ISTANBUL TECHNICAL UNIVERSITY

ENERGY INSTITUTE

ENERGY EFFICIENT BUILDING DESIGN - EBT 530E

FINAL STUDY

EXAMINATION OF A TRADITIONAL WESTERN BLACK SEA HOUSE

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1) ABSTRACT

The present study is aimed to introduce a traditional Black Sea house in Zonguldak County from Turkey and examine it through considering all of factors which have various effects on this house. The house is located in Topallı Village, Ereğli district. Topography, availability of building materials, climatic conditions, agricultural works and all of other factors have been studied in detail general structure of Black Sea houses have been determined. Materials, structures, orientation and location had been specified for Black Sea houses.

The house is located in the hillside because of hilly natural structure of Black Sea region and has two floors that lower floor is used as a barn and top floor is living place. There is a garden in the back of the house which is oriented on slope and rear facade is facing south. The climate of village can be categorized under Oceanic Climate due to similarity about seasons and conditions. As in other traditional Black Sea houses, this building has two basic materials that are wood and stone. In the next chapters, general information about Black Sea houses, detailed introduction of selected house and detailed identification of House are examined.

A software was used for analysis of specified structure components. Analysis was performed for lightening (artificial & natural), U value of wall for different materials and polyurethane coating, heating and cooling and shade effects of components.

2) INTRODUCTION

The basic factors of traditional structure formation process are identified with several topics. Climatic condition, topography, availability of building materials, transport facilities, agricultural works and housing-dependent life can be specified as the basic factors. Structures are also shaped with culture, climatic benefits and need for natural sources. In midterm report, a traditional house from West Coast of Black Sea of Turkey is introduced and examined in terms of traditional structural features.

The fundamental structure materials of Anatolian architecture can be specified as wood, stone and adobe [1]. Therefore, Traditional Black Sea houses were built with this kind of structure elements. Climatic condition, topography and availability of building materials have a big influence on these structures. There are a lot of building materials and those materials are combined with wood with variable techniques which have appeared for hundred years. The original structural materials of this region are wood-stone and wood-adobe also some of houses were built only with timber [2].

a) <u>Structural Features</u>

Wood masonry system, wood carcass system and mixed system constitute the basic structure of the building. According to 3, Bartın houses which have same structure with Zonguldak Houses were built with wood carcass and the first floor of house was built by stone to prevent them from flood [3]. Wood carcass system can be effected from moist air because wood absorb moisture from air and can be deformed easily so, wood have to be exposed to air circulation to extract moisture. In order to providing air circulation, structures were built at a certain height above the natural ground. Mixed structure is another method to build a Wall. There is a wood carcass and spaces of carcass can be filled by structural materials. In literature, there a many techniques for build a wall of house and "Hımış" is the most common one [1]. This technique is about combining of timber and the other structural elements which are stone and adobe. Timbers are connected each other and create carcass in a horizontal or vertical way and spaces can be filled by structural elements. The example of "Hımış" can be seen in figure 1.

Figure 1: "Hımış" wall structure.

Various techniques about structure of wall are used for Black Sea Houses and some of this techniques are showed as below in figure 2.

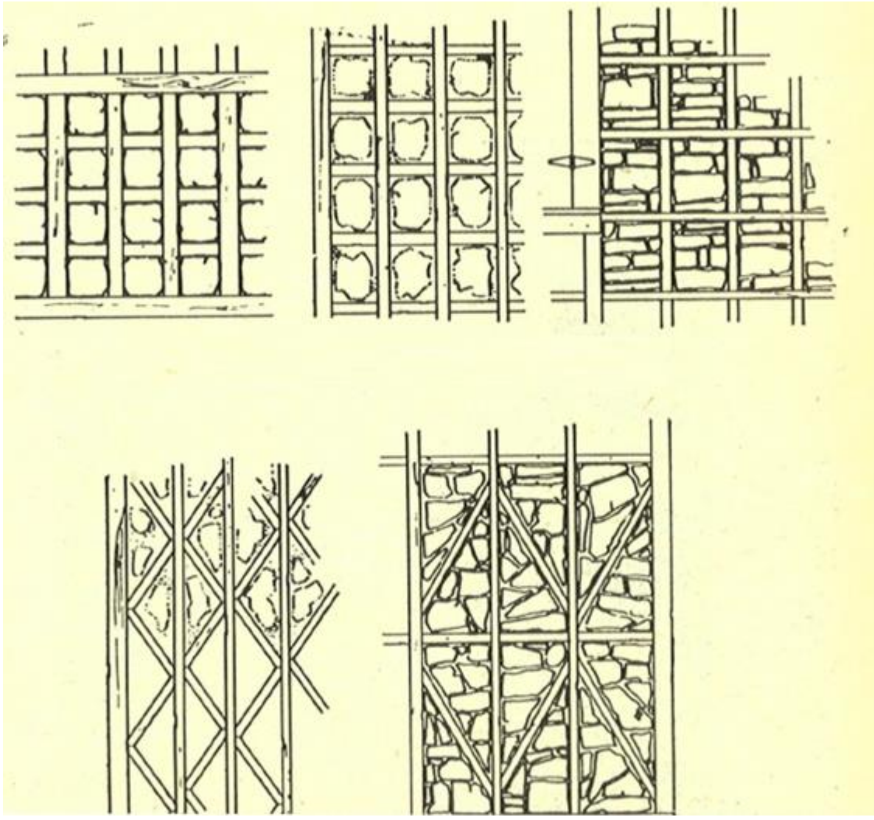


Figure 2: Different kind of wall structures

Gaps between woods are filled by some kind of materials. Materials can be changed by region and conveyor members may not be in the same section. Various filling gap techniques can be seen in a same house for different walls [4].

Roof and eave can be shaped with climatic conditions and structural materials [1]. Generally, the basic aim of eaves protect house from climatic effects. There are several types of roof and eave. Roof is tilted sufficiently because Black Sea Region has rainy seasons and water can be transferred to the ground and also it can be useful for drain snow from roof easily as shown in figure 3.

Figure 3: Examples of roofs from Safranbolu Houses.

There are three types of roof which have been used for black sea houses can be named as saddle, three shoulders and four shoulders. This roof types are available in figure 4.

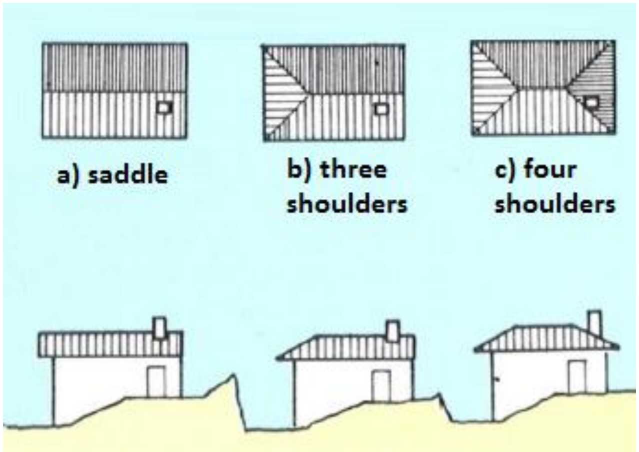


Figure 4: Roof types [5].

Saddle type is generally used at upcountry houses and this type of roof is available for storage. Construction of this roof is easier than others. Three shoulders type roof can be used directly. There is no need to any precaution for using roof as a room. Four shoulders type roof is generally used at houses which are nearby to coast [5]. To prevent water from entering the roof slope upward direction, roof has to be has no tilted component at this direction.

Wind direction is an important criterion for roof structure. The house has to be protected from negative effect of wind and with suitable roof structure, it can be provided as figure 5.

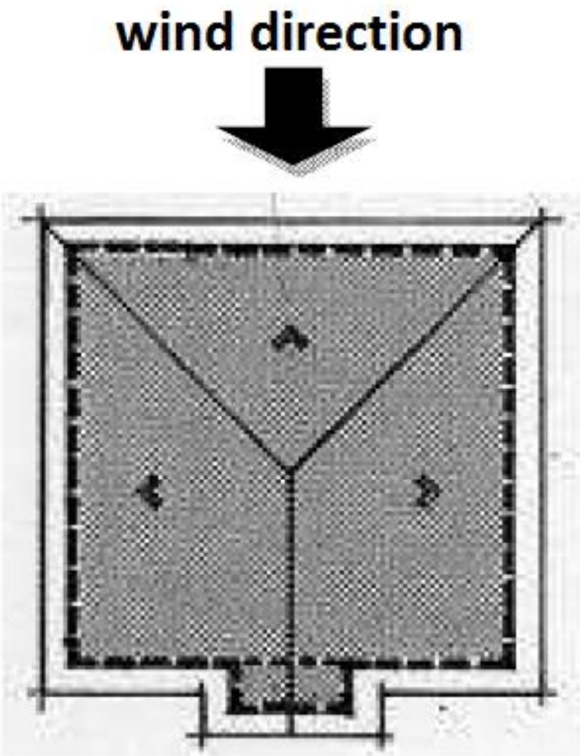


Figure 5: Wind direction and roof structure [1].

Openings have an important role for these structures because air ventilating, sight and view depend to openings which can be defined as Windows, doors and balconies. In figure 6, several openings are showed. Lighting is provided through the windows arranged in the direction of state. According to the angle of incidence of the sun and the direction of the room, top windows can be used. Also, Regulations about using natural light reduce the amount of energy consumption [9].

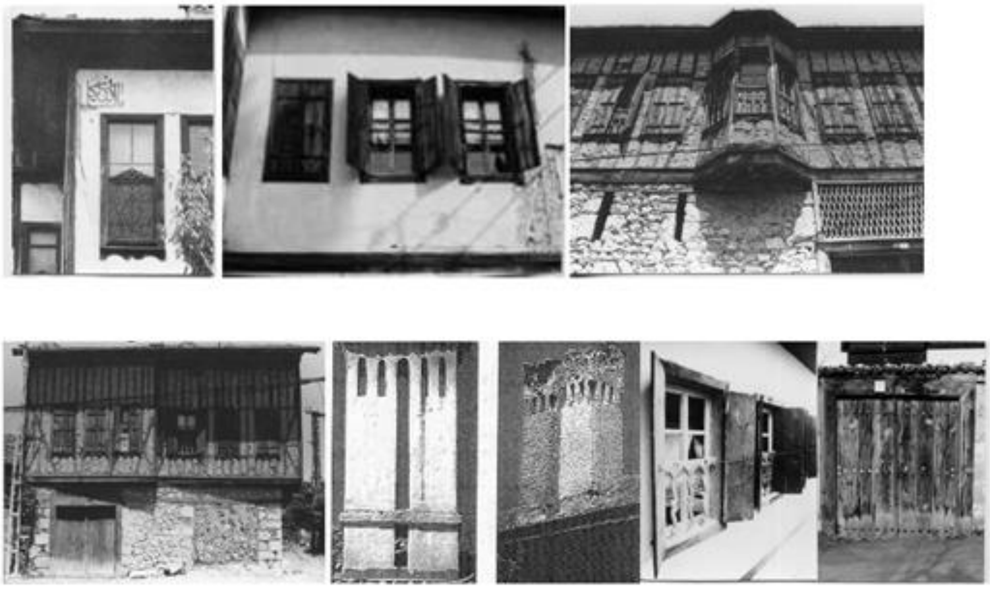


Figure 6: Openings

Traditional structures generally have two or three floor. There is a sofa inside house and rooms are located around this sofa. Symmetrical structure approach has a big influence on black sea houses [3]. There is high ground floor and no windows in the walls of the house facing north for decreasing the negative effects of wind and cold air [8]. Additional construction structures can be classified in three embodiments as in figure 7 [1].

