IJBES

International Journal of Built Environment and Sustainability
Published by Penerbit UTM Press, Universiti Teknologi Malaysia
IJBES 10(3)/2023, 1-11

Climate-sensitive Design in Traditional Residential Architecture: Kars Karakurt Houses

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ABSTRACT

Design based on performance and energy efficiency is important in residential buildings. The design approach, which considers climatic data and energy conservation, was also used in traditional building design. In this context, it is aimed to evaluate the Karakurt houses in Kars, built during the Russian occupation period (1878-1918) in Turkey, within the scope of climate-sensitive design. The inadequacy of studies in the literature on Kars Karakurt houses, which are traditional architectural examples that preserve the original texture of the region as qualified representatives of Baltic architecture, constitutes a research gap. In this study, qualitative and quantitative research methods were used. The architectural plan and facade typologies of the buildings in Karakurt village were obtained by measuring techniques and tools. In the qualitative research part, information about the buildings was obtained from on-site investigations and a situation analysis was made. In the quantitative research part, orientation analyses of buildings and spaces, and window-wall area ratios of facades have been evaluated according to climate-sensitive design approaches. In the research findings, design criteria such as plan, facade, roof and material properties of 10 Karakurt houses, were examined and it was seen that the buildings were standardized within the scope of climate-sensitive design. It is seen that the north direction, where the wind is dominant and the sunlight penetration is the least, is not preferred for the orientation of the buildings and the space, and the window/wall area ratio is kept to a minimum, reducing the energy loss especially due to the openings.

Article History

Received : *8 December 2022*
Received in revised form : *8 April 2023*
Accepted :*15 May 2023*
Published Online : *31 August 2023*

Keywords:

Baltic architecture, Climate-sensitive design, Karakurt houses, Residential building, Russian period architecture, Traditional architecture

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DOI: 10.11113/ijbes.v10.n3.1088

1. Introduction

Today, buildings represent one of the most energy-consuming economic sectors. In parallel, buildings are also responsible for approximately one-third of global greenhouse gas emissions. At this point, there is a need to reduce energy demand and replace fossil energy sources with renewable energy sources to solve these problems (Bot et al., 2019). In Europe, buildings account for about 40% of the energy consumption, which is an important part of the economy. For this reason, energy efficient buildings that consider energy efficiency criteria have been included in the energy policies of many countries. New standards have been introduced in energy policies that may vary from region to region (Michalak, 2019; Jakubcionis and Carlsson, 2018; Çakıcı and Sorguç, 2009). Traditional buildings are role models today with their energy efficient design approaches (Manurung et al., 2022).

With the need for housing from the past, plans have been made according to solar, wind and other environmental factors (Leng et al., 2019). Necessary comfort conditions are provided in the building by considering the climate factor (Angın et al., 2020).

Providing energy efficient solutions in traditional buildings reduces energy consumption and carbon emissions (Webb, 2017). Traditional building typology differs from other buildings in terms of physical characteristics (Er Akan et al., 2021). In these buildings, where local construction methods and natural materials of the region are used, there are door and window openings and natural ventilation systems (Cantin et al., 2010). The circulation of energy in traditional buildings also contributes to sustainability. For this reason, traditional buildings can continue their functions without being destroyed (Carbonara, 2015). To ensure sustainability, annual energy consumption and carbon emission parameters should be examined, considering into account environmental conditions (Bellia et al., 2015; Ascione et al., 2011). It can be inferred that the buildings that have survived to this day and have been largely preserved, are minimally affected by the harmful effects of the environment and have a high capacity to adapt to the climate of the region in which they are located (Er Akan et al., 2012; Smit and Wandel, 2006; Er Akan and Çakıcı, 2005). The building materials of traditional buildings are also important in transferring the building stock to future generations by affecting the energy efficiency. Considering the local climatic conditions and traditional buildings that provide advantages in natural factors such as heat, lighting and ventilation, it is seen that the use of natural building elements such as porches, skylights, stone and adobe walls is common. It can be said that the building elements, which are supportive of maintaining the natural balance, positively affect the energy performance (Takva et al., 2022; Hegazi et al., 2021, Örmecioğlu et al., 2013).

