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1995 DEPREMİ SONRASI DİNAR'DA KURULMUŞ OLAN AFET KONUTLARININ TS 825 BİNALARDA ISI YALITIM KURALLARI'NA UYGUNLUĞU AÇISINDAN İNCELENMESİ

Neşe Dikmen *

Özet

Türkiye'de enerji tüketiminin büyük bir kısmı sanayi ve konutlarda gerçekleşmektedir. Konutlarda tüketilen enerjinin ise %27'si ısıtma amaçlı kullanılmaktadır. Bu çalışmada Dinar'ın köylerinde inşa edilmiş olan afet konutu projesi TS 825 Binalarda Isı Yalıtım Kuralları'na uygunluğu açısından incelenmiştir. İzoder TS 825 hesap programı kullanılarak yapılan bu araştırmada öncelikle projenin mevcut durumunun TS 825 standardına uygunluğu incelenmiş, daha sonra proje 3 farklı aşamada standarda uygun hale getirilmiştir. Sonuç olarak çatıda kullanılmış olan cam yünü 5cm.'den 12cm.'e çıkarılmış; duvarlarda 8cm. expande polistren köpük ve toprağa outran döşemede 7cm. ekstrüde polistren köpük kullanılmıştır. Bu durumda binanın yıllık ısıtma enerjisinde (Q) 296,68 kWh/m², yapı elemanlarından iletim yoluyla gerçekleşen ısı kaybında (H_T) 247,8 W/K ve birim hacim veya birim alan başına tüketilecek yakıt miktarında 4.137,08 kg. tasarruf sağlanmıştır.

Anahtar Kelimeler: TS 825 Binalarda Isı Yalıtım Kuralları, Isı Yalıtımı, Izoder TS 825, Afet Konutları.

AN EVALUATION OF THE POST-DISASTER HOUSES BUILT IN DINAR AFTER THE 1995 EARTHQUAKE IN TERMS OF THEIR CONFORMITY WITH THE TURKISH THERMAL INSULATION STANDARD (TS 825)

Abstract

Residential and industrial buildings in Turkey consume a great amount of energy, with 27% of the energy consumed in housing being for the purpose of heating. In this study, the post-disaster housing project conducted in villages of Dinar is examined in terms of its conformity with the Thermal Insulation Regulations contained within the TS 825 Thermal Insulation Standard in Buildings. The research is carried out using the Izoder TS 825 calculator, through which the current conformity of the project to the Thermal Insulation Standard in Buildings has been examined. As a result, the project has been updated to meet the standard in three separate steps: The glass wool ceiling insulation has been increased from 5cm to 12cm; 8cm expanded polystyrene foam has been used on the walls; and 7cm thick extruded polystyrene foam has been used on the "slab-on-grade" foundation. The saving in the annual heating energy requirement for the building (Q) was found to be 296.68 kWh/m², with dissipation occurring due to conductivity of the construction elements (H_T) by 247.8 W/K; and the amount of fuel required per unit volume or unit area decreasing by 4,137.08 kg.

Keywords: Turkish Thermal Insulation Standard (TS 825), Thermal Insulation, Izoder TS 825, Post-Disaster Houses.

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1. Introduction

Turkey imports 50% of the vast amounts of energy consumed by its industries and homes, with domestic heating accounting for 27% of the total home energy use (Yılmaz, 2009, Kılıç ve Diğerleri, 2009). As a result of the country's dependence on such fossil fuels as coal, petroleum and natural gas, Turkey produces great quantities of waste gases, such as carbon dioxide (CO_2) and sulphur dioxide (SO_2), giving rise to considerable air pollution. These waste gasses (especially CO_2) cause the earth to absorb the sun's rays, bringing about a raise in temperature and causing what is known as the greenhouse effect, which will result in continued climate change in the coming years. Sulphur-based flue gas waste also combines with moisture in the air to produce sulphuric acid rain, destroying vegetation cover and buildings (Şişman, 2005). SO_2 and CO_2 particles, as well as other emissions resulting from energy consumption, are significant problems on a regional scale. The greatest quantities of air pollution, particularly in the winter, when pollution reaches levels that threaten human health as well as flora and fauna, originate from processes involving the consumption of energy (Koçlar Oral, 2007).

In recent years, energy policies in developed and developing countries have targeted conscientious use of energy by industry and householders and in transport; and increasing insulation to reduce energy consumption has been the most crucial point of the policies developed to address the concept of energy efficiency the world over (Koçlar Oral, 2006).

