotect. Thus, it became possible to make evaluations and comparisons between the houses. Figure 9 shows three-dimensional model of a village house produced for the analysis of physical environment.

The villages and the corresponding climate types included in this study are as follows: Region 1 (warm and humid Aegean Climate): Küçükdere, Kuyucak, Tarlabaşı villages; Region 2 (mild and dry Continental Climate): Akçaköy, Dereli, Kireç, Mahmudiye, Örenli, Saraç villages; Region 3 (mild and humid Marmara Climate) Babayaka, Emre, Pehlivanhoca, Turan villag-

*Table 3.* Illuminance levels accepted by the IES (Illuminating Engineering Society) for residential buildings (IES 1968) (Tzempelikos 2005).

house	lux
Living spaces	100
Study room	400
Bedroom	50
Kitchen	200

es. The village houses in three regions were analyzed in terms of daylight, thermal protection and comfort and energy usage.

#### 4.1. Daylight utilization

The study aimed to define the spatial and visual comfort values for the village houses. The objective is to see if there is any change in the visual comfort values in those spaces where technologies of construction and material have been affected by climate factors.

#### 4.1.1. Daylight analysis

As a result of the studies in each of the three regions, the average and extreme daylight illuminance level values of first and third regions are found to be very close to each other. Also the values of the second region can be considered close to them. In the first climate region, the maximum and minimum daily daylight illuminance level values were found to be 383 and 93 Lux, and average 203.7 Lux. In the second climate region, the maximum and minimum daily daylight illuminance level values were found to be 334 and 68 Lux, and average 196 Lux. In the third climate region, the maximum and minimum daily daylight illuminance level values were found to be 381 and 93 Lux, and average 204.6 Lux. The overall average of all three regions were found to be 202.2 Lux, as a result of calculations made for village houses from 13 villages of rural Balıkesir, using Radiance software under CIE standard overcast sky. Table 3 shows the illuminance level of IES for residential buildings.

The value found is above the required levels given in Table 3, for the visual comfort of spaces. An example from the Daylight Illuminance Level analyses is shown in Figure 015.

As it is seen in the Figure 10 that aspect ratios of houses analyzed in Balıkesir rural areas haven't changed so much. At each of the three climate regions, in living areas, maximum daylight levels are around 350 lux, and minimum daylight levels are around 100 lux. These levels are appropriate for living rooms, according to illumination level accepted by Illuminating Engineering Society.

Evaluation of the physical environment in Anatolian rural architecture

**Table 4.** (a) Average illuminance levels for the villages with three climate regions of balkesir, (b) Average values of illuminance level for three climate regions of Balkesir (c) Illumination levels of village houses in three climate regions of Balkesir, according to wall construction material.



*Table 5.* Maximum Overall Heat Transfer Coefficient (U) values for walls, defined by TS825 according to climate regions(10).

Overall Heat Transfer Coefficient (U) [W/m²K]	TS825 Climate region 1	TS825 Climate region 2	TS825 Climate region 3	TS825 Climate region 4
Opaque surface	0,7	0,6	0,5	0,4
Transparent surface	2,8	2,6	2,6	2,4

Table 4a and Table 4b illustrate average daylight illuminance levels for villages in regard to climate regions. The average daylight illuminance level for all 13 villages exceed the limit values set forth for residential buildings.

# 4.1.2. Dependent structural differences in terms of material use daylight

The distribution of illumination levels according to wall material and construction technology is shown in Table 4c. It is seen that average illumination levels are quite close to each other. The illumination levels in all regions for all construction techniques are within the limit values.

#### 4.2. Thermal protection and comfort

The village houses were also evaluated for the spatial thermal comfort. The purpose is to see how materials and construction technology differentiation associated with climate affects thermal comfort.

**Table 6.** (a) Average wall overall heat transfer coefficients (U) for the villages with three climate regions of Balıkesir, (b) Average values of wall overall heat transfer coefficient for three climate regions of Balıkesir (c) The overall heat transfer coefficients for walls of Balıkesir village houses, according to climate regions and material used in wall construction.