In the literature, there are studies on energy in buildings built with traditional and local materials. Dehshiri (2022) investigated the usability of hybrid energy systems on traditional buildings due to the dense population and pollution in the city of Isfahan, Iran. Six scenarios for renewable energy systems have been proposed. Evaluations were made with the use of multi-criteria decision-making method and software. Orman et al. (2022) studied the thermal comfort of traditional and smart buildings in Poland. A subjective evaluation of indoor conditions was performed according to occupants' thermal senses and preferences. Survey studies were conducted out together with physical measurements depending on the air temperature and relative humidity. Shadmand and Arslan Selçuk (2022) identified climate-responsive architectural design elements and approaches in the traditional Tabriz houses, located in the cold-arid climatic zone. Közoğlu et al. (2022) calculated the annual energy consumption of traditional Sille houses in Konya using a software program. According to the results, the factors affecting the annual energy consumption were examined. Salom et al. (2021) made an energy assessment of traditional buildings in sustainable positive energy regions. Using a holistic methodology, the keywords of energy and power performance, flexibility, greenhouse gas emissions, indoor environmental quality, cost, sustainability and smartness are emphasized. Obafemi and Kurt (2016) investigated the carbon emission and annual energy consumption of the building using a computer-based simulation method on a traditional adobe building in Northern Cyprus. The energy efficiency of the adobe building material is highlighted. Asadi et al. (2016) investigated Yazd traditional houses and their thermal behavior in Iran. The thermal performance of these houses in summer was examined with an energy software. Oikonomou and Bougiatioti (2011) presented the bioclimatic and environmental aspects of traditional architecture in the town of Florina, located in the northwest region of Greece. The building typology, thermal behavior of the building envelope and thermal comfort conditions of forty buildings that have survived from the 19th and early 20th centuries were examined.

The number of studies on the efficient use of energy in buildings is increasing day by day. Because of changing climatic conditions and economic fluctuations, the efficient use of energy resources has come to the fore. The fact that the houses that make up the living spaces are at the top of energy consumption shows the need for solutions. Climate-sensitive design plays a key role in this respect. Designing the buildings according to the climatic conditions of the region ensures the effective use of energy resources. Traditional houses, where energy is used effectively and efficiently, constitute the scope of the study. In this study, it is aimed to evaluate the climate-sensitive design principles in traditional residential buildings. When the literature studies were examined, the parameters of photovoltaic panel, thermal comfort, indoor environment and annual energy consumption values were analyzed in traditional buildings. In these studies, the lack of space orientation and window/wall area ratio analyses was observed as a research gap. In addition, the limited information about Kars Karakurt traditional houses in the literature shows the importance of this study. Traditional Kars Karakurt houses were selected for analysis by privatizing residential buildings and were examined according to climate-sensitive design criteria. Inferences were made considering the climate of the region.

2. Climate-Sensitive Design

The increase in the demand for energy and the consumption of natural resources affect the climatic conditions and ultimately cause climate change and global warming (Alrashed and Asif, 2015). Because of global warming and climate change, sea-level rise, seasonal irregularities and natural disasters occur. Considering that climate change has a negative impact on humans and natural systems, nations and companies have started to work on this issue (Sánchez et al., 2020). Comprehensive support packages based on gradual and intersectoral actions are prepared in cities by conducting research on this subject to adapt (Aguiar et al., 2018). It is aimed to support sustainable developments with the Paris Agreement, which is a global agreement to deal with energy and environmental problems that have negative effects of climate change. The construction industry is also affected by climate change. At this point, the building stock is one of the main areas in the development of sustainable standards (Khan and Asif, 2017). Due to the synergy between climate conditions, global warming and urban heat island effects, energy performance in buildings significantly changes (Yılmaz et al., 2021).

