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Examination of the Impact of Contemporary Additions on the Historical Building's Energy Performance

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Highlights

- This article focuses on the impact of contemporary additions of historic building.
- An approach to contemporary addition design is proposed in the study.
- The hypothesis was confirmed by a reduction in building performance in the simulation analyses.

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Keywords

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Historical building
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Abstract

Historical buildings are being destroyed over time and energy losses are increasing. Therefore, energy efficient preservation of historical buildings is an important issue. However, the application of contemporary additions has increased in cases such as the revival of building units that have not survived to the present day or when a new post-functional space is required. The aim of this study is to evaluate the impact of contemporary additions on the energy performance of historic buildings through a case study. For this purpose, energy simulation analyzes of the historical Süleyman Pasha Bath in Kocaeli province were performed through Design Builder. Before the simulations applied, information about stone, which is the original material of the building, and glass applied with contemporary materials were entered into the programme. The provinces of Izmir, Konya, Sivas, and Erzurum were selected from five climatic regions for the contemporary additional analysis. In these provinces there are many traditional bathing buildings with similar plan types. According to simulated results, it was concluded that the application of modern additions after the restoration negatively affected the energy performance in all five climate zones. Before applying contemporary additions to historical buildings, factors such as the microclimate, material properties and geometry of the building should be taken into consideration during the design phase and a decision should be made as a result of various analyses. Consequently, when contemporary additions to historic buildings are required, using the most effective construction techniques and materials is important in terms of building sustainability and effectiveness.

1. INTRODUCTION

Increasing energy consumption worldwide, decreasing energy resources and increasing negative environmental impacts in parallel with these developments have been a significant threat for years. The building sector is one of the largest consumers of energy in the world, accounting for around a third of primary energy consumption. [1]. The contribution of the building sector to the global energy consumption is between 20% and 40% in developed countries and this ratio is increasing [2]. Due to this increase in energy consumption and consequent climate change and greenhouse gas emissions, energy efficient building design has become common [3]. In this context, analyzes and interventions that make up the concept of energy efficiency provides sustainable development and reduces emissions to the environment, while reducing energy demand [4]. For this purpose, many countries have developed various energy policies to improve the energy performance of buildings. However, according to the studies of the International Energy Agency (IEA), despite the energy policies adopted by many countries, there has still been no serious improvement in the average energy consumption per capita since 1990 [5]. Energy efficient

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retrofitting of worn-out old buildings has been recognized around the world as a good solution [6]. Energy efficiency in the building sector which can be applied in many ways, offer sustainable potentials to reduce CO_2 emissions and energy consumption of the buildings [7]. Because of these potentials , energy-efficient interventions should also be applied to the worn-out historical buildings without damaging their historical value. Since historical buildings mostly consist of civil architectural or public buildings, they need both renewal with building interventions and energy improvements at certain intervals [3].

Since existing buildings account for 60 percent of total energy consumption, simply building new buildings is not enough to reduce energy consumption. It is important to renew the existing building stock with energy efficiency [8]. Historical buildings, which are part of the existing building stock, are considered as immovable cultural and natural assets that are important to protect in terms of their architectural, historical, aesthetical, archaeological and other characteristics. Historical buildings provide information about traditional construction methods and socio-cultural characteristics by building bridges between the past and the future [9]. Therefore, it is important to preserve the cultural values of historical buildings. In addition to preserve the unique values of historical buildings, it is very important to increase energy efficiency. However, energy efficient renovation of historical buildings is more difficult due to the conservation status and strict regulations [10]. Restoration, protection and reuse of historical buildings can not function currently is a common and beneficial process in terms of sustainability [11]. In this process, cultural heritage conservation involves the highest quality renovation work to preserve the original cultural value, while aiming to reduce energy and emissions through the use of new technologies and materials. [12]. It is seen that a contemporary addition is made if the original elements of the historical building are damaged or lost or if there is no solution to today's needs [13]. However, while adding contemporary additions to the historical building during the restoration process, the effect of this addition to the energy efficiency of the building is not taken into consideration. Nevertheless, this is an important issue for the sustainability of both cultural heritage and energy and should not be neglected. Although this is an important issue worth examining, it is seen that it has not been adequately studied in the literature [14].

In restoration process of historical buildings, a new and contemporary addition can be applied which is different from the original material. Contemporary addition reflecting architectural traces created in certain periods. It affects many factors such as social, cultural, cost, aesthetics and energy on a wide scale, from the building scale to the global scale [15]. This study aims to evaluate the impact of the contemporary addition to the restored historical buildings in terms of energy efficiency, depending on various climatic regions and the use of different materials. Because the impact of contemporary additional applications on the whole building and its surroundings throughout its life is an important issue that needs to be addressed and researched. Historical buildings are so important that they cannot be replaced. Therefore, any intervention in them must be based on a multifaceted approach. In addition, another aim of the study is to determine the effect of contemporary additions according to climate, and it is expected that the study will create suggestions for traditional bath building with similar plan types in other provinces of Anatolia. In this way, attention is drawn to the effect of parameters changing according to the relationship between material use and climate on annual energy consumption. It is desired to raise awareness about the impact of the interventions throughout the life of the building. In this study, the Süleyman Pasha Bath in Kocaeli was examined and how the contemporary additions to the historical buildings affected the energy performance of the building was analyzed through variables. The methodology applied in this study consists of three steps: The first step is to create the dynamic energy simulation model of the building, the second step is to convert it into an energy simulation model using the collected data, and the last step is to analyze the results and compare them with the original condition of the building.

2. LITERATURE REVIEW

There are many studies examining design and construction techniques to reduce the energy consumption of buildings and their impact on the environment. Additionally, improving the energy efficiency of existing building stock is increasingly addressed [16]. In the study, a source search was conducted using three keywords consisting of the concepts of "energy efficiency", "historical buildings" and "contemporary addition". As a result of the research, many studies can be seen in the literature addressing the improvement of the energy performance of historical buildings. In these studies, it was seen that simulation or optimization were used as analysis methods.