### 4.2.1. An investigation of thermal conservation of village houses

The "Thermal Protection Factor" of a space is evaluated according to the Overall Heat Transfer Coefficient (U) of walls, ceilings, floors and glazing. Thermal transmission value is one of the variables that directly influence the extent of thermal loss and gain. The limit values for Overall Heat Transfer Coefficient defined by TS825 are demonstrated in Table 5 (Turkish Standard, 2008b).

As Balıkesir is in the second climate zone, "U" value (The Overall Heat Transfer Coefficient) defined for new buildings in this area is 0,6 (10). The results of U values calculated for 13 villages of Balıkesir and average U values of climate regions are displayed in Table 6a and Table 6b. The average Overall Heat Transfer Coefficient calculated for walls of traditional buildings in rural Balıkesir is 1.20 W/m<sup>2</sup>K.

It is seen that Region 1, where a

warm humid Aegean climate prevails, has the lowest values of "U" value. Maximum and minimum U values in this region, are around 1.25 W/m<sup>2</sup>K and 0.7 W/m<sup>2</sup>K. In terms of U values, Region 2 where mild dry continental climate prevails, is close to Region 1. In this region, maximum and minimum U values were calculated as around 1.5 W/m<sup>2</sup>K and 0.75 W/m<sup>2</sup>K. The highest values of thermal conductivity were calculated in Region 3, where a mild humid Marmara climate prevails. Maximum and minimum U values in this region, are around 2.5 W/m<sup>2</sup>K and  $0.8 \text{ W/m}^2\text{K}$ .

## 4.2.2. Structural differences dependent materials and thermal conservation

The intention was to determine the changes in the thermal performances of house walls, in relation with climate and wall types. Therefore, the wall details of each house were tested for the

Evaluation of the physical environment in Anatolian rural architecture

**Table 7.** (*a*) Average values of thermal decrement factor for walls of Balikesir village houses according to climate regions and material used in wall construction. (b) Average values for the time lag factor in the specified village houses of Balikesir, according to climate regions and wall material.

6,8



(a) Average values of thermal decrement factor for walls of Balıkesir village houses according to climate regions and material used in wall construction



Time Lag Factor (hours)

8.6

Thermal Conductivity Factor. The results were calculated taking into consideration the material and the details of walls. Table 6c illustrates the impact of construction technique, based on climate and material, on The Overall Heat Transmission coefficients (U) for Walls values.

An evaluation of the Overall Heat Transfer Coefficients indicates that, none of the techniques in any region of Balıkesir meet the standard thermal values defined for today's spaces. Adobe materials have higher thermal conductivity values when compared to stone. This is the result of two construction preferences present in Balıkesir; one is the frequent use of adobe as noggin (studwork) material, the other is constructing thinner walls with adobe when compared to stone.

Table 7a illustrates a comparison between regions and materials in terms of the thermal decrement factor. Region 1 and Region 2 are relatively superior to Region 3 regarding the thermal decrement factor. In Region 1 and Region 2, the thermal decrement factors ranges between 25 % and 15 %. But in Region 3, the thermal decrement factors determined were in the range of 11% and 0 3%.

In rural architecture, one of the factors affecting the comfort is time lag factor of spaces. The houses are analyzed for this factor by using the Autodesk thermal response factor methodology and software ("Thermal: Analysis Methods," 2014).

(b) Average values for the time lag factor in the specified village houses of Balıkesir, according to climate regions and wall material)



*Figure 11. Psychometric graph of the Percentage of Dissatisfied People, as seen in the interface of "Predicted Mean Vote" software.* 



Figure 12. An example comfort analyses for each village house.

The comparison of time lag factors between regions in relation to materials is shown in Figure 21. A time lag factor of 8 to 10 hours is found to have a positive influence on the comfort level of the space: However, time lags down to 6 hours remain acceptable for



**Table 8.** (a) Average spatial PPD values for the villages with three climate regions of Balikesir,(b) Average spatial PPD values for three climate regions of Balikesir.