Developing designs according to climate has cost-effective solutions. Savings and improvements can be made in energy efficiency and renewable energy integration with heating and cooling systems in the thermal environment (López-Ochoa et al., 2019; Congedo et al., 2015). Climate change should also be considered in buildings. By taking strategic measures against climate change, energy efficiency arrangements should be made for existing housing stocks (Soutullo et al., 2018). A balance of indoor air thermal comfort must be achieved within the framework of energy reduction potentials (Wan et al., 2012). Thermal energy storage systems also constitute advanced energy technologies that improve the sustainability of buildings and energy efficiency (Zhu et al., 2009). Strategies such as reducing energy demand, adopting passive systems and optimizing the energy efficiency should be developed to reduce energy usage in buildings and the impact of climate (Mwasha et al., 2011). With the implementation of these strategies, it has been determined that housing costs are balanced compared with a traditional house (Chang et al., 2011). In the literature, studies are conducted on the performance of buildings depending on climate change. In these studies, building simulation approaches are generally adopted to evaluate the impact of climate change on the energy performance of buildings (Ismail et al., 2021).

In the literature, there are many studies in connection with traditional houses using climate-sensitive design approach that constitute the subject of this study. Lin et al. (2022) developed an architectural education program that combines the study of local climate, vernacular buildings, climate-sensitive design strategies, and simulation tools. As a case study, a vernacular building located in a dense area within a hot-humid climate zone in Guangzhou, China was chosen. Features such as climate-sensitive characteristics, sustainable design strategies were tested. Chiou and Elizalde (2019) conducted a study on the indoor thermal performance and climate-sensitive design strategies of three traditional houses in Guanshan town, eastern Taiwan. Keywords such as space usage, thermal insulation and natural ventilation were examined within the framework of design strategies in the hot and humid climate zone. Sim and Sim (2016) analyzed alternative wall solutions with an energy simulation model to improve the energy performance of environmentally friendly South Korean traditional buildings. Five different wall systems were applied to traditional buildings in three different climate zones in South Korea. The system that yields the best solution was given. Nematchoua et al. (2014) conducted a questionnaire-based statistical study of four regions of Cameroon under different climatic conditions. In the study conducted on the inhabitants of the region, questions were asked on thermal comfort and energy consumption. Traditional and modern buildings were compared. Curtis (2010) studied traditional buildings in Historic Scotland due to climate change. It investigated how thermal performance in the traditional building environment can be improved by sensitive intervention. Additionally, inferences were made on passive energy benefits and sustainability. Er Akan and Çakıcı (2005) stated that climatic factors are effective on the design of traditional Turkish houses. The built environment and plan types were analyzed with three case studies selected from different climatic regions of Turkey.

Based on the information obtained from literature studies on traditional buildings, climatic characteristics were considered in the building design. Climatic factors, land use and construction decisions, construction systems and material selection constitute the basic criteria that affect the building design (Çakıcı and Sorguç 2017). Figure 1 shows the parameters affecting the building design. Solar radiation, air temperature, wind speed and humidity are the climate elements that make up the design parameters. Heating indoor environments with solar energy in winter allows for maximize direct solar gains and keep the heat within the thermal mass of the building. Passive solar energy strategies are used on building facades and roofs (Tejero-González et al., 2016). Rapid urbanization and population growth affect land use and construction decisions. The building design should be considered according to the settlement pattern of the location of the building and the flat-slope of the land (Wang et al., 2013). Environmentally friendly and sustainable construction systems and materials that are resistant to harmful gas emissions extend the life of a building. Building elements that offer technological solutions within the scope of climate-sensitive design and that can adapt to the climate zone should be selected (Švajlenka et al., 2018).

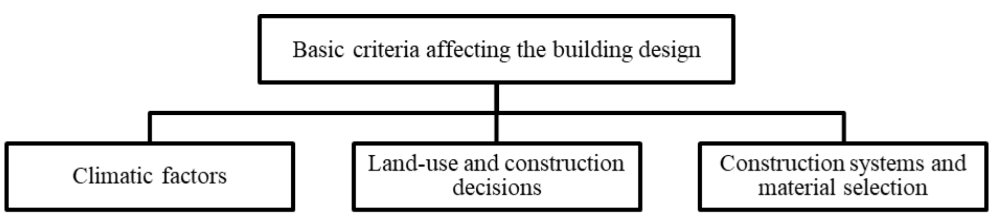


Figure 1 Factors affecting buildings within the scope of climate-sensitive design (by the authors)