Among the studies that analyze with the energy simulation method; Calcerona et al. [17] in their study al. aimed to propose a workflow to increase the efforts of public local authorities and conservation specialists to improve the energy efficiency of the historic building stock. The study also aimed to demonstrate the scalability of historic buildings in the Mediterranean region. For this purpose, 9 case studies from 7 different Mediterranean regions were studied. In order to improve the energy and environmental impacts of publicly owned historic buildings through case studies, interventions were proposed through Building Information Modelling (BIM) programme and a workflow was developed to test its reliability. Fedorczak-Cisak et al. [18] studied energy improvement without damaging the historical value of a historic wooden building in Poland. In this study, strengthening methods were proposed by making on-site measurements and recommending internal insulation, comparing the measurements and simulation results before and after insulation. Galbiati et al. [19] developed a framework on energy efficiency by ensuring the reliability of the model produced in a pre-intervention simulation programme (WufiPlus), emphasising the importance of the historic building stock. In the study, a process consisting of sensitivity analyses, calibration and validation was managed through the model of the Chauderon Administrative Building in Lausanne. As a result, a validated renovation proposal has been developed that improves the current energy performance, reduces costs and preserves cultural values. In the study of Onecha and Dotor [20], they worked on improving the internal thermal comfort conditions of the historical Maria del Mar Basilica in Barcelona. In the interior thermal conditions of the basilica, the problem of extreme heat in summer and extreme cold in winter is observed. In the study, it was shown that thermal comfort could not be provided with passive conditions and optimum solution proposals were studied. According to the conditions of the building, a single and effective active system was developed on three rules and a proposal for energy management was presented. Danial et al. [8], presented energy retrofit through a case study through BIM programs, with an emphasis on retrofitting existing buildings. The study proposes a framework for BIM and retrofit integration, aiming for a 68% improvement. Etemad et al. [21], aims to provide improvements in the amount of energy consumed by working on cooling systems due to changing environmental conditions in historical museum buildings. In the study, a BIM-based building energy model was created and thanks to the recommended retrofit strategy, an approximately 31% decrease in the estimated building thermal comfort average was achieved. On the other hand, Lucchi [22], drew attention to the issue of balancing cultural heritage and energy conservation by developing certain standards, policies and innovative technologies. The study aimed to create an up-to-date perspective on the applications that can be utilised from renewable technologies in a heritage-compatible manner. Design criteria, acceptability and practical approaches are identified and advanced solutions and future perspectives are developed. Timur [23] worked on thermal improvements in traditional buildings with outer sofas over urban and rural Muğla residences. According to the Design Builder simulation results, it has been shown that thermal insulation applications was applied to provide significant improvements in the thermal performance of the building. With these improvements, it has been determined that 38.0% savings are achieved in the total energy use of buildings for urban sub-settlement and 49.4% for rural settlements.

Among the studies that analyze with the energy optimization method; Han et al. [24] in their study, In their study, aimed to provide zero energy by proposing solar renovation in traditional courtyard residential buildings. Energy simulation (BESI software) was performed with the system integrated without disturbing the shell of the historical residential building. Optimization studies were carried out on the most suitable panel system, area, size and placement angle for the proposed system. In the study, significant progress has been made in producing cultural heritage conservation energy requirements. Huo et al. [25] developed an algorithm to evaluate and optimize the technology used in retrofit projects for energy efficient renovation of existing buildings. Thanks to the multi-purpose optimization model developed, the technology combination suitable for the building in hot weather in summer and cold in winter can be determined. Stellacci et al. [26] proposed a computational approach that takes into account climate change for historic buildings in extremely harsh climate zones and proposed an energy retrofit organized according to specific parameters. The proposed model is a synthesis of a parametric tool (Grasshopper) and multi-criteria decision analysis to evaluate the proposals varying according to carbon footprint, energy consumption and architectural configuration parameters. Milic et al. [27] in their study, studied life cycle cost (LCC) optimization for 12 different building types of historic buildings in the Northern European climate using by software (OPERA-MILP). In the study, a cost-effective heating system was selected to improve energy renewal and environmental performance. The study also achieved a reduction in LCC costs between almost 12% and 38%. Bakonyi and Dobszay [28] aimed to reach the most ideal window solution by creating window groups in appropriate optimization and comparing window solutions with the MATLAB-based dynamic energy simulation software, EPICAC-BE, which they developed for the window renewal of historical buildings. Rospi et al. [29] in their study, they used a method based on in-situ measurements and energy simulations from three historical buildings in the city of Matera, Italy. By using the Energy-Plus program, two different thermal system improvements were analyzed, and the optimum improvement proposal was determined.

The main aim of the energy improvement is to strengthen the historical buildings by preserving its original value, to provide the necessary services with minimum energy by ensuring the comfort of the building users, and to benefit from renewable energy technology to meet the energy needs of the building. [30]. The overall aim of the energy improvements is to reduce the total energy consumption and carbon emissions of the building. However, the implementation of these reinforcement works in buildings with historical value and built with traditional techniques brings some difficulties. Therefore, energy retrofits of historical buildings are interventions that do not damage the external appearance of the historical building, do not cover its historical value and include a complex balancing system that will provide a long-term useful life [31]. It is seen that passive strengthening techniques, which do not change the appearance of the facade, are mostly used in the strengthening of historical buildings. In historical buildings, there are examples where active systems are applied in a way that does not change the external appearance of the building, to the extent permitted by the conservation rules. It is aimed to minimize energy consumption by integrating these systems into the historical building. However, since active energy systems are an important intervention decision in the historical building, it should be investigated and examined in detail before this decision is taken. When existing studies are examined, it is seen that applications such as radiant heaters, fan coil units, underfloor heating, heat pumps and air conditioning systems are preferred from Heating, Ventilation, and Air Conditioning (HVAC) systems to solve the heating and cooling problem in cases where passive systems are insufficient [32-34].

Although there are many studies on the energy performance of historical buildings, there is very little research on the energy performance of new and contemporary additions to historical buildings after restoration. Within the scope of this study, a hypothesis was established that these contemporary additions, which reflect today's technology have a negative impact on the energy performance of the historical building. To test this hypothesis, the energy consumption values of the building were analyzed with the simulation results and numerical data were obtained. The novelty of this study is the evaluation of the energy efficiency scenarios of a restored historical building with a contemporary addition based on energy simulation according to material and climate data variables. It is expected that this gap in the literature will be filled with this study and other studies to be developed by making use of computer technologies.