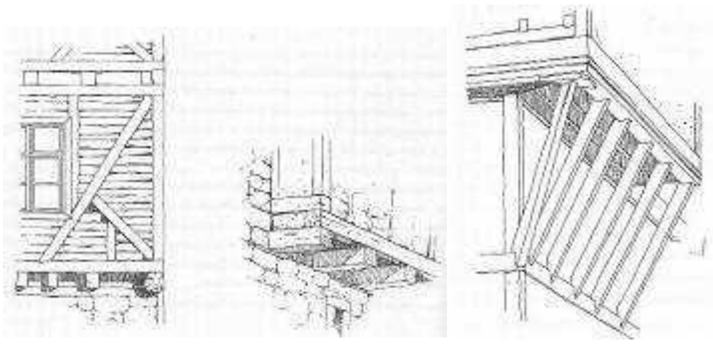


Figure 7: Additional structure [1].

b) <u>Building Materials</u>

Climatic condition, topography, availability of building materials, transport facilities, agricultural works and housing-dependent life have a big influence of materials which are used for building structures. Material selection is an important criteria and materials have to be does not require a lot of energy in sections of production and application [7]. Materials can be recycled, local and must be in the appropriate thermal conductivity. Wood, natural stone and adobe are most used materials in structures of black sea houses. Wood is an easy shaped material and can be easily found in this region and does not cause adverse environmental impacts throughout the life cycle. It is flexible and sustainable building material which is derived from renewable resources and is located between the environment-friendly and recyclable materials [7]. Thermal conductivity of wood is between 0.04 - 0.4 W/mK and it means that the wood can prevent heat dissipation. Briefly, wood can be obtained easily, suitable for mixed structures, prevents condensation, has a lower heat transfer coeffient, resists to tensile forces, can be repaired easily and easy to recycle.

The wood can be used with natural stone or adobe. Gaps between wood lines are filled with natural stone or adobe [1]. Thermal conductivity of stone is nearby to 1.3 W/mK and thermal conductivity of adobe is nearby to 0.57 W/mK. Abode provides more efficient thermal insulation than stone. Stone which shaped throughout human history is used as a building material. The structure of the stone material should be durable and do not harm the environment in the production and provides the possibility of recycling which allows them considered as a sustainable building material [7]. Stone brings effective solution for the construction of walls which have the potential to carry its own weight and more. It prevents heat dissipation and has water resistant [9]. It is generally used at garden, courtyard and ground floor walls because of strength. Briefly, stone can be obtained easily, is used as a carrier building material, prevent condensation, links up the floor and structure [9].

According to the direction in housing, appropriate materials and constructions are chosen. Filling construction was used in the section where precipitation is less and moisture-resistant hardwood and stone walls were used in the section where rain comes with wind and wood was used in the sunny south direction [7].

c) Location and Orientation

The land declination has more influence on orientation of house than land scape and sun acts. The front side of the house is the facade which is facing the opening downhill [1]. Land structure does not force the orientation of house. In contrast, orientation of house is adjusted to land structure as seen in figure 8 and in figure 9.

Figure 8: Orientation of houses.

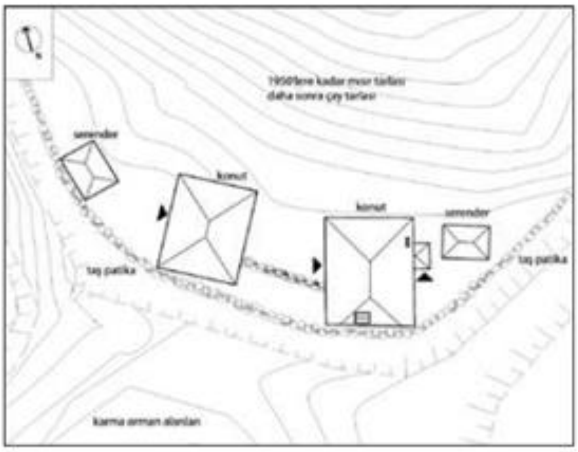


Figure 9: Drawing of orientation of houses.

People who engaged in agriculture have built additional structure. This structure can be called as "Serender" which means cool and airy and can be seen in figure 10. The fundamental aim of serender protects nutrition against decomposition. There is no living space in serender and it is used for storing only [6].

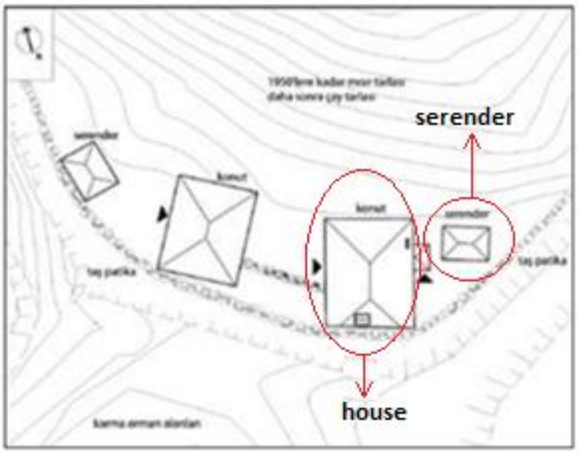


Figure 10: House and serender [6].

Scattered settlements of the Black Sea houses are caused by the topography of the region and houses are built to areas which are suitable to farming. Therefore, people want to provide all of their needs from house and environment of house [5].

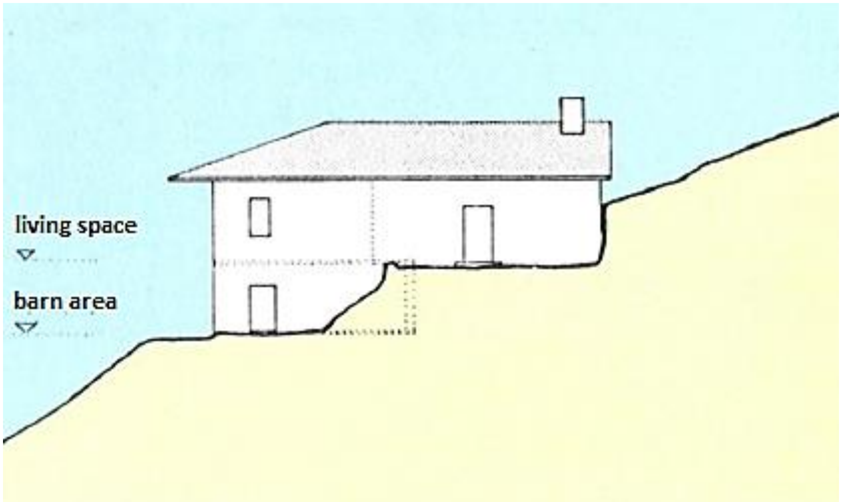


Figure 11: House and slope.

Houses in this topography are generally installed to inclined slopes which has between %5-%50 inclinations. Therefore, the etching is performed in the upward direction which can be seen in figure 11 [6]. Lower floor which is named as barn area is used as a barn and top floor is the living space. Barn area is built with natural stone. It has a one door and one little window. The height of roof is nearby to average human height and it provides high internal temperature. Living space is the top floor of the house. Structure of walls at living place generally is built by “hımış” technique [6]. Traditional Black Sea House has a stone structure at lower floor. It has one or two floor on the lower flood which is built by wood or mixed components [7].

d) Climatic Conditions

Black Sea region has a mild climate with high and evenly distributed rainfall the year round. At the coast, summers are warm and humid, and winters are cool and damp. The Black Sea coast receives the greatest amount of precipitation and is the only region of Turkey that receives high precipitation throughout the year. The eastern part of that coast averages 2,500 millimeters annually which is the highest precipitation in the country. Snowfall is quite common between the months of December and March, snowing for a week or two, and it can be heavy once it snows. The water temperature in the whole Turkish Black Sea coast is always cool and fluctuates between 8° and 20 °C throughout the year. Every season is rainy and the temperature difference is low throughout the year [10].

e) Worldwide Perspective

The climatic condition of West Black Sea region has same properties with “Oceanic Climate”. Seasons have similar conditions about temperature and amount of rain so it can be said that vegetation can be similar for this regions which has Oceanic Climate. The oceanic climate is prevalent in a good portion of Western Europe, the European part of northern Turkey and Black Sea coast in northern Turkey. Structure materials for traditional Western Europe houses can be classified as wood and stone. Stone or wood can be used as only main component also mixed component are available for Western Europe houses which have a lot of similarities with Black Sea houses [11]. The roof structures of houses are similar to traditional Black Sea houses which are tilted with narrow angle to extracting water and snow. Moreover, a draw well is being nearby to house which provides fresh water.

3) CASE STUDY

A traditional Black Sea house is introduced with this case study in terms of location, orientation, plan section, materials and structure.

a) Location

The house was built by author's grandfather at 1963 which is in west coast of Black Sea, Topallı village of Ereğli in Zonguldak County, Turkey (41°16' North longitude & 31°25' latitude and 196 m altitude) [16].

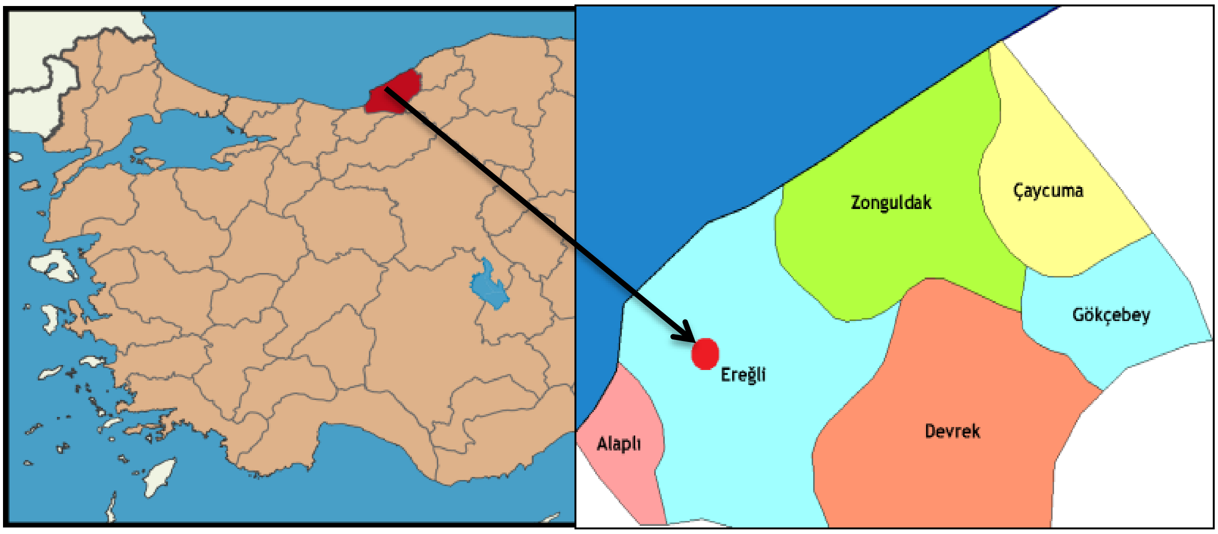


Figure 12: Location.

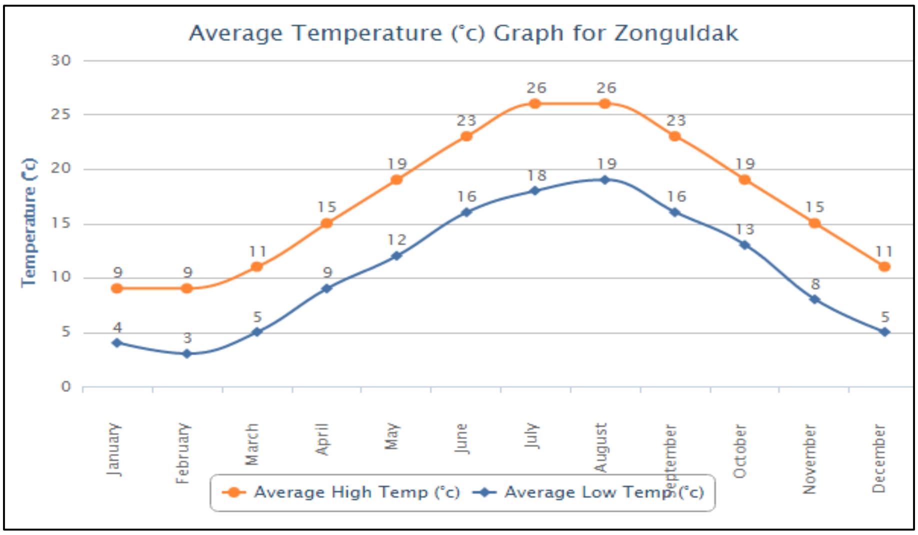
Figure 13: Orientation [16].