3. Methodology

Kars is a city where its traditional and local texture are preserved. In the city, which has been home to different civilizations for centuries, different architectural expressions and variations have emerged along with the cultural diversity. Kars Karakurt, where the traditional and local texture remains alive, was examined in the scope of this study. In this region, where qualified examples of Baltic Architecture are seen, research studies were conducted. In the study, qualitative and quantitative research methods were used (Figure 2). In the qualitative research part, the research methodology was developed by collecting data through observations and documents with the tracking technique. By conducting on-site investigations, information was obtained about the building elements and a situation analysis was conducted. In the quantitative research part, structural scale analyses were performed considering the data obtained. The plan and facade features of the buildings were examined. Within the scope of energy efficiency and climate-sensitive design, orientation analysis of buildings and spaces was made. Additionally, evaluations were made in the context of climate-sensitive design by investigating the window-wall ratios on the facades and building materials used.

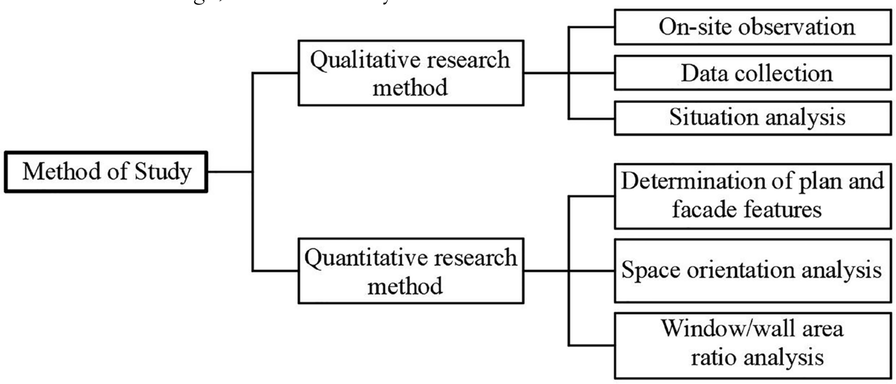


Figure 2 Parameters that make up the method of the study (by the authors)

4. Kars Karakurt Houses

Kars, which has had a dense settlement throughout history due to the suitability of natural conditions and its military and commercial importance, was built on a 1750-meter-high plateau as a military fortress (Kara et al., 2005). Located in northeastern Turkey, Kars has hosted many civilizations for centuries. In the 11th century, the Seljuk Turks conquered the Kars and since then, it has been under the control of different civilizations such as Byzantines, Mongols and Georgians. The Ottoman-Russian War (93 War), which started in 1877, resulted in the defeat of the Ottoman Empire, and Kars, Batumi and Ardahan were left to the Russians (Jukić Buča et al., 2020). With the agreements made with the Russians in Moscow and Kars in 1921, the border between Turkey and Russia was drawn, and Kars and its surroundings joined the territory of the Republic of Turkey. Kars province is located in the northeastern part of the Eastern Anatolia Region, between 42º 10' and 44º 49' east longitudes and 39º 22' and 41º 37' north latitudes and has a surface area of 10,127 km2. (Bilgici Cengiz, 2020). Kars is surrounded by Ardahan from the north, Erzurum from the west, Ağrı from the south and Iğdır from the southeast. Kars province, located on the eastern border of Turkey, forms the border with its eastern neighbor Armenia (Jukić Buča et al., 2020). Figure 3 shows the location of Kars and Sarıkamış on the Turkish map, on the border with Armenia.