3. MATERIAL METHOD

In this study, examinations were made on the historical Süleyman Pasha Bath located in Kocaeli in the Marmara Region of Turkey. As a result of the restoration works initiated in 2010, the effect of the contemporary addition on the energy performance of the building was examined. The reason why this historical building was chosen as a case study is that the building, which has undergone a significant restoration process, has historical and cultural value. In addition, it has undergone a functional and user profile change with the addition of a space built from contemporary materials after the restoration. The contemporary addition to the building has been selected as a case study because it is enough to form a space and it is thought that it will affect the energy performance of the building. In the analyzes made on the historical bath, the energy simulation method was used with the Design Builder program.

3.1. Kocaeli Süleyman Pasha Bath

Süleyman Pasha Bath, also known as Dere Bath and Yukari Pazar Bath, located in Kocaeli Akçaova Neighborhood, was built during the Early Ottoman Period by the prince Süleyman Pasha, who also had the Orhan Gazi Mosque built. One of the many works that Süleyman Pasha had built in Kocaeli, the Suleyman Pasha Bath is the earliest dated Ottoman Period bath building in Kocaeli that has survived to the present day. The epitaph on the building does not exist today.

The restoration works of the bath, which was seriously damaged in the 17 August 1999 Earthquake, started in 2010 [35]. Instead of the coldness space that has not survived until today, a glass addition built with contemporary materials. This contemporary construction was added to the front façade of the existing bath building for the need of cafeteria space required by the new function. At the base of the cafeteria, a reinforced concrete foundation was used, unlike the warm and hot areas. With the contemporary additional intervention, the total area of the cafeteria space has shrunk compared to its original condition (dressing hall). The historical bath continued as a museum until before restoration. However, after the restoration, it gained the functions of both a museum and a cafeteria [36] (Figure 1).

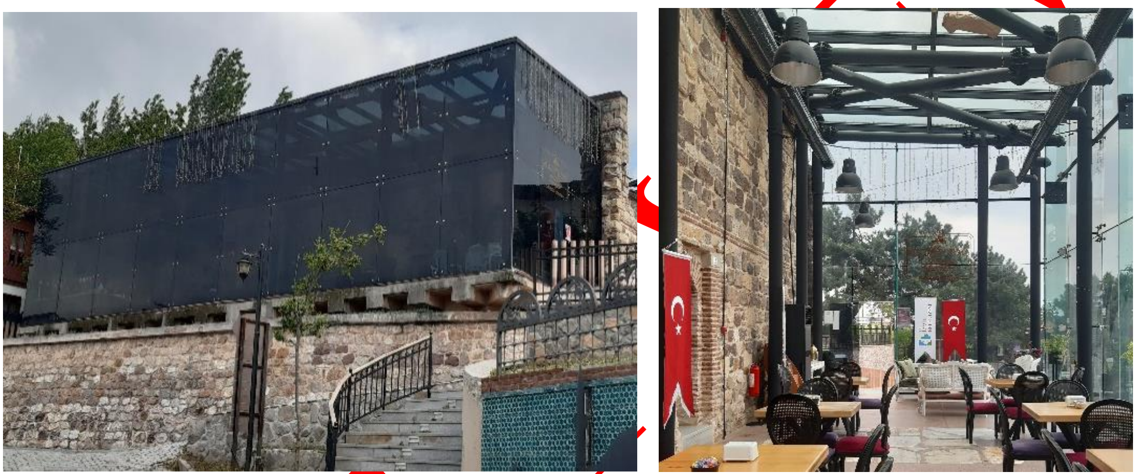


Figure 1. *Suleyman Pasha Bath and Cafeteria Space After Restoration (Personal Archive)*

3.1.1. Architectural features of Süleyman Pasha bath

Süleyman Pasha Bath is located in Akçakoca Neighborhood in Kocaeli on section 85, block 368 and parcel no. 4 (Figure 2). It was built by Süleyman Pasha in the 14th century in the Early Ottoman Period as a double bath separately for men and women. As a bath plan feature, it consists of dressing hall, warm area and hot area, respectively (Figure 3). Since the dressing hall could not reach the present day and was destroyed, it was rebuilt with the restor-ations and started to serve as a cafe. There are man's and woman's toilets in the east and west directions. The woman's toilet in the western direction is covered with a dome. It is possible to pass from the warm areas to the toilets on the side. The hot area and the warm area are covered with double domes. However, the height of the dome of the warm room is higher than that of the hot area. The domes are plastered on their inner surfaces and naturally illuminate the space with elephant eyes. There is a furnace and water tank throughout the north of the hot areas [35]. In Klinghard's research and his surveys in 1925; The dressing room, measuring 9.50 m x 9.50 m, warm room is 3.85 m. x 3.60 m and hot room is 3.85 x 3.85 m. It is stated that the spaces are covered with a double dome [37]. For these reasons, these comments can be reached about the plan features of the dressing hall that have not survived to the present day. Klinghard's surveys were also helpful in the pre-restoration model of the building created in the simulation program.

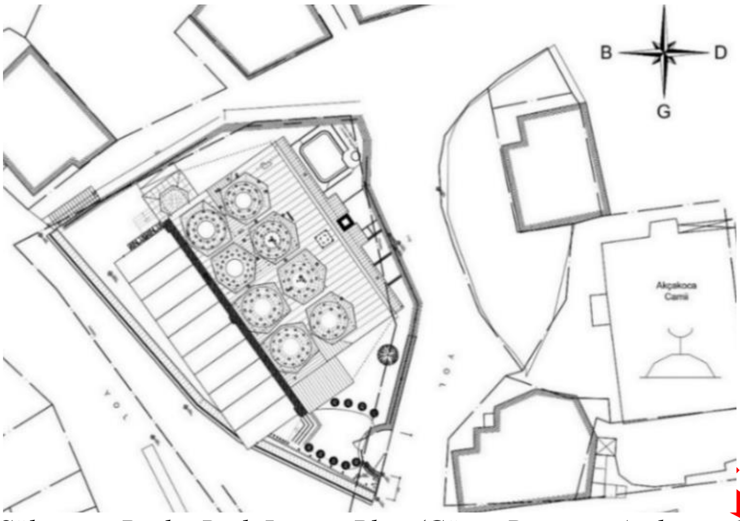


Figure 2. *Süleyman Pasha Bath Layout Plan (Güner Design - Architect Gülhan Dilaver)*