Figure 14: North side of house.

The name of Topallı Village is based on First World War. In time of war, all of men in village joined the army to defending the country. Only one of them stayed in village and he was called as “Topal Ali”. During the wartime, constabulary was looking for men to get them to army and asked a woman about men who had to be join army. Women said that only a disable man was staying here who was Topal Ali. Years later, the name of Topal Ali was derived and the village took its name Toplallı. Population of village is estimated as nearby to 300.

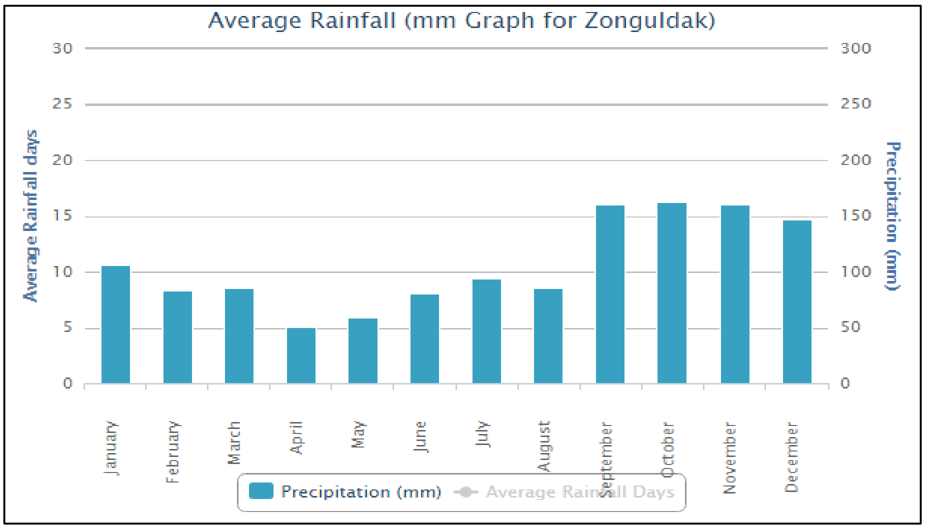
b) Climatic Conditions

A mild climate with high and evenly distributed rainfall the year round. Annual temperature distribution is available as below in graphic 1. Temperature fluctuates between 4ºC - 9ºC for winter and 19ºC - 26ºC sum summer through the year.



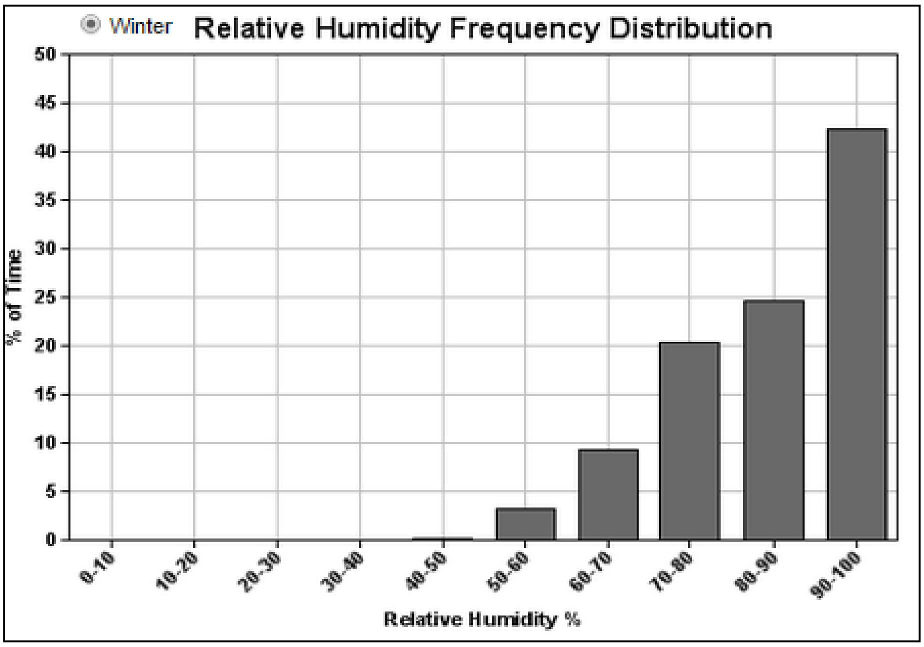
Graphic 1: Annual temperature distribution [13].

Average rainfall is between 5 mm – 15 mm through months. A common perception for Black Sea that high and evenly distributed rainfall through the seasons can be specified with graphic as below.

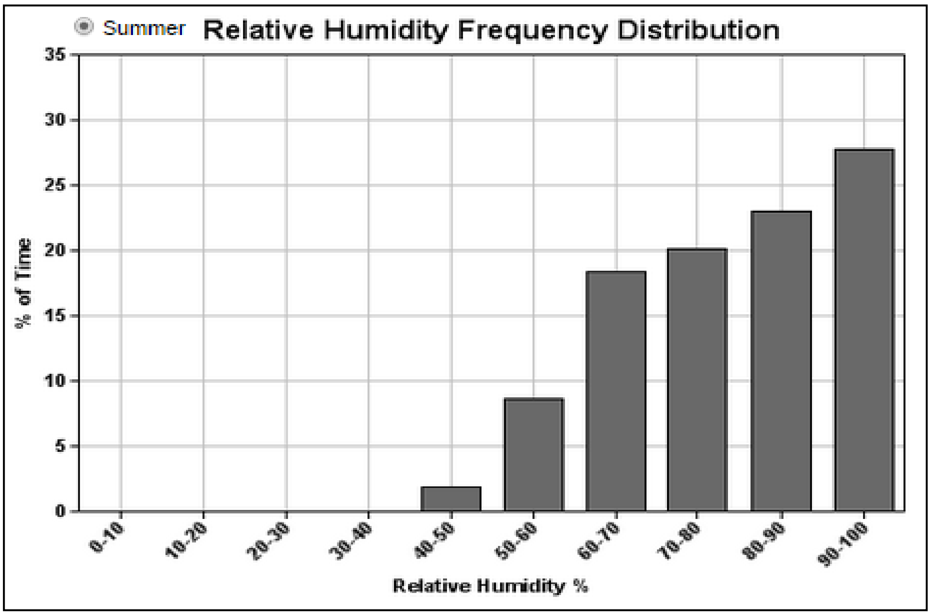


Graphic 2: Average rainfall [13].

Relative humidity which can be identified as the gram water in the kilogram dry air has an important effect on vegetation, annual rainfall and structure of house. Through the months relative humidity is high for all seasons. There are graphics as below for winter and summer.

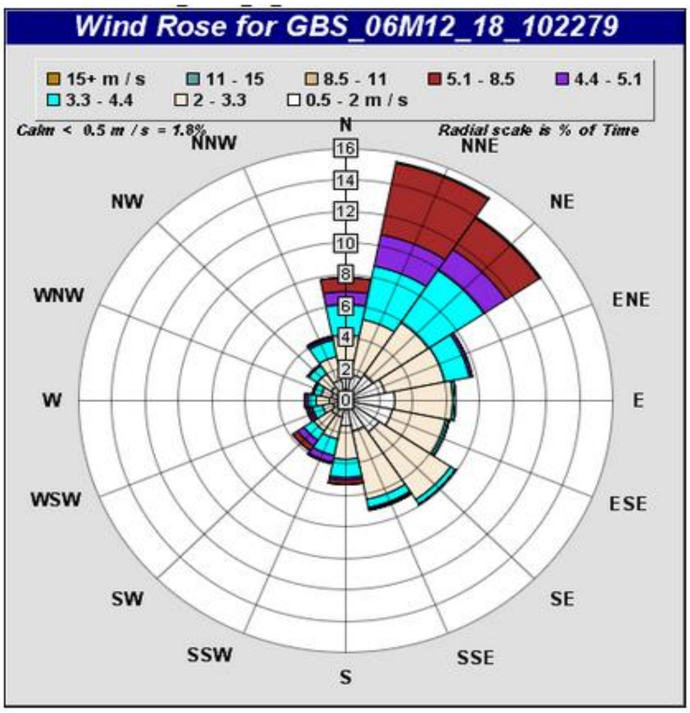


Graphic 3: Relative humidity frequency – Winter [13].

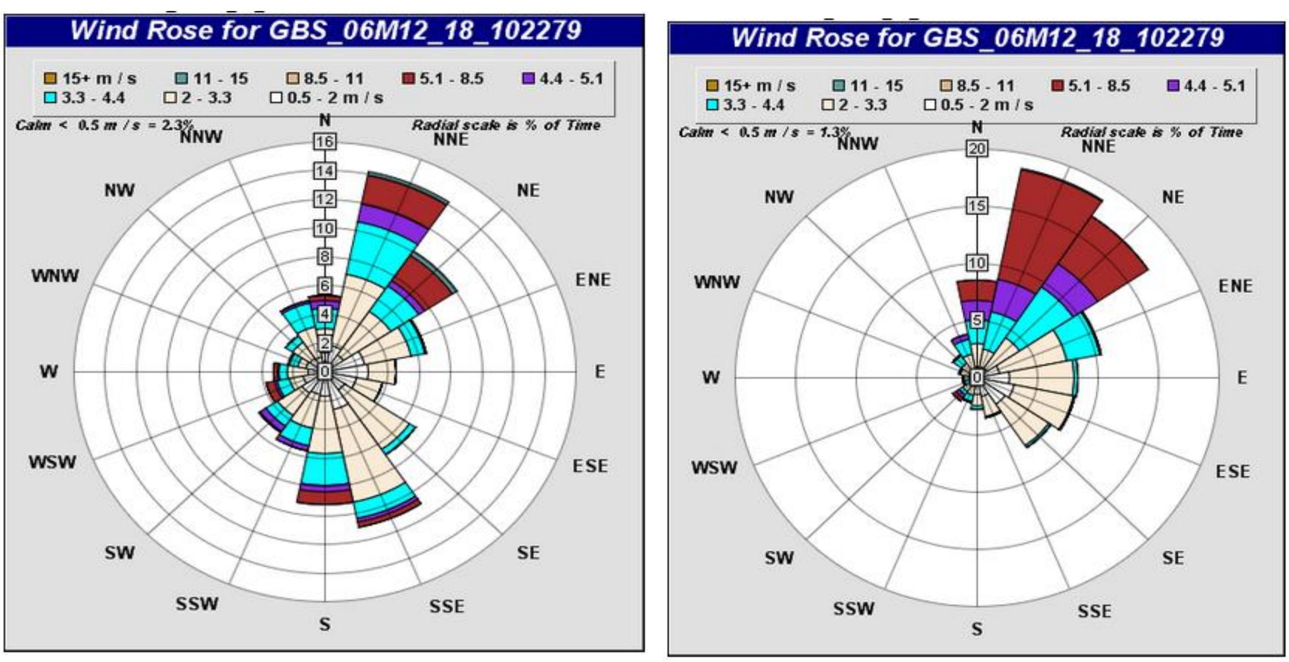


Graphic 4: Relative humidity frequency – Summer [13].

Dominant wind direction is an important parameter for structures because air ventilation and direction of rainfall are effected by dominant wind direction. Especially for natural ventilation, knowledge of the dominant wind direction gives shape to the structure. The distribution of the wind direction is indicated in the graphics as below.



Graphic 5: Dominant wind direction - Annual average [13].



Graphic 6: Dominant wind direction – Winter & Summer [13].

Dominant wind direction is North North East and average wind speed is 4-5 m/s.

c) Orientation

The house is located in the hillside because of hilly natural structure of Black Sea region. There is a garden in the back of the house which is oriented on slope and rear facade is facing south. In figure 15, the house is showed.

Figure 15: Traditional house for case study – North Facade.