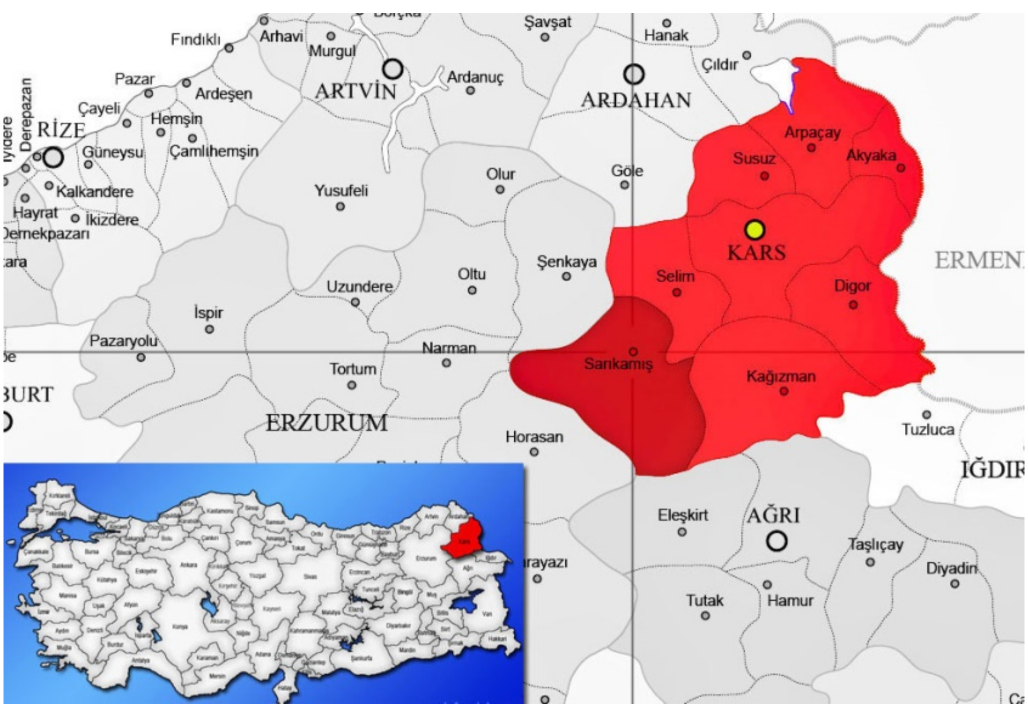


Figure 3 The locations of Kars and Sarıkamış on the map of Turkey (URL-1)

When looking at the residential architecture of the Russian occupation period (1878-1918) in Kars, the houses in the new settlement established in the south of the city are mostly single-storey, but there are also a few two-storey houses. The city was under the influence of Baltic architecture during this period. In the city, which has a grid plan, the houses stretching along the streets consist of rectangular or almost square rectangular geometry (Altunsoy, 2005). In the front row facing the street, there are the rooms and hall, while the back row facing the life, there are the workshop spaces. There are coops, warehouses, toilets and tandoori in the life, which are quite large in most of the houses. There were no corridors in the residential buildings. Transitions between spaces are mostly provided from the middle axis. There are no recessed-protruding surfaces on the house facades (Türkan, 2017). An important element that attracts attention in Russian period buildings is the heating elements called 'peç'. They are designed in a way similar to the heating systems in baths. The number of peç varies according to the size of the house. By using the thickness of the wall, the smoke of the wood burned in the peç spreads through the channels opened in the wall and heats all the spaces of the building by circulating. Peç, which are also symbols of ostentatiousness, are made of sheet metal, iron, or brick, and are the furniture of the house with geometric and plant decorations (Arslan, 2015). In Figure 4, buildings belonging to the Russian occupation period are given. During this period, in addition to the center of Kars, it is seen that similar buildings were built in Sarıkamış, Karakurt village.

Figure 4 Russian occupation period buildings (by the authors)

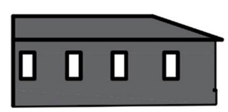
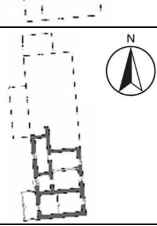
Important buildings of the Russian occupation period are also located in the village of Karakurt in Sarıkamış, Kars. Karakurt village is 80 kilometers avay from Kars city center and 27 kilometers from Sarıkamış district center. Located between the roads to Kars, Erzurum and Iğdır, the village is located in the Aras valley. A continental climate is observed in the region where a village is located. In this study, the residential architecture of the village was examined. The locations of the selected Kars Karakurt residential buildings on the map are shown in Figure 5, depending on the land use and construction decisions at the city scale.