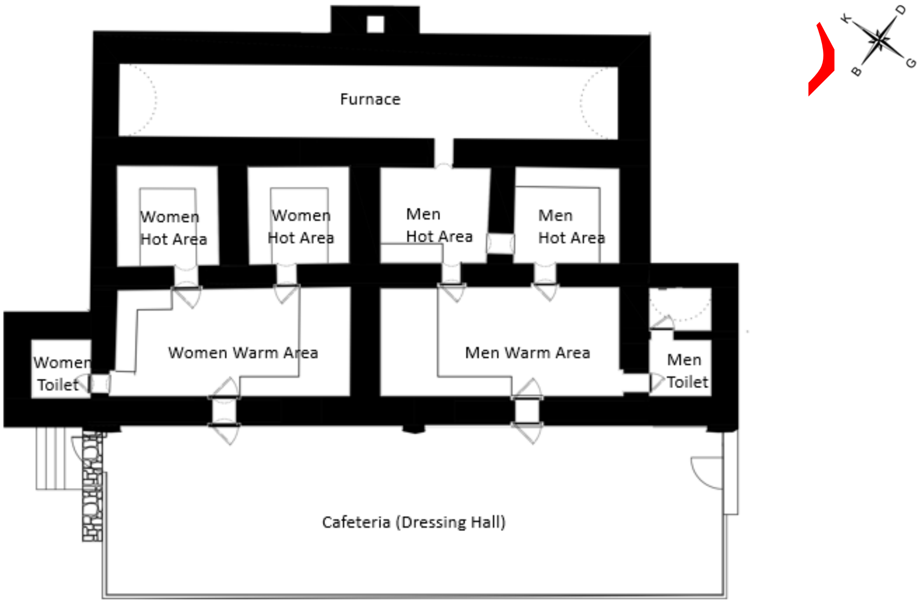


Figure 3. *Süleyman Pasha Bath Ground Floor Plan (Güner Design - Architect Gülhan Dilaver)*

3.1.2. Material features of Süleyman Pasha bath

Süleyman Pasha Bath consists of dressing hall, warm and hot areas in accordance with the traditional Turkish Bath culture. Warm and hot areas are covered with a dome by using pendentives, one of the transition elements to the dome. The dome covers are built with brick materials, but the inner surfaces of the dome are covered with plaster. The diameter and height of the dome covering the hot area is larger than the dimensions of the warm area. The facades of the bath were built in an alternating pattern from a mixture of stone and brick. However, the restaurant, which was built instead of the dressing hall of the building, which has not survived, is made of glass and steel materials, unlike the original material of the building. The façades of the building are generally built without windows or with small windows for privacy reasons in the traditional bath culture. Marble was used in the interior floors and basins of the bath. There is a glass floor measuring 1.51x1.28 m in the male and female warm areas of the bath (Figures 4-5).

Figure 4. *Suleyman Pasha Bath Warm Area and Hot area material details (Personal Archive)*

Figure 5. *Glass Flooring Detail of Warm Area and Süleyman Pasha Bath Toilet (Personal Archive)*

3.2. Method

The historical bath, which is the case study, needs to be analyzed due to the changing user profile and thermal conditions with the contemporary additional intervention. Therefore, simulation method was used to analyze the energy performance of Süleyman Paşa Hamam after restoration. The scope of the performance analysis is limited by evaluating the annual heating and cooling loads. In addition, the function and material variables of the building were assumed based on the existing conditions before and after restoration. According to these assumptions, the original condition of the historical bath building and its present-day addition were compared, and the energy loads were analyzed. Since the function of the historical bath before the restoration was a museum, the function definition was made by paying attention to this in the simulations. After the restoration, the comfort conditions of the spaces of the building, which functions as both a museum and a cafe, have changed. To determine the impact of this situation on the energy performance of the building, the restoration plan of the building was obtained from the author of the restoration project of the Süleyman Pasha Bath. In the second stage, the building was modeled with the help of the selected energy simulation program, and necessary material definitions and climate data were entered. According to the determined scenarios, the simulation results of the pre- and post-restoration situations were obtained. According to these results, the effect of contemporary addition on energy performance in various climatic regions was analyzed.

In the study, the Design Builder program was chosen as a building energy simulation tool due to its many positive contributions such as ease of use, ease of access and various analyzes. The Design Builder program, which is an Energy Plus based energy simulation tool, provides easy use thanks to its clear interface. In addition, it allows the building to be examined to be modeled in the program as well as to create the model in another program and transfer it to the Design Builder program. At the same time, the program has the feature of evaluating the energy performance of the building according to various conditions, calculating heating and cooling loads, making lighting calculations, daylight analysis, determining user density and analyzing many evaluations such as CO_2 emission. While making these evaluations, it provides the user with the opportunity to benefit from the features of the materials and construction elements in own extensive library in the designer's model and to evaluate the effects of various materials and methods [38]. Solmaz [39] compares 9 building performance tools and it is revealed that the Design Builder tool provides many opportunities and is recommended according to today's requirements. Also Tayari and Nikpour [40] validated the Design Builder program on a traditional courtyard house. According to the comparative analysis of the simulation results and the experimentally measured results, the performance analysis of the program was verified since the difference was less than 10%. Similarly, according to the calibration study conducted by Abba et al. [41] the Design Builder program is recommended to be able to predict indoor thermal comfort and roof thermal performance. After the selected simulation program, in order to reach the desired analyzes in the study, two types of models were created as before and after the restoration. The first model was made according to the original plan and material of the dressing room, which was destroyed (Figure 7). In the second model, the cafeteria space addition after the restoration is modeled (Figure 6).

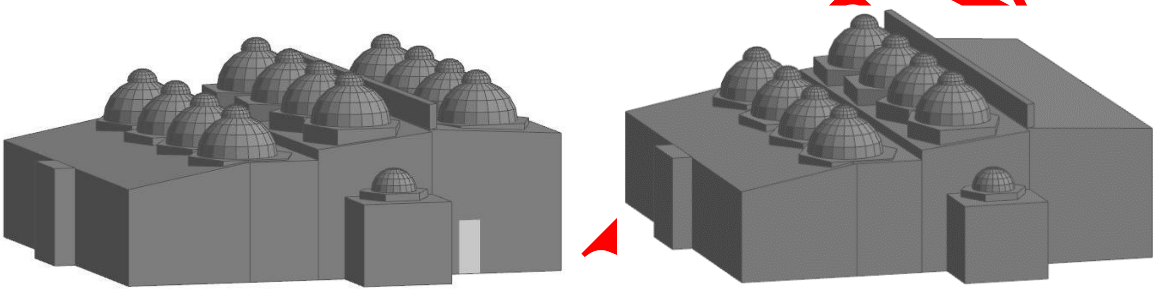


Figure 6. *The model of Süleyman Pasha Bath before and after restoration created in the Design Builder*