The climate of village can be categorized under Oceanic Climate due to similarity about seasons and conditions. The mean temperature in the whole Turkish Black Sea coast is between 15^{o}C and temperature difference whole year is nearby to 13^{o}C. Seasons are rainy and the temperature difference is low throughout the year. Annual rainfall is 1000-1500 mm.

In early of 1960, daily bread of people is generally agriculture and livestock. Therefore, a garden is oriented back side of house. Even if people did not sell the harvest, they used gardens for their daily consumptions and they produced their own nutrients through years. This type houses can be named as self-sufficient structure because people could continue their life without leaving the houses. Moreover, a draw well is being nearby to house which provides fresh water.

Figure 16: Sides of house.

d) Plan Section

Plan section of house is as below;

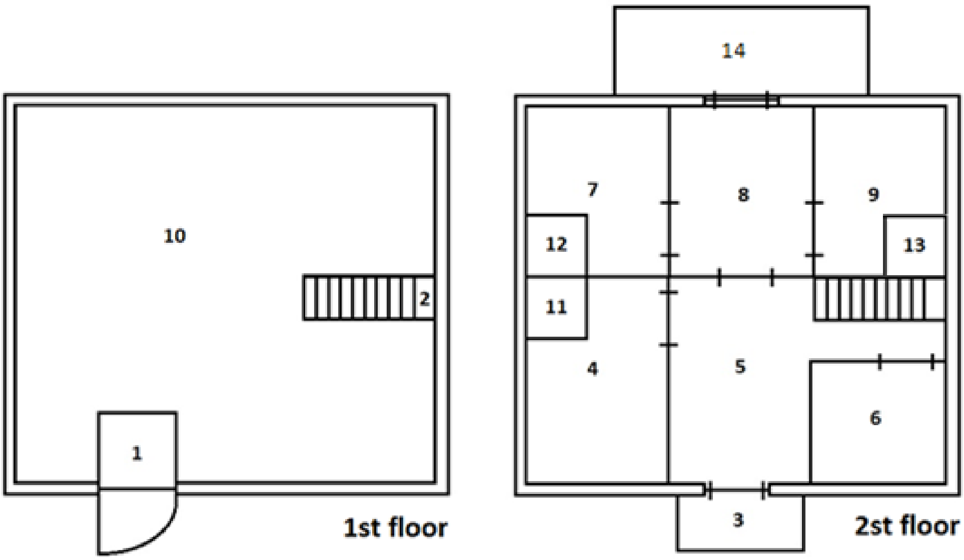


Figure 17: Plan section of house.

1. Entrance	8. Living room
2. Stairs	9. Bedroom
3. Oriel	10. Barn
4. Bedroom	11. Bathroom
5. Living room	12. Bathroom
6. Kitchen	13. Bathroom
7. Bedroom	14. Balcony

d) <u>Materials</u>

Material selection is an important criterion for houses. As in other traditional Black Sea houses, this building has two basic materials that are wood and stone. Materials are stone and wood that these two materials were used together. According to Climatic condition, topography, availability of building materials, transport facilities, agricultural works and housing-dependent life, these materials are suitable for a traditional Black Sea house.

Natural stone were used for lower floor due to low heat conductivity and it can be obtained easily also this kind of material is a good heat absorber.

Figure 18: Natural stone – Lower floor material.

Walls have two kind of materials which are used together are wood and stone. These two components were combined with certain techniques that can be seen for traditional Black Sea houses. Moreover, bricks are used as roof material.

Figure 19: Wall – Top floor materials.

Columns and beams which are carrier elements of houses are wood. In figure 20, these carrier elements can be seen.

Figure 20: Carrier elements – Wood.

Frames of windows, door, top floor ground, stairs and some structure of house are wood that can be seen in figure 21.

Figure 21: Wood Structures.

e) <u>Structure</u>

The house has two floors that lower floor is used as a barn and top floor is living place. The material of lower floor is stone and structure of walls is masonry wall that provides certain strength to house. Top floor has mixed materials and structure of walls based on mixed usage of these two materials. “Hımış” technique were used for wall structure that stone and wood were used together.

Structure of roof can be named as four shoulders. It basically depends on climatic conditions which are used to get advantages of nature and protect it from negative effects.

Frame of window have a medium width which are wood. Besides, material of oriel is wood and it has a traditional shape with some certain figure. It was fitted on three timbers which is a technique for construction of oriels.

Figure 22: Wood Structure of oriel.

4) IDENTIFICATION OF SELECTED HOUSE

Materials and structures of house have examined in the previous section. Identification of all of these specifications is an important point for understand the house and improve it if necessary.

The house is located in the hillside that can be seen in figure 23 because a rugged natural structure is dominant for Black Sea Region so terrain had graved and a part of house had located inside the ground. Temperature of soil does not change constantly and fluctuation of temperature is low for this region. Therefore it provides a good thermal condition for barn area which can preserve the heat inside also natural stone which is the material of barn area is a good heat absorber. Besides, a part of north side had located inside the ground and surface area of north facade is decreased with this technique so building is prevented from negative weather conditions and cold winds.

Figure 23: Orientation of houses.

Material between first floor and top floor is wood and also the ground of top floor is wood which can be obtained easily in Black Sea region, has a good compressive strength and provides sufficient isolation for house. Carrier elements are wood and they had constructed with certain techniques.

In barn area, some of little windows had oriented due to extract moisture from wood because the strength of wood decreases with moisture and it causes collapse so air circulation can be created with this windows and entrance. Structure and window can be seen in figure 24.

Figure 24: Wood structure and window

The ground of top floor is wood and air circulation must be created to preserve it. The space between wood and ground at first floor provides air circulation and moisture extracted from wood which is specified in figure 25.

Figure 25: Space between wooden structures.

Walls have mixed components which had constructed with “Hımış” technique. Interface between stones and wood is important for thermal insulation and strength of wall. This interface is filled by the adhesive materials that can be dry plaster. These materials can be obtained easily in Black Sea region and do not require high amount of energy during manufacture and constructor sections.

Openings have an important criterion for these traditional houses. Sight, air ventilation depends on openings which can be classified as windows and balcony entrance doors. Material of windows frame is wood and single row of glass is oriented to frame. Multi-compartment windows are used at every side of house also top windows are available.
According to the direction of the room and the angle of incidence of the sun, top windows had been used which can be seen in figure 26. Corrosion and deterioration have occurred on windows frame and material needs to be restoration.

Figure 26: Windows and wood structure.

Moreover openings have a big influence on thermal conditions inside and using of natural light. Interface between frame and wall material some troubles occurs to providing insulation and it causes adverse thermal conditions than desired conditions.

The oriel which is located at the north side of house is settled on three wooden blocks. These blocks can be seen in figure 27.

Figure 27: Oriel and wooden blocks.

These kinds of oriel structures are available for traditional Black Sea houses. Besides, shade can be created by oriel at entrance and also collecting of snow and rain can be blocked by oriel again. In figure 28, oriel is specified with red circle and entrance is specified with black circle.

Figure 28: Oriel and entrance.

Structure of roof can be specified as four shoulders type roof. It has four tilted main components. Annual amount of rainfall is too high for this region and water have to be transmitted easily to ground so four shoulders type roof is a suitable structure. Material of roof is tile and is combined with wood through roof structure. Four shoulders roof structure generally do not permit to any space to living or storage.

Natural sources can be used for certain activities as like air ventilation. Therefore, people must consider the direction of wind and air circulation through house. Northeastern winds are effective in Western Black Sea coast so air circulation is started from north side of house. In this house, foreseen air circulation is showed in figure 29 We can suppose that air circulation had took into account of by builders of house.

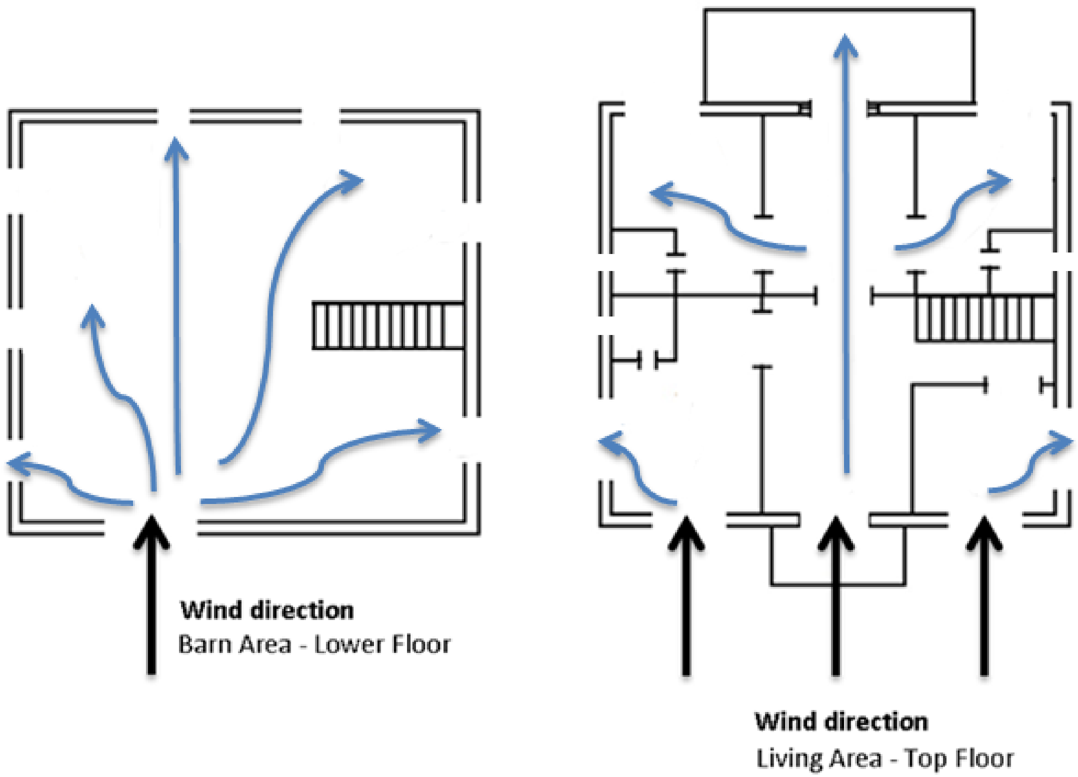


Figure 29: Air circulation for floors.

Ground of the roof had covered with wooden plates as seen in figure 30. Heating is done by coal stove and there is no equipment for air ventilating, circulation and cooling. The house sustains itself about air ventilation. There is a garden at the south side of house which is oriented in slope that is used for farming. In black sea region and especially in villages, people used to grow their vegetables in their gardens.

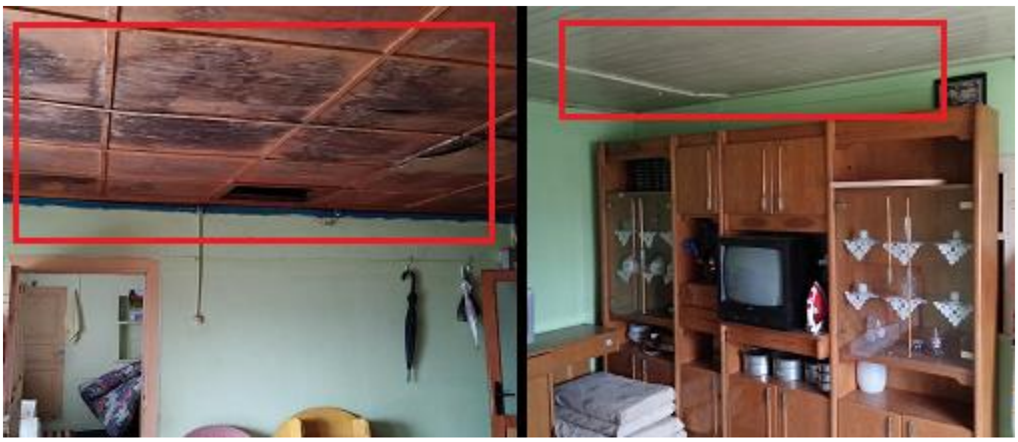


Figure 30: Wooden covered ceiling.