*Table 9.* (*a*) Average heating load values for the villages with three climate regions of Balıkesir, (*b*) Average heating load values for three climate regions of Balıkesir.





*Figure 13.* An example output from energy software demonstrating analysis results on heating and cooling load for each village.

rural areas (Eichler, 1968).

It is seen in the Table 7b that Region 2, where mild dry continental climate prevails, has the highest values for thermal time lag factors. Maximum and minimum time lag values in this region are around 11 hours and 5 hours. Region 3, having a mild humid Marmara climate has the lowest thermal conductivity values. In this region, maximum and minimum time lag values are around 9 hours and 2 hours. In Region 1 where a hot humid Aegean climate prevails maximum and minimum time lag values are about 10 hours and 4 hours.

#### 4.2.3. Thermal comfort

The village houses were also analyzed for thermal comfort and "Predicted Percentage of Dissatisfied People" (PPD) values were defined. PPD is a model for evaluating thermal comfort, approved by ISO 7730 Standards. If it is not satisfied by the space, then PPD is accepted as 100%. Full satisfaction is defined by a PPD value of 5% (ISO7730, 2005).

The "Predicted Mean Vote" software was used for calculating PPD values. Comfort values were calculated using the data collected between the hours of 2 and 3 pm, during the hottest day of the year and also using data available for the specific region. For the hottest day of the year, the comfort values were accepted as 0.50 m/ (mild breeze) for indoor air flux, and 0.6 for clothing level ("Human Comfort, Predicted



Table 10. (a) Average cooling load values for the villages with three climate regions of Balikesir, (b) Average cooling load values for three climate regions of Balikesir.

Mean Vote," 2014).

Considering the sample village houses, the average Percentage of Dissatisfied People for whole region of Balıkesir, is % 28.2. Figure 10 shows the psychometric graphic and calculations of the dissatisfaction ratio, computed at the "Predicted Mean Vote" software, and according to ISO7730 Standards, Table 8a and Table 8b shows distribution of the average spatial PPD values, for villages and climatic regions, and Figure 11 and Figure 12 shows an example of comfort analyses for each village house.

#### 4.3. Energy consumption

Energy consumption levels have been taken into account in accordance with "Code of Energy Performance in Buildings" in Turkey since 2008. TS825 defines the heating energy limit values for Turkey in relation with degree-day regions (Turkish Standard, 2008a, 2008b).

#### 4.3.1. Energy usage analysis results

Thermal gain and loss analyses of village houses were made by computer simulation techniques. It uses the CIBSE Admittance Method to calculate

In Region 2, annual average tem-Table 11. Average heating and cooling loads for village houses of Balikesir, according to climate region and wall material (a) Average heating loads (b) Average cooling loads.



ITU A Z • Vol 13 No 3 • November 2016 • Ü. Arpacıoğlu

heating and cooling loads for any number of zones within a model, based on the typical meteorological year ("Thermal: Analysis Methods," 2014). With the data gathered from these analyses, average values were determined for the villages, climate regions and for the whole of Balıkesir.

Figure 13 gives the values of Energy Consumption of each village house. The heating load for village houses was calculated separately for each month. The results were then added together to find an annual total heating load; according to which the final values and regional averages were organized and presented in Table 9a and Table 9b. The average heating load per unit area of all inventories in Balıkesir was found to be 58,9 kWh/m2. This value is above 50,3 kWh/m2, the limit value predefined for this region.

The monthly cooling load values were observed and collected; the calculated annual cooling load was thereby determined. The annual values for cooling load are demonstrated by the graph in Table 10. Average cooling load per unit area for Balıkesir is 4.25 kWh/ m2.