Along with the spaces of the building have different heating, cooling and ventilation systems from each other, the usage function of each space varies according to the user density, heat gains and losses. Each group that shows similar work in this diversity is called a zone. Each zone is defined independently as it has different characteristics. Therefore, the spaces of the building are divided into various zones according to their heating and cooling properties and indoor activities. Information about the usage time interval of the zones, the average temperature of the place, the heating and cooling system used are entered (Table 1). The spaces of Süleyman Pasha Hamam are used every day between 12:00 noon and 20:00 on weekdays and weekends. No HVAC system was used in the warm and hot areas of the bath. In the cafeteria space, 4 pedestal split air conditioners are used (Figure 7). Today, the warm and hot areas, which do not serve as a bath, function as a museum so that those who come to the cafeteria can visit. Before the restoration, the building was not used as a bath and served as a museum for years. While defining the function in the model, the existing function before and after restoration was considered. Therefore, while the thermal zones are defined in the models, the warm and hot areas are entered in the museum function in both models. The functions of these areas were considered constant in the analyses.

After the modern addition to the Süleyman Pasha Bath, both the building envelope material and space function have changed. This change effected the thermal comfort expectations in the interior space. The space, which functioned as a museum before the restoration, started to function as a cafe after the modern addition. It is ideal for the museum interior temperature to be around 20-22 C in winter and 24-26 C in summer [42]. Thermal expectations for the café space are derived from the Design Builder programme. The set point for the heating is 23°C and for the cooling is 25°C as seen in Table 1. While operating as a museum, natural ventilation was used to provide indoor thermal comfort for users at values close to the specified temperatures. The target illuminance in the pre-restoration space was 200 lux, while the lighting power density was 22 W/m2. Additionally, while occupancy density is 0,11 people/m2, equipment power density is 2,00 W/m2. In the cafe area after restoration, the target illuminance is 150 lux and the lighting power density is 10 W/m2. While the occupancy density for the cafe venue is 0,2 people/m2, the equipment power density is 18,88 W/m2 (Table 1).

Table 1. *Parameters defined in the programme for contemporary addition*

	Function	Total square meters (m²)	Target Illumi-nance (lux)	Lighting power density (W/m²)	Occupancy density (people/m²)	Equip-ment power density (W/m²)	Heating setpoint (°C)	Cooling setpoint (°C)
Before Restoration	Museum	429.46	200	22	0,11	2,00	20	23
After Restoration	Cafe	396.92	150	10	0,20	18,88	23	25

Figure 7. *HVAC systems used in the restaurant of Süleyman Pasha Hamam (Personal Archive)*

It was aimed to determine the effect of contemporary additions on energy performance not only for the Kocaeli province, but also for Ottoman baths of similar plan types in Anatolia, and to create ideas and awareness in their design. For this purpose, provinces from five different climate regions in Turkey were selected (Figure 8).

Figure 8. *Türkiye degree day regions map [43]*

Konya, Kocaeli, Sivas, Izmir and Erzurum provinces were determined as the study area for energy analysis and scenarios were created based on these provinces (Figure 9). The data climate of the provinces determined for analysis evaluation was purchased from the White Box Technologies. Five provinces were selected from the five regions of Turkey, which are divided according to degree day regions. While the average air temperature measured in summer in Izmir from the 1st region is 43°C, the lowest air temperature is 22.4°C on average. In the province of Kocaeli, which is the original location of the building from the 2nd region, the average highest air temperature in summer is 44.1°C, while the lowest air temperature is -8.3°C. The highest air temperature measured in Konya province from the 3rd region is 22.8°C on average in summer, while the average temperature in winter is 0.6°C. In the province of Sivas, from the 4th region, the average temperature measured in summer is 38.3°C, while the average temperature in winter is -34.6. In the province of Erzurum, from the 5th region, the average temperature value in summer is 36.5°C, while the average temperature value in winter is -37.2°C [44].

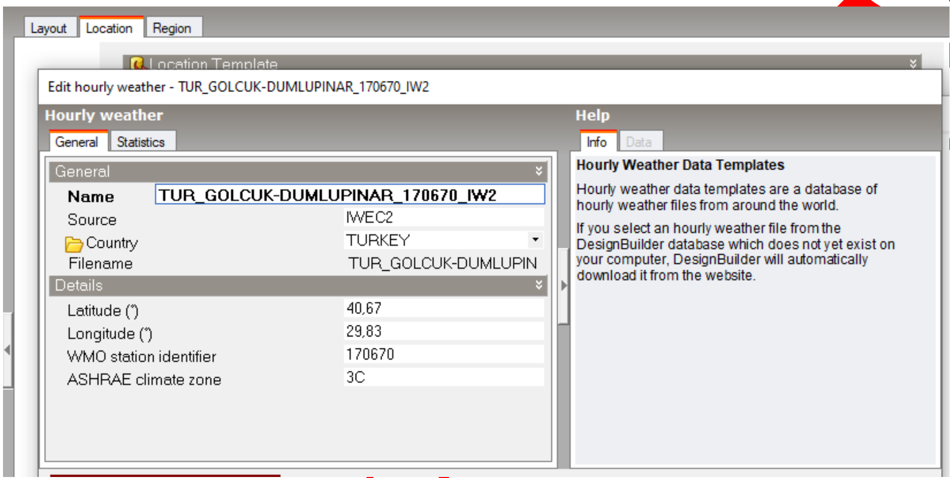


Figure 9. *Processing of Kocaeli Province Climate data into Design Builder program*

In the bath buildings of the Ottoman period, the transition between the dressing room, warm room, heat and private system of the Seljuk period continued. While selecting the provinces from the climatic regions of Turkey, attention was given to the provinces with a high density of bath buildings with traditional bath plans. Selected Kocaeli (Suleyman Pasha Bath, Historical Ottoman Bath, Historical Yali Bath, etc.), Izmir (Bergama Hacı Hekim Bath, Tire Hekim Bath, Saadet Hatun Bath, etc.), Konya (Subaşı Bath, Sahib Ata Bath, Healing Bath, etc.), Sivas (Meydan Bath, Kurşunlu Bath, Eski Pasha Bath, etc.) and Erzurum (Murat Pasha Bath, Sheikhler Bath, Lala Mustafa Pasha Bath, etc.) there are important building with a traditional bath plan in the provinces. It is expected that the historic baths in these selected provinces will provide ideas for the projects to be created, taking into account the possibility that they may gain a modern addition as a result of restoration in the future.