People who engaged in agriculture have built additional structure for storing their harvests. This structure can be called as "Serender" which means cool and airy and can be seen in figure 31. The fundamental aim of serender protects nutrition against decomposition. There is no living space in serender and it is used for storing only.

Figure 31: House and serender

Fire place is important structure for traditional house because heating is provided with place. Moreover, people use stone oven for daily cooking. The back wall of stone oven as seen in figure 32 is placed through the living room which is an important technique to getting benefits of oven and using of waste heat to providing comfort level.

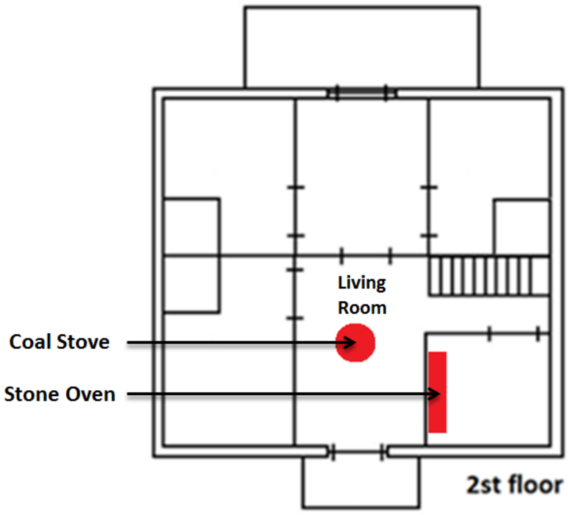


Figure 32: Fire places.

5) EXAMINATION OF SPESIFIC PROPERTIES

Examining the energy efficiency of the house is important criteria for understanding of the components and their specific properties. A commercial program (Autodesk – Ecotech) was used to examination. Analysis was performed for lightening (artificial & natural), U value of wall for different materials and polyurethane coating, heating and cooling and shade effects of components. A 3-D model was sketched with Ecotech [12] that can be seen as below with dimensions.

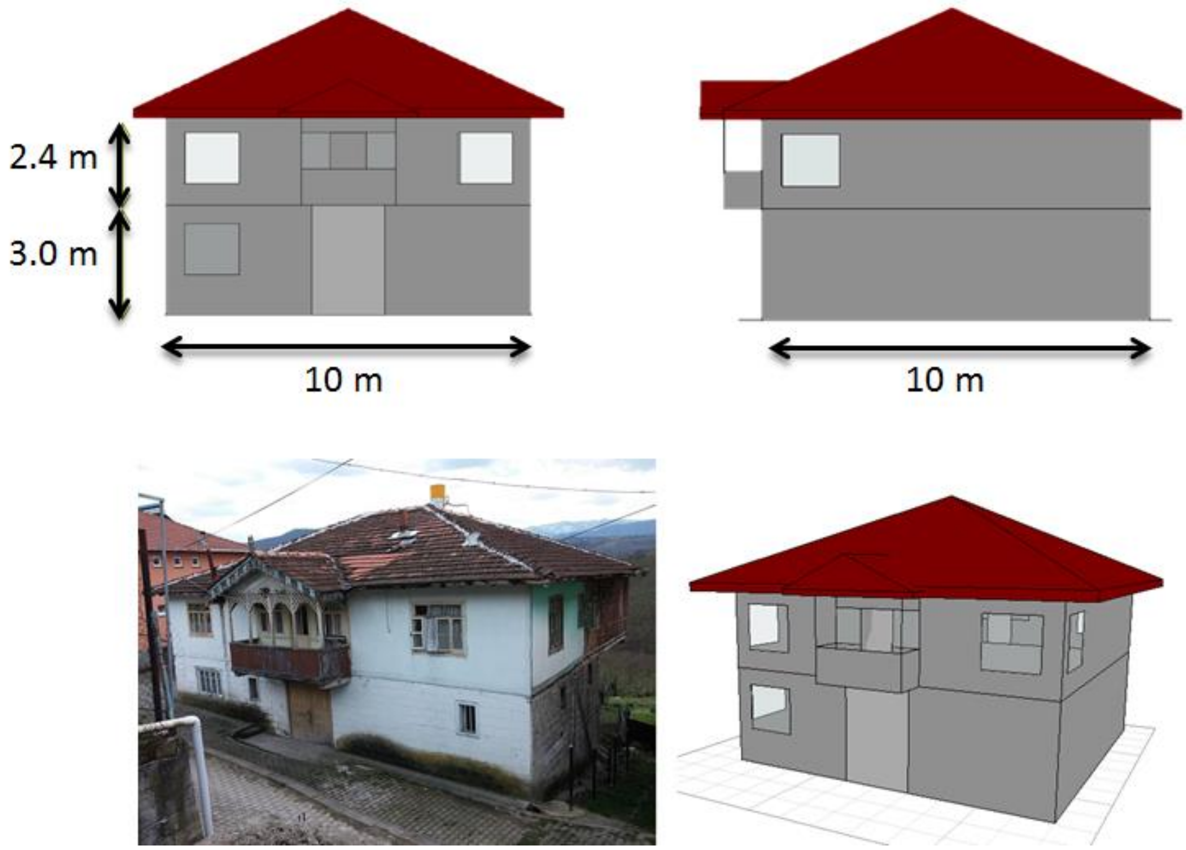


Figure 33: 3-D Model of house with dimensions [12].

a) **Lightening**

Lightening is an important feature for people about their comfort and energy consumption. Through cleverly placed openings annual energy consumption for lightening can be decreased as %30. With simulation, we can see that openings are sufficient for getting natural light into structure efficiently.

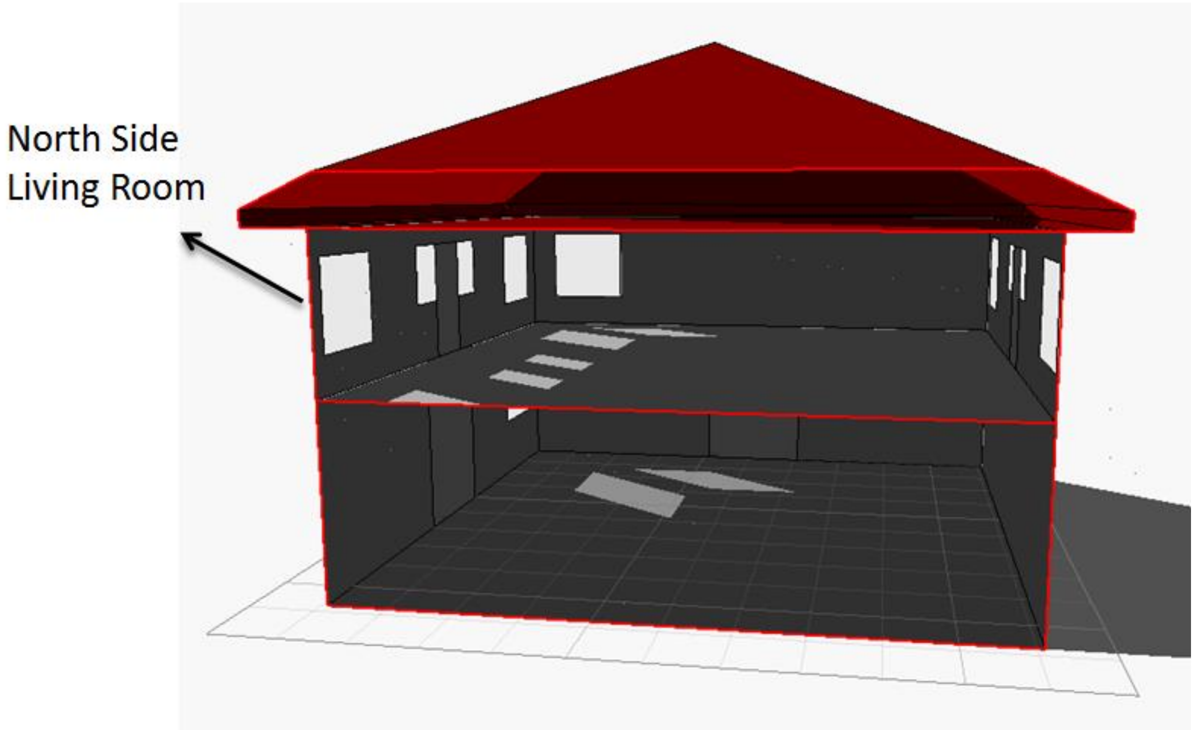


Figure 34: Annual average naturel lightening at 11 a.m.

Another important feature about lightening can be defined as artificial lightening. Location of lambs and their lumens values has an important effect of lightening efficiency. Potential value for domestic lightening is around 300-400 Lux. Lambs are located with 2 meter gaps and 8 lambs is used for artificial lightening which has 1500 lumens for each. With the results of analysis, it can be supposed that number of lambs and their lumen values are sufficient for an effective lightening. The lux value approaches to 300 Lux as seen in picture as below.

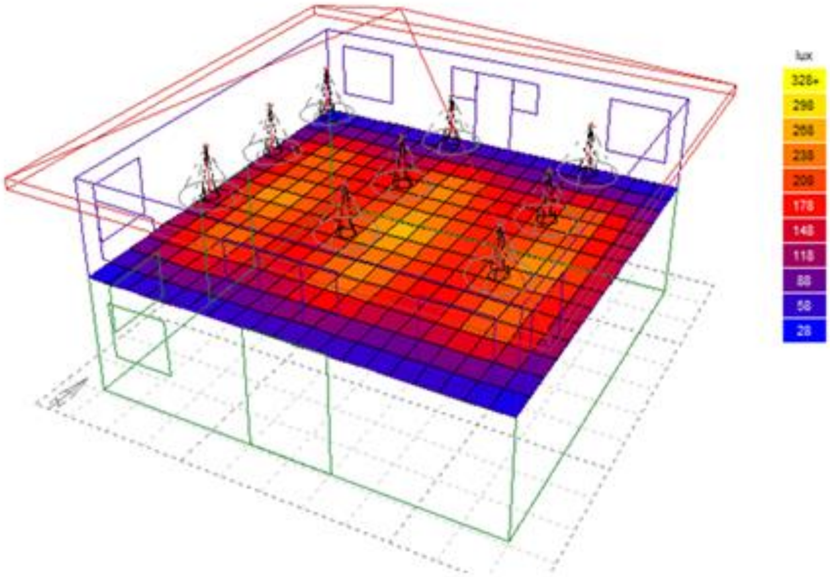


Figure 35: Artificial lightening analysis.

b) U Value of Wall

U value is a measure of heat loss in a building element such as a wall, floor or roof. It can also be referred to as an 'overall heat transfer co-efficient' and measures how well parts of a building transfer heat. This means that the higher the U value the worse the thermal performance of the building envelope. A low U value usually indicates high levels of insulation. They are useful as it is a way of predicting the composite behavior of an entire building element rather than relying on the properties of individual materials. Calculation of U value can be defined as below [15].

$$R = \frac{d}{\lambda_h}$$

R : Thermal resistance ($m^2.K/W$)
d : Thickness (m)
λ_h : Thermal conductivity (W/m.K)

$$U = \frac{1}{R_i + R + R_e}$$

U : Total thermal resistance ($W/m^2.K$)

Turkish Standards Institute specifies U values for different zones in TSE 825 report. Zonguldak is in zone 2 which is limited U values around $0.6 W/m^2K$.

TSE U VALUE STANDARTS	U_D (W/m²K)
1. ZONE	0,70
2. ZONE	0,60
3. ZONE	0,50
4. ZONE	0,40

Figure 36: Turkish Standards Institute U Values for different zones [14].

The structure of wall can be defined as Timber-frame brick wall. U value of wall is 0.89 W/m2*K and thickness is 26 cm. The window can be defined as Single-glazed timber-frame. U value of window is 5.1 W/m2*K. The door can be defined as Oak timber. U value of door is 2.26 W/m2*K and thickness is 5 cm. Moreover, U value of Polyurethane coated (5 cm) Timber-frame brick wall is 0.55 W/m2*K and thickness is 31 cm.