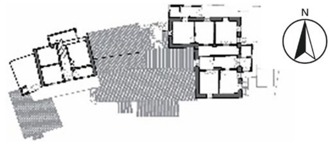
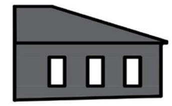
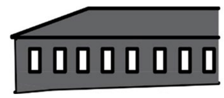
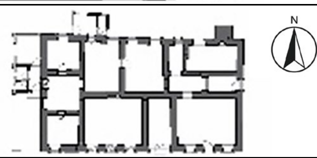
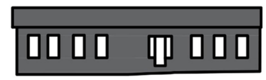
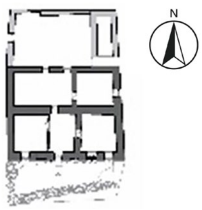
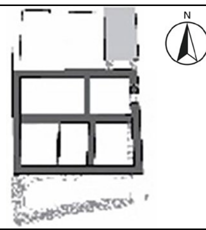
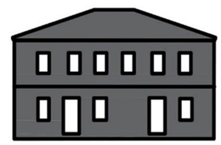
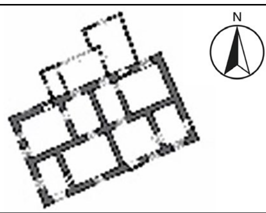
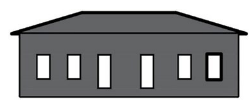
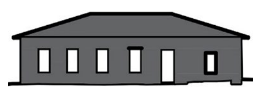
Figure 5 Locations of registered Karakurt residential buildings on the map (by the authors)

5. Findings and Discussions

Ten of the registered buildings that were built during the Russian occupation period and still maintained their originality to a great extent were selected and examined within the scope of this study. When the general characteristics of Karakurt residential buildings are examined at the building scale, it is observed that the plan schemes in rectangular geometry are predominant. While eight of the examined houses are single-storey, two of them are two-storey. Plan schemes and facade configurations of the houses are given in Table 1. When looking at the floor plans and facades of the buildings, it is seen that the buildings usually consist of quadrangular geometry and there is no recess-protrusion on the facade. Window/wall ratio expresses the ratio of the gap ratio (total of door and window areas) to the total of wall areas. As shown in Table 1, the window/wall area ratios of Karakurt houses vary between 5 and 20%.

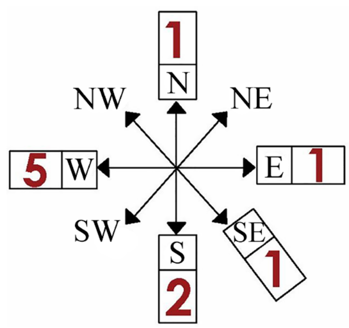
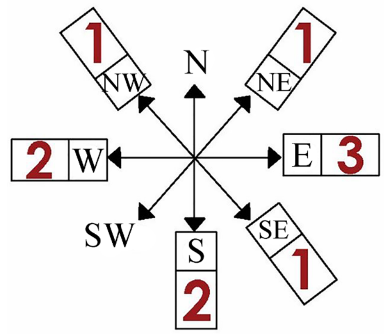
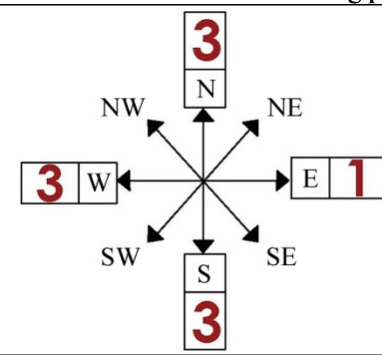
Table 1 Plan and facade features of buildings (by the authors)

Building number	Ground-floor plan	First-floor plan	Building facade	Window/wall area ratio
1		---	 East facade	11%
2		---	 West facade	13%
3		---	 South facade	5%

4			 South facade	11%
5		---	 East facade	16%
6		---	 East facade	18%
7		---	 East facade	20%
8			 East facade	17%
9		---	 Southeast facade	18%
10		---	 Northwest facade	19%
Main building	Added building part(s)			

The orientation of the buildings is also important in the context of climate-sensitive design. When looking at the main entrance orientations of the houses, five buildings face west, two buildings face south, one building faces north, one building faces east, and one building faces southeast (Table 2). When the orientations of the rooms in the house are examined, three buildings are located in the east, two in the west, two in the south, one in the northwest, one in the northeast and one in the southeast. The orientations of the added building parts also vary. Building parts added to three buildings are located to the north, building parts added to three buildings are located to the south, building parts added to three buildings are located to the west, and building parts added to one building are located to the east.