After modeling the building and entering the climate data the thermal conductivity calculation value λ (W/mK), density value (kg/m^3) and specific heat values (J/kgK) of the building components and material values of the bath were entered into the program (Figure 10). Material properties are taken from TS 825 Standard. The material library of the Design Builder program was used for the values that could not be reached in the TS 825 Standard (Tables 2-3).

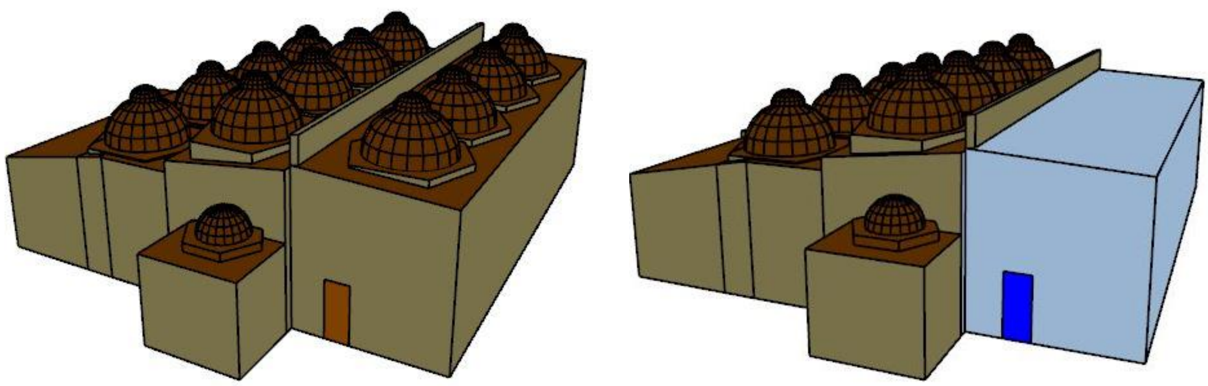


Figure 10. *The model of the Bath's before and after the restoration the material was identified*

Table 2. *Building materials used in building components before restoration and building envelope values according to their thermophysical properties*

Building Component	Materials	Thickness (cm)	Thermal Conductivity λ (W/mK)	Density (kg/m^3)	Specific heat (j/kgK)	U value (W/m^{2}K)
Wall 1	Rubble Stone	83 cm	0,81	1600	840	0,80
	Lime-based plaster	5 cm	1,00	1800	840	
Wall 2	Lime-based plaster	5 cm	1,00	1800	840	0,87
	Rubble Stone	71 cm	0,81	1600	840	
	Lime-based plaster	5 cm	1,00	1800	840	
Floor	Marble floor covering	5 cm	3,50	2800	1000	0,83
	Mortar	2 cm	0,42	1200	840	
	Stone Masonry foundation	60 cm	0,81	1600	840	
	Earth ground	10 cm	0,52	2050	180	
Roof 1	Tile Coating	2 cm	1,00	2000	800	1,80
	Sticking mortar	0,2 cm	0,51	1120	960	
	Rubble Stone	30 cm	0,81	1600	840	
	Lime-based plaster	2 cm	1,00	1800	840	
Door	Door (Wood)					2,82

Table 3. *Building materials used in building components after restoration and building envelope values according to their thermophysical properties*

Building Component	Materials	Thickness (cm)	Thermal Conductivity λ (W/mK)	Density (kg/m^3)	Specific heat (j/kgK)	U value (W/m^{2}K)
Wall 1	Rubble Stone	83 cm	0,81	1600	840	0,80
	Lime-based plaster	5 cm	1,00	1800	840	
Wall 2	Lime-based plaster	5 cm	1,00	1800	840	0,87
	Rubble Stone	71 cm	0,81	1600	840	
	Lime-based plaster	5 cm	1,00	1800	840	
Wall 3	8 mm tempered silver gray	0,8 cm	0,052	840	140	1,70
	Air gap	0,05 cm	R: 0,11			
	8mm tempered laminated glass	0,8 cm	0,052	840	140	

Floor	Marble floor covering	5 cm	3,50	2800	1000	0,83
	Mortar	2 cm	0,42	1200	840	
	Stone Masonry foundation	60 cm	0,81	1600	840	
	Earth ground	10 cm	0,52	2050	180	
Floor 2	Mosaic stone layer	3 cm	3,49	2880	840	1,43
	Mortar	2 cm	0,42	1200	840	
	Concrete floors	60 cm	2,50	2400	1000	
	Earth ground	10 cm	0,52	2050	180	
Roof 1	Tile Coating	2 cm	1,00	2000	800	1,80
	Sticking mortar	0,2 cm	0,51	1120	960	
	Rubble Stone	30 cm	0,81	1600	840	
	Lime-based plaster	2 cm	1,00	1800	840	
Roof 2	6 mm sunguard super silver 35	0,6 cm	0,052	840	140	1,78
	Air gap	0,16 cm	R: 1,18			
	5 + 0.78 pvb + 5 mm laminated glass	0,5 cm	0,052	840	140	
Door	Door (8 mm tempered silver gray + 8 mm tempered laminated glass)					1,70

4. THE RESEARCH FINDINGS AND DISCUSSION

The annual heating and cooling loads of the building are determined according to the heating and cooling systems used to maintain the space temperature within the specified time period and at the desired comfort conditions. The heating and cooling loads were calculated with limitations based on the functional changes of the building, the time period and the functional gains of the museum after the restoration. In addition, some values were neglected in the calculations. The neglected points are as follows;

- Elephant eye illuminations on the domes of the bath were not included in the model.
- The original walls of the bath were built in a mixture of stone bricks (alternate order). The use of bricks was neglected due to their very small amount, and they were taken into consideration as a rubble stone wall.
- The glass rectangular floors in the center of the bath's pre-restoration mosaic and post-restoration marble floors were neglected.

Ten scenarios were defined and run in the Design Builder program for the building model, which was created according to the omissions explained and the specified features, and the results were compared and expressed in the tables.