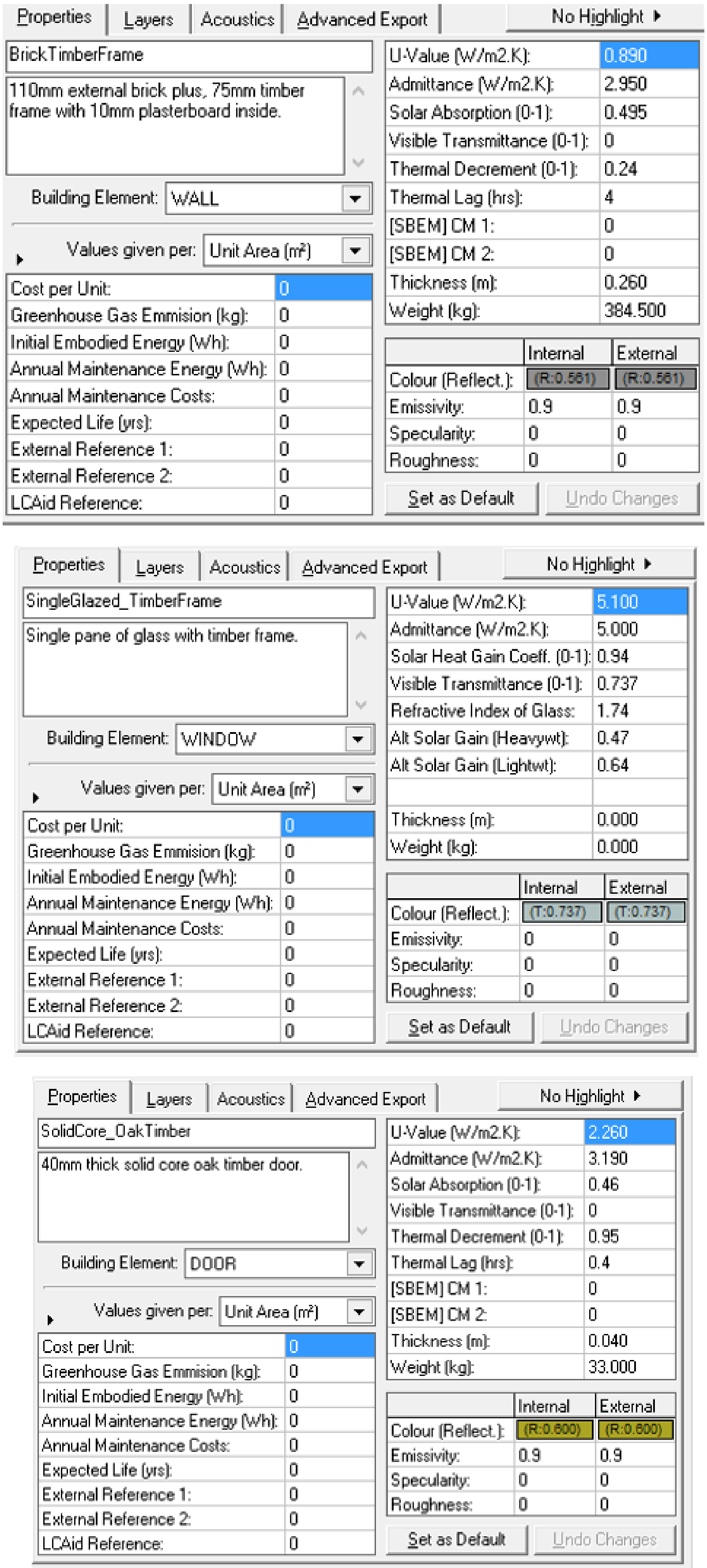


Figure 37: Structures of Timber-frame brick wall, Single-glazed timber-frame, Oak timber.

c) Heating and Cooling Loads

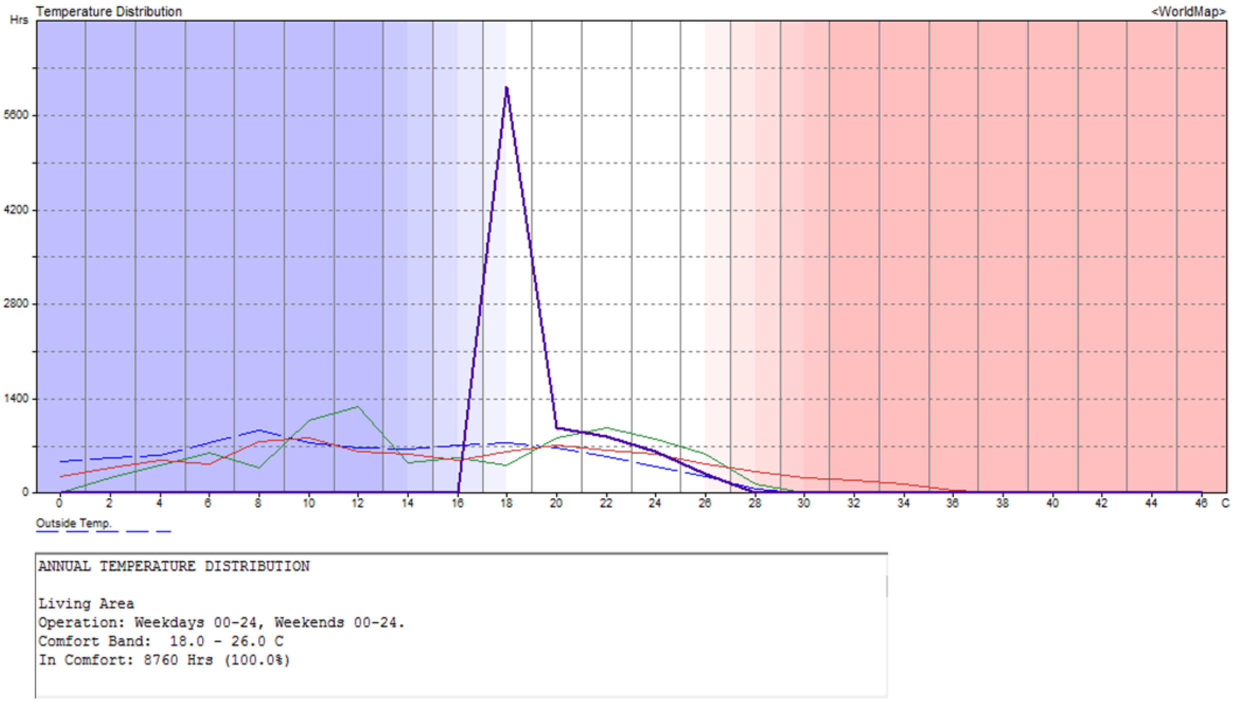
Analysis was performed for 3 different situations that Timber-frame brick wall, Stone material, Polyurethane coated Timber-frame brick wall. Thermal analysis was performed for living area and Comfort Band was determined between 18^{o}C - 26^{o}C.It means that, if temperature through living area is under 18^{o}C heating is required and over 26^{o}C cooling is required. Besides, temperate distribution through year for living room was analyzed by Ecotect.

Analysis for Timber-frame brick wall

U value: 0.89 W/m2*K

Thickness: 26 cm

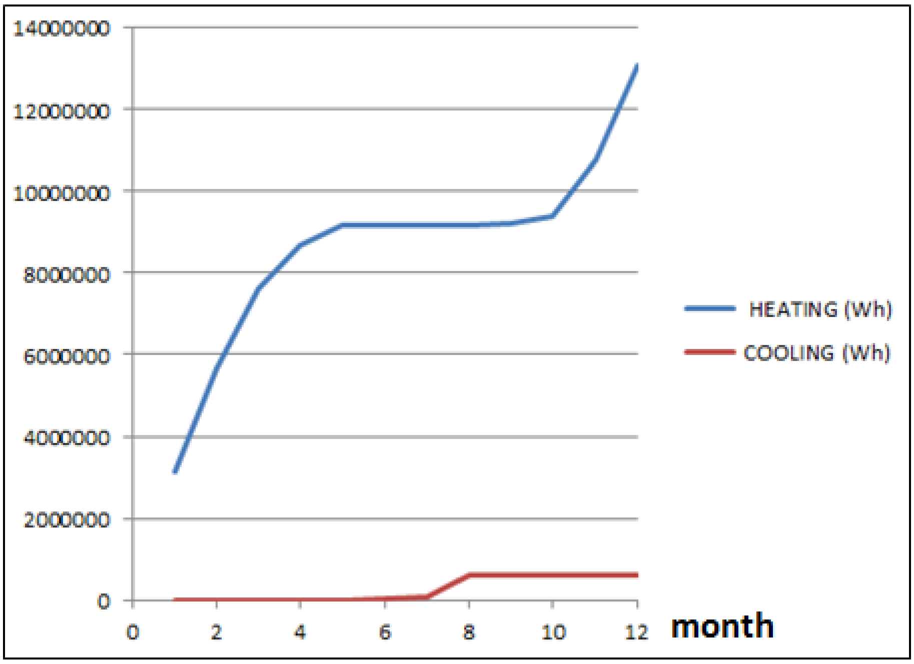
Annual temperature distribution for living room with cooling and heating can be seen at graphic 7. The bold purple line indicates living room. Left axis is total hours and right axis is degree of temperature.



Graphic 7: Annual temperature distribution for living room – Timber-frame brick wall.

Annual heating and cooling loads are defined as below for each month. Total values of loads are indicated in table and graphic as below.

MONTH	HEATING (Wh)	COOLING (Wh)
Jan	3152251	0
Feb	5678590	0
Mar	7620375	0
Apr	8688885	0
May	9175510	0
Jun	9193660	7101
Jul	9193660	53084
Aug	9193660	585521
Sep	9199377	585521
Oct	9417496	585521
Nov	10768789	585521
Dec	13074808	585521
TOTAL	**13074 kWh**	**585 kWh**



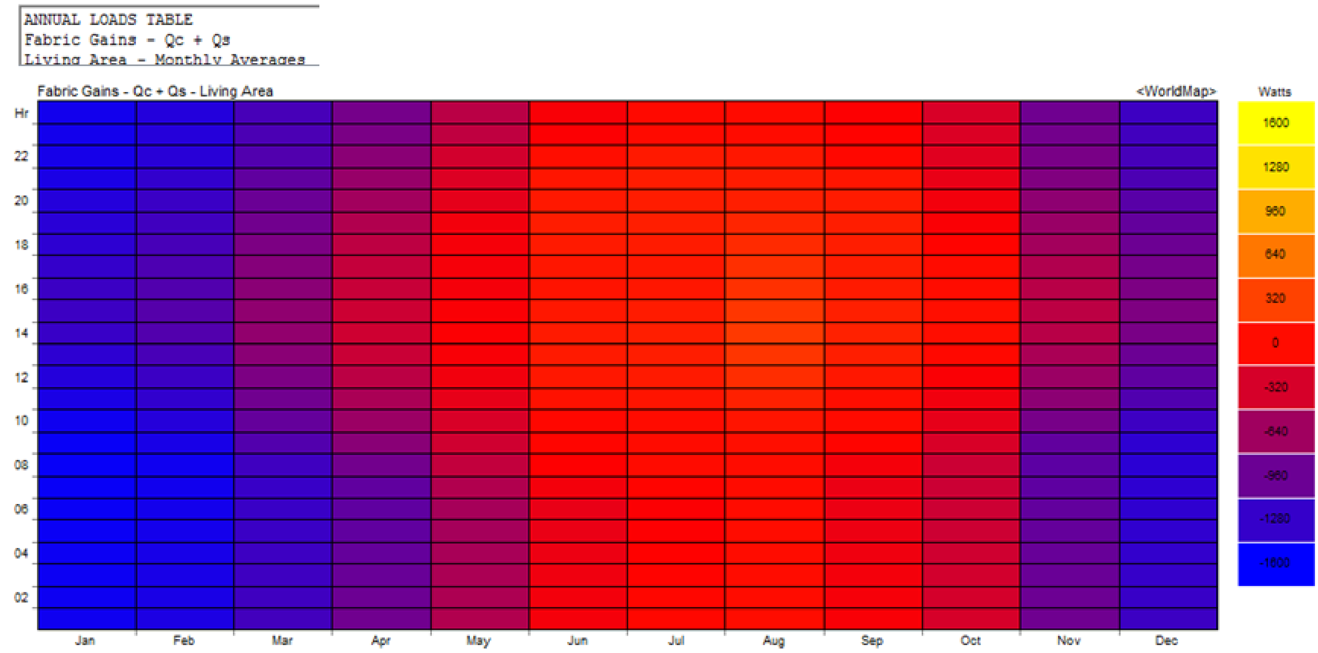
Graphic 8: Heating and cooling loads – Timber-frame brick wall.