Table 2 Space orientation analysis of Karakurt residential buildings (by the authors)

Main entrance orientation	Orientation of spaces	Orientation of the added building parts
		

W: West, NW: Northwest, N: North, NE: Northeast, E: East, SE: Southeast, S: South, SW: Southwest

There are similarities in terms of building materials in 10 residential buildings in Karakurt village during the Russian occupation period. Metal-sheet coating stands out as a roofing material in all the main buildings and added building parts. It is estimated that the original roofs were covered with tiles, but today it is believed that metal-sheet coating has been switched to enable rapid evacuation according to climatic factors such as snow and rain. It is seen that gable and pitched roofs are preferred as roof forms. The roofs of the added building parts were in the form of porch roofs. Three different stone building materials were used on the facades of the houses with a rectangular plan form. Cut, rubble and chipped stone materials were preferred in the buildings in terms of being suitable for the climate and being ampful in the region. The described properties are given in Table 3. Considering the number of spaces, it is seen that there are seven spaces on average in the buildings. In the buildings where the masonry construction technique was applied, there are kitchens, living rooms and bedrooms. With the increasing needs over time, space additions were made. Among the structures examined, the traditional house with the lowest square meter is 80 square meters. In the added building parts, additions were made up to a maximum of approximately 50 square meters.

Table 3 General characteristics of Karakurt residential buildings (by the authors)

Building number	Main building-roof formation	Added building parts- roof form	Main building-number of spaces	Added building parts-number of spaces	Main building-size (square meters)	Added building parts-size (square meters)	Facade material
1	Pitched roof	Porch roof	7	3	100.56	47.14	Cut and rubble stone
2	Pitched roof	Porch roof	6	1	80.48	11.76	Cut and rubble stone
3	Gable roof	Porch roof	7	2	154.26	9.77	Cut and chipped stone
4	Gable roof	Porch roof	15-15	7	279-231	16.32-25	Rubble stone
5	Pitched roof	Porch roof	9	1	117.38	11.74	Cut and chipped stone
6	Pitched roof	Porch roof	13	4	199.23	14.90	Cut and chipped stone
7	Gable roof	Porch roof	11	5	208.8	25.24	Cut stone
8	Pitched roof	---	7-5	---	103.71-96	---	Cut and rubble stone
9	Pitched roof	Porch roof	8	3	97.19	31.11	Cut and chipped stone
10	Pitched roof	Porch roof	8	2	122.38	6.6	Cut and rubble stone

6. Conclusion

It is seen that the traditional houses in Kars Karakurt village, which has a severe continental climate, are located in a separate order, but close to each other in the street order, do not prevent each other's connection with the sun and do not cause shading. While most of the buildings can be accessed from the west facade, it is seen that the living spaces are located on the east, west and south facades to ensure maximum benefit from the sun's rays. It is seen that the north direction, which has the dominant wind direction and the least sunlight access, is not preferred in the orientation of the buildings and space, and the entrance of the buildings is protected from this direction. At this point, Kars Karakurt houses are designed to be sensitive to climate in the context of the city scale. It is seen that the houses with a compact plan typology have a rectangular plan form and the indentations and protrusions are minimal on their facades, thus minimizing the external facade area that loses energy. It has been determined that metal pitched roofs are used in the houses to prevent rain, snow load and icing, and windbreak areas are created with the added building parts, thus preventing direct heat losses. Additionally, notably energy loss is reduced through openings by keeping the window/wall area ratio at a minimum. These features show that these buildings were constructed sensitively to climate conditions at the building scale. On the exterior, cut stone, which is a local building material and in accordance with the Baltic architecture, is predominantly used. No plaster is used on the exterior, but the thick exterior walls contribute to the thermal performance of the buildings. Additionally, the use of peç systems for heating the buildings in the cold climate zone and where the winter months are harsh due to the continental climate conditions shows the level reached in terms of heating technology. As a result, it was concluded that the traditional Kars Karakurt houses built during the Russian occupation period were designed and built in accordance with the cold climate conditions in the context of climate-sensitive design.

Acknowledgements

We would like to express our sincere gratitude to reviewers for their valuable opinions.

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