The heating load is 16.613,58 kWh while the cooling load is 12.378,29 kWh when stone material, which is the original material is used for Kocaeli province, which is located in the 2nd climate region of Turkey. When the glass material designed for the dressing room was used after the restoration, the heating load of the building was calculated as 23.357,71 kWh and the cooling load was calculated as 13.849,10 kWh. According to the calculations for Kocaeli province, the annual total energy consumption before restoration is 28.992,15 kWh. The energy consumption the building, which is 429.46 m^2 in total, is 164.96 kWh/m^2.

After the contemporary additional intervention during restoration for Kocaeli, the annual total energy consumption of the building is 37.206,81 kWh. The energy consumption of the building, which is 396.92 m^2 in total, is 197.35 kWh/m^2. When the data obtained from the program were compared, it was determined that there was a significant increase in the annual total energy consumption of the building as a result of the contemporary additional intervention. Although the total area of the building decreased after the restoration, the demand for energy consumption increased (Table 4).

Heating and cooling load values were obtained for Konya province before and after restoration for two different materials. When the stone material, which is the original material for Konya province, is used, the heating load is 24.682,98 kWh, while the cooling load is 6.912,20 kWh. When the glass material designed for the dressing room was used after the restoration, the heating load of the building was calculated as 34.596,17 kWh and the cooling load was calculated as 9.113,39 kWh. According to the calculations made for the province of Konya in the Design Builder program, the annual total energy consumption before restoration is 31.595,18 kWh. In total, the energy consumption of the building is 171.03 kWh/m^2. After the contemporary additional intervention after the restoration for Konya, the annual total energy consumption of the building is 43.709,56 kWh. In total, the energy consumption of the building is 209.80 kWh/m^2. Significant increases were observed in both heating and cooling load demands after the contemporary additional intervention for Konya, which is located in the arid climate region (Table 3).

Heating and cooling load values were obtained for two different materials, before and after restoration, for the province of Izmir, which was chosen as another study area. When the stone material, which is the original material for İzmir province, is used, the heating load is 14.305,37 kWh, while the cooling load is 13.446,36 kWh. When glass material is used after restoration, the heating load of the building is calculated as 21.648,51 kWh and the cooling load is calculated as 15.967,03 kWh. According to the calculations made for the province of Izmir in the Design Builder program, the annual total energy consumption before restoration is 27.751,73 kWh. In total, the energy consumption of the building is 162.08 kWh/m^2.

After the contemporary additional intervention to the building for Izmir, the annual total energy consumption of the building is 37.615,54 kWh. In total, the energy consumption of the building is 194.45 kWh/m^2. Since İzmir is located in the 1st climate region of Turkey, the required cooling load has been higher than all other climate zones due to the increasing temperature especially in summer months. In addition, due to the warm climate-related winter months, the annual total heating load was lower than the other four climatic regions (Table 4).

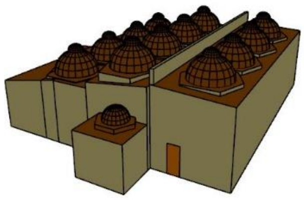
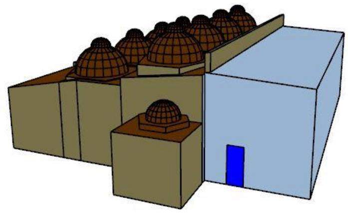
Heating and cooling load values were calculated for two different materials, before and after restoration, for the province of Sivas, which was selected from the 4th climate region of Turkey. When the stone material, which is the original material for Sivas province, is used, the heating load is 27.000,78 kWh, while the cooling load is 5.761,77 kWh. When the glass material designed for the dressing room was used after the restoration, the heating load of the building was calculated as 42.331,32 kWh and the cooling load was calculated as 7.522,48 kWh. According to the calculations made for Sivas province in the Design Builder program, the annual total energy consumption before restoration is 32.762,55 kWh. In total, the energy consumption of the building is 173.74 kWh/m^2.

After the contemporary additional intervention after the restoration for Sivas, the annual total energy consumption of the building is 49.853,80 kWh. In total, the energy consumption of the building is 225.28 kWh/m^2. With the contemporary additional intervention after the restoration, a serious demand for energy has emerged in the design in Sivas. Increasing demand for heating load, especially towards cold climatic regions, is clearly observed (Table 4).

Heating and cooling load values for two different materials, before and after restoration, were calculated in the program for Erzurum, which is located in the 5th climate region of Turkey, which was chosen as the study area. When the stone material, which is the original material of the building for Erzurum, is used, the heating load is 44.825,92 kWh, while the cooling load is 2.943,94 kWh. When the modern addition designed for the dressing room after the restoration is used, the heating load of the building is calculated as 65.797,54 kWh and the cooling load is 4.826,35 kWh. According to the calculations made for the province of Erzurum in the Design Builder program, the annual total energy consumption before restoration is 47.769,86 kWh. In total, the energy consumption of the building is 208.69 kWh/m^2.

After the restoration for Erzurum province, the annual total energy consumption of the building is 73.623,89 kWh. In total, the energy consumption of the building is 277.61 kWh/m^2. Erzurum province, which is in the cold climate zone, has the highest heating load requirement compared to other provinces. Among the 5 climate regions calculated, the lowest cooling load demand was found in Erzurum. In the post-restoration calculations, the highest heating load and the lowest cooling load demand belong to Erzurum province. A significant increase was observed after the modern addition in the already high heating load (Table 4).

Table 4. *Heating and cooling load results obtained according to different climatic regions*

		Stone Material (Before restoration-429.46 m^2) 			Glass Material (After Restoration – 396.92 m^2) 			
HDD	CDD	Heating Load (kWh)	Cooling Load (kWh)	Total Energy Consump-tion (kWh)	Heating Load ((kWh)	Cooling Load (kWh)	Total Energy Consump-tion (kWh)	Total Energy Consumption increase (%)
Kocaeli		16.613,86	12.378,2	28.992,15	23.357,71	13.849,10	37.206,81	%28,33
1176	324							
İzmir		14.305,37	13.446,3	27.751,73	21.648,51	15.967,03	37.615,54	%35,54
790	702							
Konya		24.682,98	6.912,20	31.595,18	34.596,17	9.113,39	43.709,56	%38,34
2325	263							
Sivas		27.000,78	5.761,77	32.762,55	42.331,32	7.522,48	49.853,80	%52,16
2837	72							
Erzurum		44.825,92	2.943,94	47.769,86	65.797,54	4.826,35	73.623,89	%54,12
4030	23							
HDD: Heating Degree Days CDD: Cooling Degree Days [44]								

5. RESULTS

The changing conditions of today's technology and the development of users' comfort levels have increased the demand for energy. This energy demand is especially important for the construction industry. Because today's modern buildings consume significant energy to provide heating, cooling and ventilation systems that provide space comfort. For this reason, almost zero-energy buildings are being built by paying attention to designs that reduce energy consumption, especially as a result of studies conducted in recent years. However, as well as the importance of energy in today's building design, the energy performance of the historical building that make up our traditional cultural heritage is an important issue. Especially, the change in energy consumption of buildings that have undergone restoration and new additions is a factor that drives the designs.