A calculation is done for fuel consumption providing sufficient heating and cooling load. Natural Gas is the efficient fuel which can be declared in figure 38.

Fuel	Efficiency %	TL/1000 kwh	Total Price for Heating (TL/Year)	Total Price for Cooling (TL/month)
Natural Gas	90	0,1351	1766	147
Lignite	65	0,1825	2386	199
Electricity	99	0,3647	4768	397

Figure 38: Comparison of fuels

Fabric gains can be seen in graphic 9. This graph shows an average day each month, with months along the horizontal axis and hours of the day along the vertical. The color of each grid square represents the average gain or loss. The analysis was performed through living room. Gains and losses are the average values for the whole room structure. This shows that heat gains from the building fabric, due to both external temperatures and incident solar radiation, occur mainly all the time in summer. In winter, heat losses increases and losses continues throughout the winter.



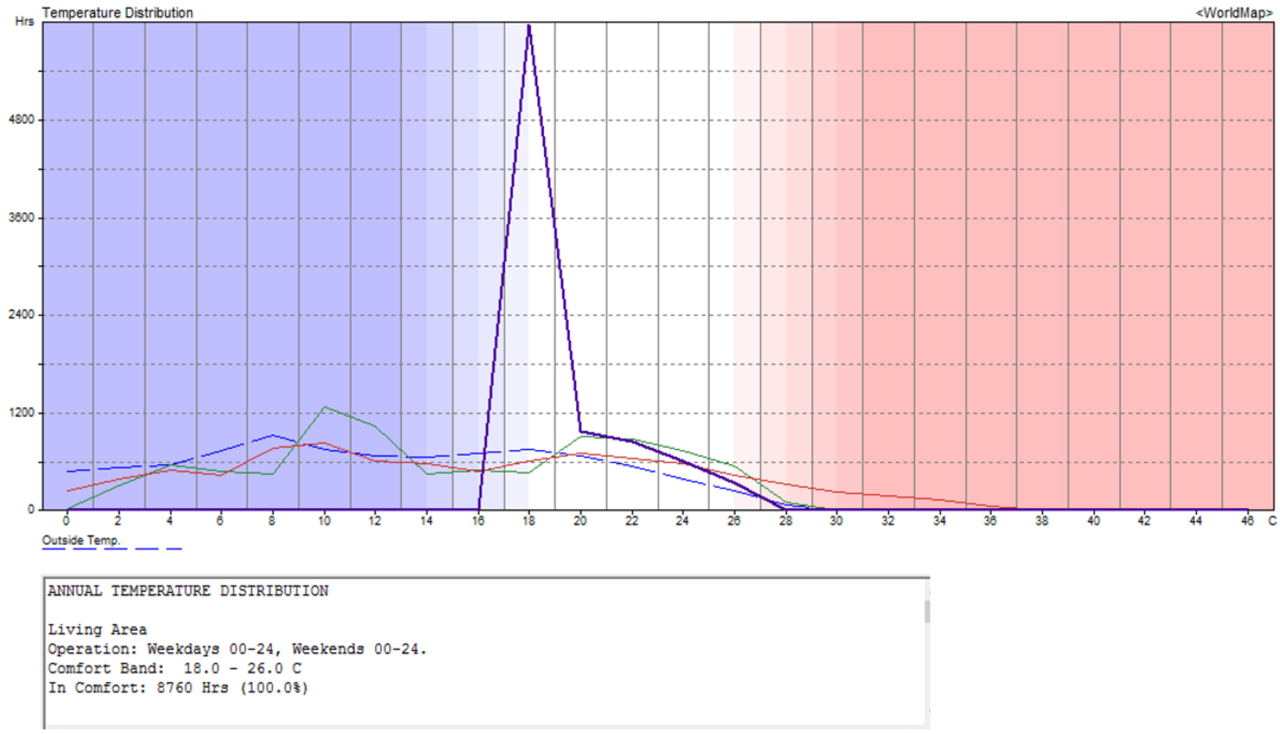
Graphic 9: Fabric gains – Timber-frame brick wall.

Analysis for Stone wall

U value: 1.8 W/m2*K

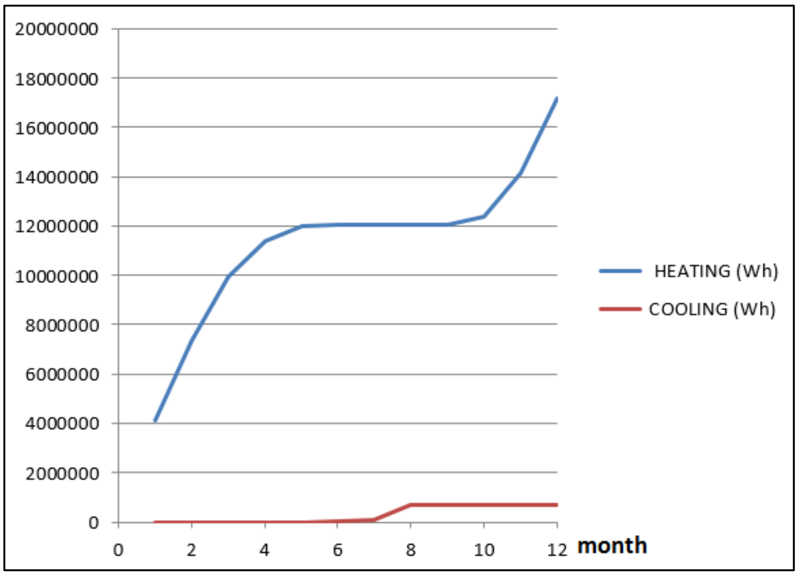
Thickness: 26 cm

Annual temperature distribution for living room with cooling and heating can be seen at graphic 10. The bold purple line indicates living room. Left axis is total hours and right axis is degree of temperature.



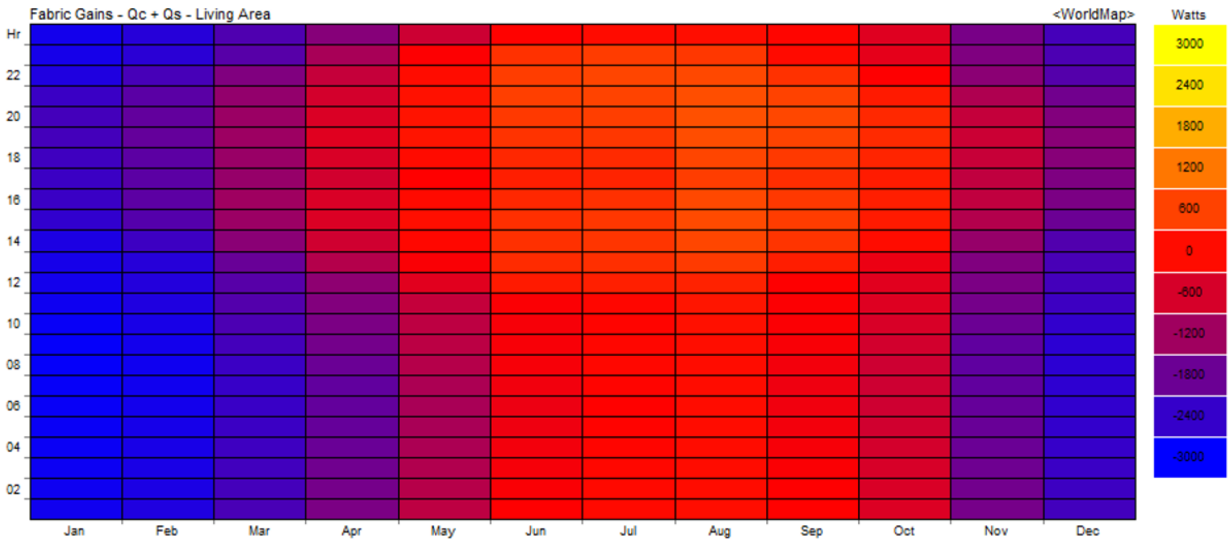
Graphic 10: Annual temperature distribution for living room – Stone wall.

Annual heating and cooling loads are defined as below for each month. Total values of loads are indicated in graphic as below.



Graphic 11: Heating and cooling loads – Stone wall.

Fabric gains can be seen in graphic 12. This graph shows an average day each month, with months along the horizontal axis and hours of the day along the vertical. The color of each grid square represents the average gain or loss. The analysis was performed through living room. Gains and losses are the average values for the whole room structure. This shows that heat gains from the building fabric, due to both external temperatures and incident solar radiation, occur mainly all the time in summer. In winter, heat losses increases and losses continues throughout the winter.



Graphic 12: Fabric gains – Stone wall.

Analysis for Polyurethane Coated Timber-frame brick wall

U value: 0.55 W/m2*K

Thickness: 5 cm coating + 26 cm Timber-frame brick wall

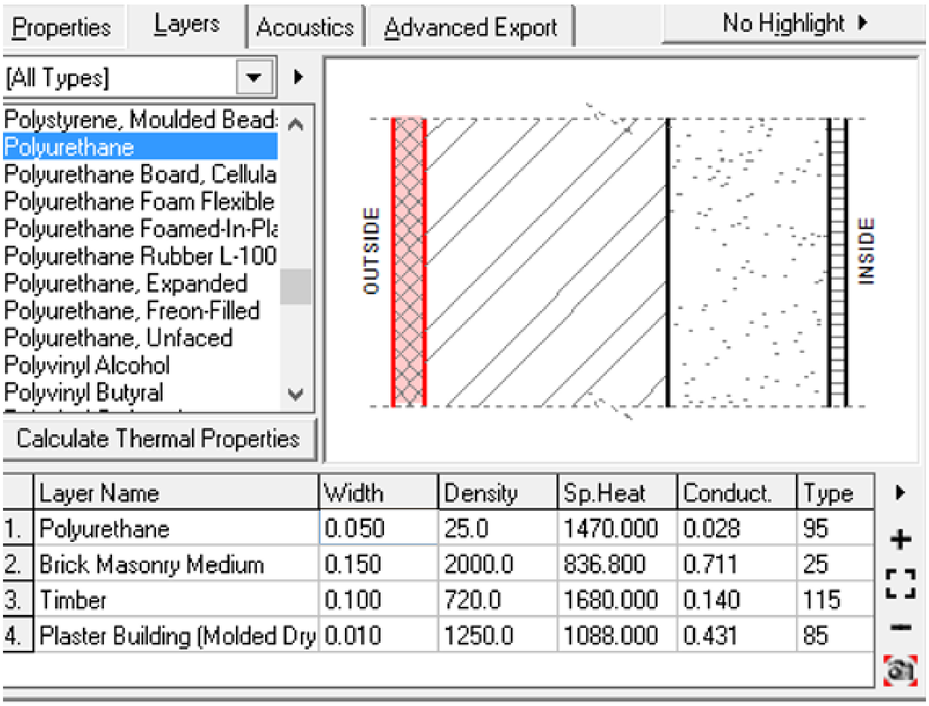
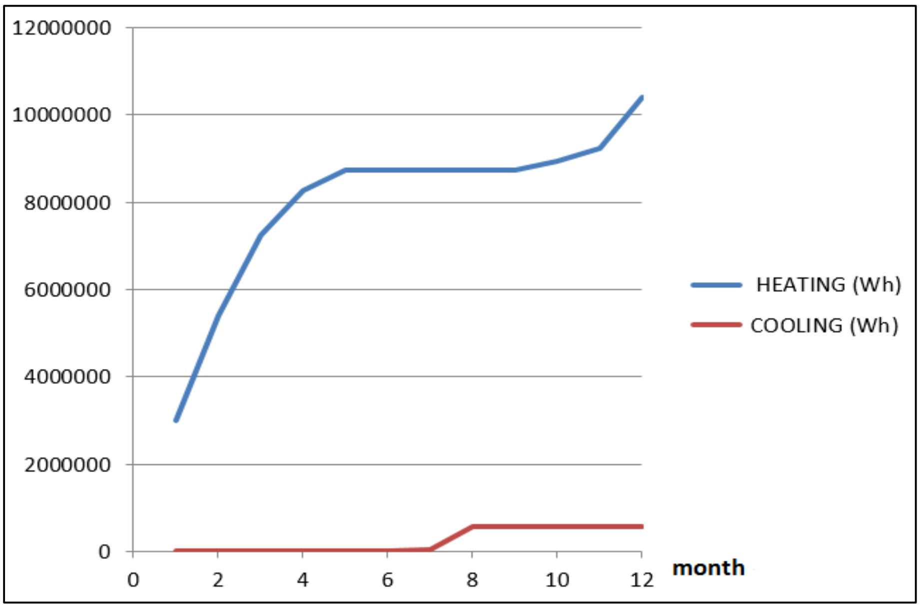