8 , 1 1 5								
	Region 1	Region 2	Region 3	Average	Required Standard Value			
Daylight Illuminance [Lux]	203,7	202,9	205,1	203,9	100-150			
Overall Heat Transmission Coefficient (U) [W/m2K]	1,0	1,2	1,5	1,2	0,6			
Thermal Decrement Factor [%]	20,8	22,2	7,9	17,0	-			
Time Lag Factor [hour]	6,5	7,7	5,2	6,5	6-8			
Thermal Comfort Factor [%]	75 7	0.1	22.0	25.0	20.20			

83.7

03

30.5

93

Heating Load [kWh/m<sup>2</sup>]

Cooling Energy [kWh/m<sup>2</sup>]

*Table 12.* Average physical environment values calculated for Balikesir village houses, in comparison to predefined standards.

perature is lower than other two regions. However, it has the highest altitude. Maximum and minimum heating loads, are found to be around 140 kWh/ m2 and 45 kWh/m2.

69,4

2.1

61.2

39

50.3

Also in this kind of climate region continental climate prevails, there are high temperature variations in the daily cycle. In these regions an attempt is normally made to take advantage of the great temperature variation during the day-night cycle, delaying the penetration of heat as far as possible so that it reaches the interior at night, when it is least bothersome. For this purpose such as clay in the form of adobe bricks or mud walls, thick stone and all the possible combinations of these solutions materials of great thermal inertia are used (Labaki & Kowaltowski, 1998).

In Region 1 (Aegean Region), the maximum and minimum heating loads are around 80 kWh/m2 and 10 kWh/m2. In Region 3, with a mild humid Marmara climate, maximum and minimum time lag values are calculated as 120 kWh/m2 and 40 kWh/m2. The variance of heating load values among the three climate regions of Balıkesir is %73. Table 10a and Table 10b presents cooling load values for the 13 villages under study, and averages cooling load values for climate regions.

In terms of cooling load, Region 1 was found to be the region with highest values. In this region, maximum and minimum cooling loads, are around 20 kWh/m2 and 5 kWh/m2. Cooling load values for the other two regions were close to zero, which means there's almost no cooling load. Variance of cooling load values among Balıkesir's three climate regions is thus 96%.

#### 4.3.2. Energy usage depending on the material terms of structural differences

The changes of average heating and cooling loads of the houses were analyzed, depending on climate regions and wall material.

In Table 11a, the relationship between construction techniques and heating loads is demonstrated for three climate regions. The results indicate that the heating load varies greatly in different regions, due to changes in climate conditions.

Table 11b illustrates the relationship between construction techniques and cooling loads for three climate regions. The situation is similar in terms of both heating and cooling loads. In Region 1 the cooling period is longer than other regions, due to having the highest yearly average temperatures among three regions. In Region 2 the cooling load is negligible because of continental climate.

Table 12 summarizes the results of physical environmental analysis in comparison with standard values. It is apparent that the local architectural culture already embraces many techniques and characteristics that can, after certain structural improvements on insulation, produce effective results for contemporary spaces. Figure 30 presents a characteristic rural settlement.

#### 5. Conclusion

In this work some part of the research project carried out in Balıkesir, Turkey is presented. The work is based on the analysis of the physical environment of the traditional architecture in rural area. The results of the research helps to produce a better judgment of traditional housing concerning compatibility to the environment, rate of usability in the modern life style and generate ideas for better adaptability for daily use.

It is seen that average values regarding daylight for three regions of Balıkesir are high and sufficient according to residential standards. it is also found that differences in climate, material or construction technique do not account for significant deviance in these numbers. That means that the conventional aspect ratios are preserved in the area,

39

Evaluation of the physical environment in Anatolian rural architecture

regardless of climate of technology factors. Minor variances in value between regions may be seen as a result of differences in construction techniques and in aspect ratios. The slight differences in values can be explained by the difference between aspect ratios; resulting from the material's various uses, as noggin (studwork) or as carrier.

In thermal analysis, it is clearly apparent that Region 1, where an Aegean climate prevails, has lowest values for thermal conductivity (U). This difference in thermal conductivity values may be associated with higher values in the thermal insulation factor; a result of building thicker walls for protecting indoor areas from the extreme temperature during summer days. The difference in (U) values between Region 2 and Region 3 is thought to be derived from differences in construction technology. Furthermore, it has been a critical observation that hot climate is an important determinant for locating a "building facade" at the planning stage; which indicates the existence of successful traditional precautions for improving comfort in summer days.