Historical buildings are important signs that reflect the original values of the region where they are located and take place in people's memories by creating their identity. Therefore, it is important to preserve the texture of these buildings for cultural and historical sustainability. It is necessary to ensure the adaptation of historical buildings that cannot keep up with today's changing and developing conditions and to continue the bridge between the future and the past. However, in this process, the issue of energy should also be taken into consideration when intervening in the building.

Within the scope of this study, it is aimed to determine the effect of contemporary additional interventions in historical buildings on the energy performance. For this purpose, analyzes were made according to the five climate regions determined by considering the current function and material use of the historical Süleyman Pasha Bath before and after the restoration. As the building applied a new function and contemporary addition after the restoration, new system was applied that aims to ensure the comfort of the building users and affects the energy load of the building. In addition, the location of the contemporary addition on the land along the southwestern facade is one of the factors that seriously affects the energy load of the building. In this study, an overview of the relationship between the concept of contemporary addition in historical buildings and energy performance is presented according to the thermal comfort analysis of the building and changes in energy consumption demand.

In the study, the Design Builder simulation program was used in the calculations according to variables over the Süleyman Pasha Bath. According to the results obtained from the program, an increase in the heating and cooling loads of the building was observed in all five climate regions with the contemporary addition after the restoration. It was determined that the difference in energy consumption before and after restoration increased even more in the 4th and 5th climate zones, especially in cold and harsh climate regions. The significant increase in energy consumption per square meter also supports this situation.

The contemporary addition to the Süleyman Pasha Bath in Kocaeli, which was acquired after the restoration, is a suitable addition in that it was designed according to the contrast relationship and reflects the architectural features of the period in which it was added. However, when its thermal properties are examined, the use of glass materials on the southwestern facade of the building in its original location and the interior comfort of the building, which is located in the temperate climate zone, caused a significant energy consumption, especially in summer. Considering Turkey's five climatic regions, it has been concluded that the modern additional intervention creates a significant increase in the heating load towards cold climate regions (in Sivas and Erzurum provinces) and in the cooling load towards hot climate regions (in Izmir and Kocaeli provinces). As a result of these calculations and evaluations, the hypothesis that the contemporary addition used for the Süleyman Pasha Bath has a negative impact on the energy performance of the historical building has been confirmed. In addition, a proposal was made regarding the material properties and land orientation to be used in the contemporary addition for bath buildings with similar plan types in Anatolia.

The interior comfort and total energy load of the building were adversely affected by the contemporary addition of the Süleyman Pasha Bath after the restoration. This negativity that developed after the contemporary addition must be resolved without damaging the historical original texture of the building and to the extent permitted by the conservation rules. Precautions can be taken by taking advantage of the physical conditions of the environment (microclimate) in which the building is located, along with passive improvement techniques. If passive methods are not sufficient, applying active improvement techniques after obtaining the necessary permits with minimal intervention without damaging the building will provide significant improvements in the energy consumption of the building. However, first choice should be to develop passive strategies compatible with the climate of each region for to decrease heating and cooling loads. For example, stone material could be used in hot, dry climate regions where the temperature difference between night and day is high, and summers are very hot. Because of its material feature, stone provides coolness in the interior in extreme heat in summer, and thanks to the heat it collects during the day, it tries to maintain the indoor temperature when the temperature drops. However, since the glass material directly transmits sunlight to the interior in summer, it causes overheating and excessive cooling in winter. When using glass materials, landscaping and orientation can be used to block wind and extreme cold, especially in winter. Additionally, the overcooling problem can be solved by incorporating a double layer of glass material and an insulation layer. By incorporating a reflective layer into glass materials and making use of newly developing glass technologies, overheating problems in indoor spaces during the summer can be solved and the use of the HVAC system can be reduced. In order to benefit from daylight according to the seasons, the amount of heat, humidity, wind and shading can be controlled by landscaping the immediate surroundings of the building.

Land orientation is also an important factor to achieve energy efficiency with passive strategies. It is possible to provide sun control and shading with appropriate orientation, especially when using glass materials. However, since the contemporary additional space of the Süleyman Pasha Bath is located on the south side, the use of glass material negatively affects exposure to daylight in summer. It causes an increase in energy consumption in summer. Stone, the original material of the bath, when positioned on the south side, contributes positively to the regulation of indoor comfort by controlling the heat within the building in terms of energy efficiency. While it reduces the cooling load demand thanks to the coolness it provides in summer, it also reduces the heating load in winter thanks to the heat it traps. Therefore, in the contemporary addition decision, significant gains can be achieved thanks to many passive strategies such as thermal properties of the building envelope, orientation to the land and building form.

Before the contemporary addition intervention to historical buildings, detailed research should be done, negative effects should be reviewed by creating design parameters according to the appropriate material usage related to the land and direction, and necessary energy analyzes should be calculated through simulation programs. As a result of these research, the most appropriate material, construction technique and form should be decided according to the selected contemporary additional design approach (repetition, harmony, contrast). Ensuring the energy efficiency of the building is as important as ensuring the cultural sustainability of historical buildings through maintenance, repair and functionalization. Therefore, before the intervention of modern additions to historical buildings, detailed research should be carried out, design parameters should be created according to the use of appropriate materials regarding the land and direction, the negative effects should be reviewed, and the necessary energy analyzes should be evaluated.

In future studies that can be done by taking this study as a reference; Instead of using only two materials, analyzes can be diversified with alternative materials. Additionally, the hypothesis can be tested again by increasing the number of buildings from similar climatic regions.

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CONFLICTS OF INTEREST

No conflict of interest was declared by the authors.

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