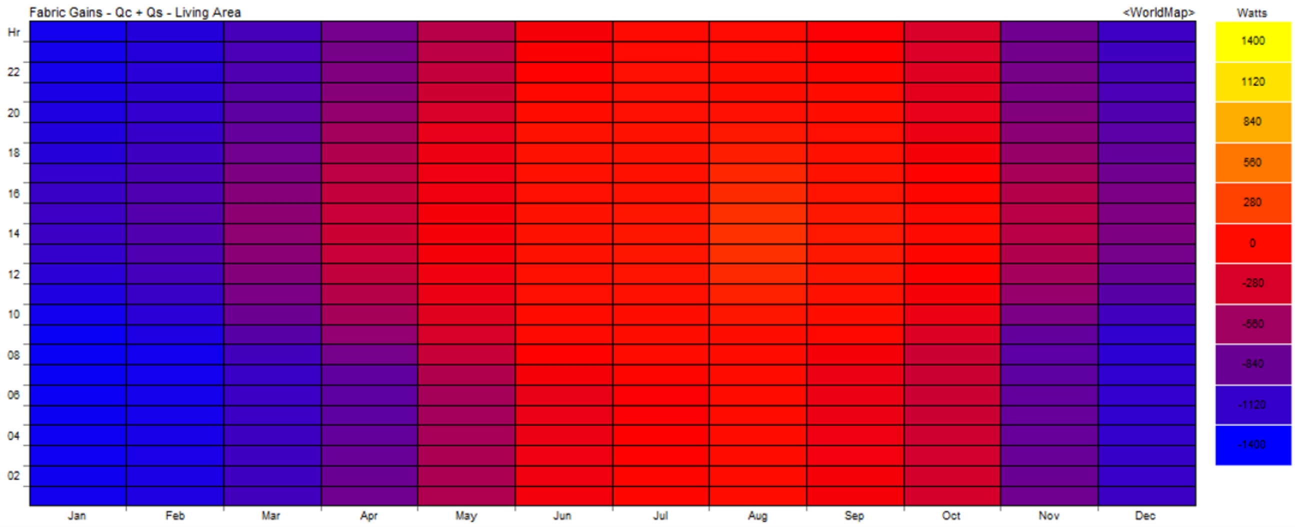
Figure 39: Structure of Polyurethane Coated Timber-frame Brick Wall.

Annual heating and cooling loads are defined as below for each month. Total values of loads are indicated in table and graphic as below.



Graphic 13: Heating and cooling loads – Polyurethane Coated Timber-frame brick wall.

Fabric gains can be seen in graphic 14. This graph shows an average day each month, with months along the horizontal axis and hours of the day along the vertical. The color of each grid square represents the average gain or loss. The analysis was performed through living room. Gains and losses are the average values for the whole room structure. This shows that heat gains from the building fabric, due to both external temperatures and incident solar radiation, occur mainly all the time in summer. In winter, heat losses increases and losses continues throughout the winter.



Graphic 14: Fabric gains – Polyurethane Coated Timber-frame brick wall.

Comparison

1) Timber-frame brick wall U = 0.89 W/m2*K

2) Stone material U = 1.8 W/m2*K

3) Polyurethane coated Timber-frame brick wall U = 0.55 W/m2*K

Material	1	2	3
U (W/m2*K)	0,89	1,8	0,55
Annual Heating Load (kWh)	13074	17177	10218
Annual Cooling Load (kWh)	585	692	582

Graphic 15: Comporison of heating and cooling load for different type material.

The original material of house Timber-framed brick wall is more efficient than stone wall and if it is coated with polyurethane foam, the efficiency of wall will be increases with decreasing of heating load that can be seen in results as above.

d) <u>Shade Effect of Components</u>

Roof extension and Balkony creates shadows around the house and roof extension blocks sunlight which directly comes to windows especially. The analysis performed with roof extension and without roof extension. As a result, extensions are very important component of house because it creates certain shade through the windows and decrease the energy consumption for cooling.

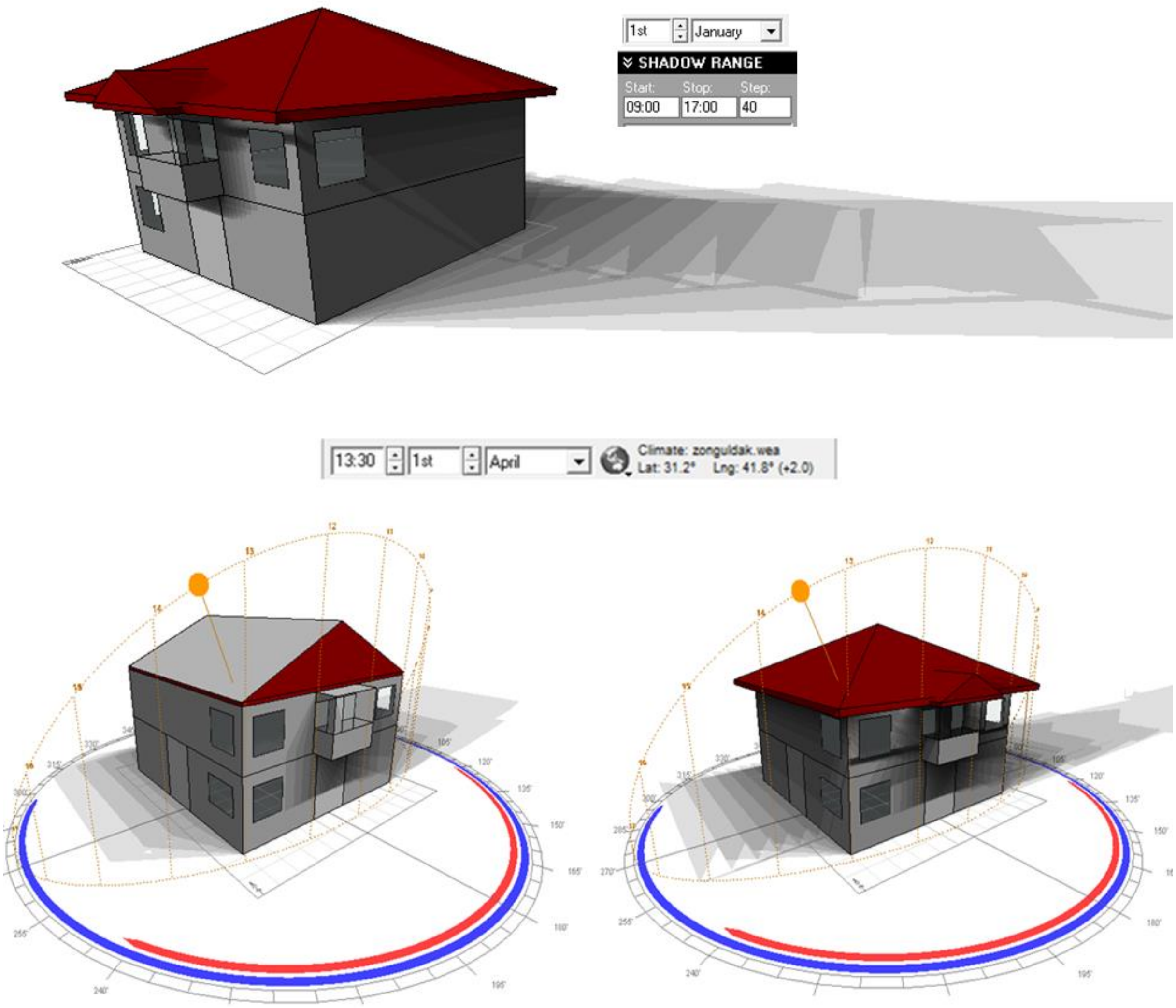


Figure 40: Shade element and effect of shade element.

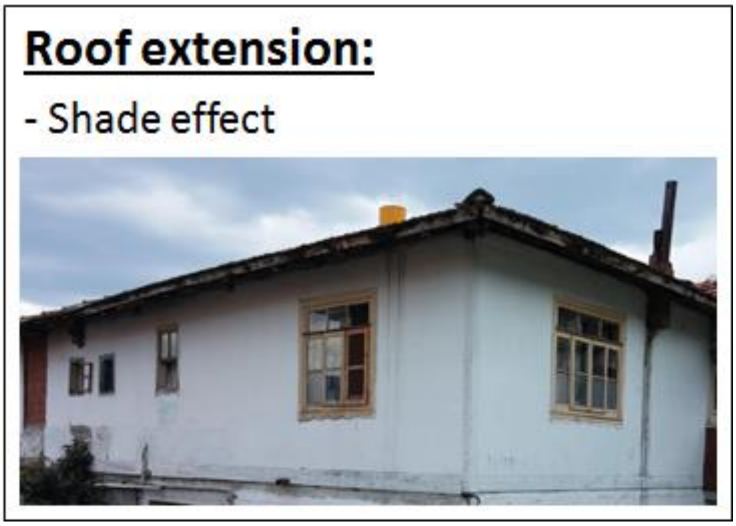


Figure 41: Shade effect of roof extension.

6) DISCUSSION AND CONCLUSION

In this house, certain techniques are used for improve their comforts at house and built a solid house. Materials which are available in Black Sea region are used for construction and provide low energy consumption, strength, a renewable and recycling building and ease of maintenance. Lack of sufficient maintenance causes troubles and inefficient building which is acceptable for this traditional house. Besides, certain structural techniques which are similar for other Black Sea houses are improved. The house is constructed depending on the terrain and existing vegetation and natural systems are intact.

Suitable planning of windows and spaces between wooden materials provide air circulation through structure which has a great effect on low energy consumption depending on conditions of materials. Windows also can decrease energy consumption with permitting of day light. Moreover, in Black Sea region, local people generally have agricultural works and this is reverberated to the structure with barn area and serender.

The biggest problem for this house is about maintenance. Even if materials can be easily provided from nature and re-cycled, people who are living here at the present time do not care about maintenance so troubles and inefficiency occur. Furthermore, the amount of annual rainfall is high for Black Sea region however water scarcity can be occur at summertime because of weakness of transmission lines so water can be collected in barrel and used for irrigation.

Heating and cooling loads were compared for the original material of house Timber-framed brick, alternative material stone wall and polyurethane coated Timber-framed brick. The U value of Timber-framed brick is higher than TSE 825 value because of facilities and materials at construction year of house but better than stone wall. The structure can be more efficient with polyurethane coated Timber-framed brick. Moreover, Shade elements creates sufficient shading throughout building which provides energy efficiency with decreasing of cooling load.

Traditional Black Sea houses were designed by considering lots of factors and every factor has an important influence on houses. People improved some certain techniques which were occurred because of needy. At first, the used techniques were developed spontaneously but years later, experience and knowledge combined with these techniques and people built their houses for a comfortable living. With this study, a traditional Black Sea house examined and this is understood that every structure has a cause and effect through material selection, climatic conditions, culture, availability to materials, habits and the other things. A structure gives us a lot of information about people who were living there, and region.

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