An evaluation of heat loss and gain results makes it possible to say that, for traditional architecture in rural areas, it appears that conduction is the most important cause of thermal loss. However, there is also a significant amount of heat loss due to ventilation and infiltration. These factors may be associated with weak insulation in windows, air leakages from the space, and spaces that connect directly to outdoor areas. When thermal gain is considered, the sun is a source of heat that is highly effective in this area. This proves it to be essential that a study of the positive and negative influences of solar heat be held before a new phase of construction in rural Balıkesir.

In Region 1, a comparison between materials used for making masonry walls shows an advantage of adobe against stone in terms of thermal conductivity. Higher values of thermal infiltration for brick material in Region 3 are a result of using bricks as noggin (studwork) material within wooden carrier systems. The reason that Region 1 and Region 2 are relatively superior to Region 3 regarding that the thermal decrement factor is the differences in construction techniques and materials in climate regions and varying average values of thermal conductivity and thermal mass. Regions 1 and 2 have average thermal decrement factor values of 20-25 %, which are able to meet today's requirements. However, the inventories in Region 3 fall below this standard.

Ideally, time lags down to 6 hours remain acceptable for rural areas. When the averages are calculated according to this value, it can be concluded that, in all types of climate, adobe material has a relatively positive influence on the quality and stability of interior space. It may also be said that this positive influence and stability is still relevant for houses in Region 3, where wall thickness is relatively less. Lower values of time lag for Region 3 may also be attributed to higher aspect ratios for facades, a natural result of using wooden carrier systems with noggin (studwork) walls.

In planning for future construction or for renovation of current structures in the rural areas, the comfort values calculated for Balikesir indicate that extra precautions would become necessary; that is, if the comfort values of Region 1 spaces are to be brought up to ideal levels without the help of mechanical cooling systems; especially for summer days. Meanwhile, no extra precautions seem necessary for spaces in Region 2. For Region 3, the need for any precaution must be determined individually for every designed space, after an extensive evaluation of the calculated comfort values. Analyses show that it is natural and possible that differences in climate can have a dramatic impact on comfort values of spaces, even among villages of the same city.

It is recommended to combine the structural details of village houses with today's contemporary structural details in order to reduce energy consumption to more reasonable levels. Specifically; if transparent surfaces, which usually come in the form of wooden window frames with single-layered glass, and other structural details that cause thermal loss are modernized properly, then it would be possible to attain physical environment and energy values that are more efficient and positive in terms of producing comfort in living.

The results indicate that the heating load varies greatly in different regions, due to changes in climate conditions and construction techniques. In the light of this data, the necessity to formally define the climate regions of Balıkesir is proven once again. Region 2 has lowest average temperature but highest heating degree-hour. The fact that adobe material is frequently used as infilling and that wall thicknesses are less in this region may account for the unexpectedly high values heating load on adobe.

The situation is not different in terms of cooling loads although wall thicknesses and aspect ratio of facades are similar in value; adobe material is found to cause more cooling load in comparison to stone material. The same significant difference is also found in the time lag factor. This condition may be explained by the nature of the material; the specific heat, that is, the heat capacity of stone material is higher than adobe material. When the thermal properties are examined for stone material, despite its unsuitable thermal conduction coefficient, the physical environment values are found to be similar with adobe material.

The study of physical environment values for traditional village houses in rural areas has produced significant results. Findings indicate that traditional rural architecture has many traits and features, that are hardly found in contemporary residences we live in today; especially those that improve the comfort value of the space. Turkey's rural architecture has developed unique techniques and methods, as a result of the influence of climate conditions. The results of this study also imply that if new structural details in the traditional rural architecture are to be added, they must be defined after a thorough study of the physical environment values. Careful consideration of these evaluations would support the conservation of architectural culture and identity, in the case of a new structures or renovations of the existing ones.

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