One of the most important functions of a healthy building is the provision of thermal comfort within spaces, and considering the current energy problem it is essential that this be targeted using the minimum of energy resources. In the provision of thermal comfort, artificial heating requirements have increased, while energy resources for this purpose (coal, petrol etc.) have decreased, resulting in increased costs. Accordingly, more pollutants are thrown into the atmosphere, to the detriment of human health. To solve these problems it is imperative that the energy being used for heating be reduced as much as possible, meaning that heat dissipation during wintertime must be decreased through the increased use of thermal insulation (Koçlar Oral, 2007).

There are many advantages to be gained from insulating buildings in terms of the environment, not least the benefits to human health. Heat insulation adds to the preservation of the environment in every season by reducing emissions and satisfying comfort requirements. Since insulation prevents heat loss or gain, it is possible to use lower capacity of the heating and cooling equipment, thus offering significant savings in initial expenditures. With the addition of thermal insulation, heating and cooling expenses are reduced, resulting in energy savings; while also the problem of moisture and mould on the walls is alleviated through the prevention of condensation. Insulation also reduces thermal loading, thus reducing thermal stress to a minimum level in the load-bearing systems, which in turn can extend the lifespan of the building. Thermal insulation can also extend the lifespan of the damp-proofing materials applied to roofs and below-grade walls by protecting them from thermic destruction (Koçu ve Korkmaz, 2003).

The regulations related to insulation in Turkey comprise "The Thermal Insulation Regulations of TS 825 Thermal Insulation Standard in Buildings", which were first published in 1970 by the TSI (Turkish Standards Institution). Revisions to the TS 825 Thermal Insulation Standard for Buildings, were eventually completed on 22nd May, 2008 by the Turkish Standards

Institute (TSI). As a result, these standards were published as Thermal Insulation Regulations for Buildings No. 24043, in the Official Gazette of 08.05.2000. The new Regulations No. 27019, which were brought in line with the revised standards, were then published in the Official Gazette of 09.10.2008, and came into effect on 1st November, 2008 (Official gazette, 2008).

2. Method

After the 1995 Earthquake, 1,234 post-disaster houses were built in villages in the district of Dinar, which is part of the Afyon province. The design, taken from the archives of the Ministry of Public Works, took the form of a two-roomed single-storey country type post-disaster dwelling. In early 2008, a survey was carried out among the residents to assess their satisfaction with their houses, which had been built prior to the date the Thermal Insulation Regulations of the TS 825 Thermal Insulation Standard in Buildings became compulsory. When asked of their opinion of the heating of the post-disaster houses, 41.7% of the residents claimed to be "not satisfied at all", 30.4% were "fairly satisfied" and 27.4% were "very satisfied." After the Standard was brought into force in 2000, thermal insulation began to be applied in the post-disaster housing projects of the Ministry of Public Works. Looking at the current designs of the 76.61 m^2 houses constructed in the Dinar project, it can be seen that thermal insulation materials have now been incorporated into the building envelope. The insulation materials, the thicknesses of which are determined according to the relevant climatic regions , were glass wool for ceilings, perlite for floors and extruded polystyrene foam (XPS) for the walls.

In this study, the post-disaster housing project executed in Dinar's villages has been examined in terms of its compliance with the Thermal Insulation Regulations of the TS 825 Thermal Insulation Standard for Buildings. The research was carried out in four phases using the Izoder (Association of Producers and Suppliers of Heat-, Water-, Sound-and Fire-proofing Material) TS 825 calculation programme (Izoder, 2009). Firstly, the actual current state of the building was examined and the permitted maximum annual heating energy requirement (Q′) and annual heating energy requirement (Q_{year}) for this building type was calculated. In the second step of the research, only the window systems have been changed; while in the third step, in addition to the changes to the windows, the U-values of the walls, ceiling and floor have also been reduced by using insulation materials on the walls and the slab-on-grade, and increasing the thickness of the ceiling insulation . The building did not meet TS 825 even after these modifications. Thus, in the fourth step, the thickness of the insulation materials used on the walls was also increased, and the building achieved conformity with the Thermal Insulation Regulations of the TS 825 Thermal Insulation Standard in Buildings. An Izocam Production Catalogue was used to determine the thickness of the insulation materials used in the study (Izocam Production Catalogue). All the four steps are xplained in greater detail in sections 4.1 to 4.4 below.

3. Calculations made related to the post-disaster houses constructed in Dinar

The post-disaster house type, built in 46 villages of Dinar following the 1995 earthquake, is a 76.61 m^2 single storey brick building. As can be seen from the floor plan in Figure 1, the external walls of the building are constructed 29 cm thickbricks manufactured according to the Vertically Perforated Factory Brick Standard, which was abandoned in 2005 (Turkish Standards Institute, 2009). The windows are wooden framed, with single glazing in the bathroom and toilet, and double glazing in all other rooms. 5 cm thick glass wool insulation has been used on the ceiling and floor, while the walls were un-insulated. The building, which has a storey height of 2.58 m, is heated by a coke and coal-burning stove.

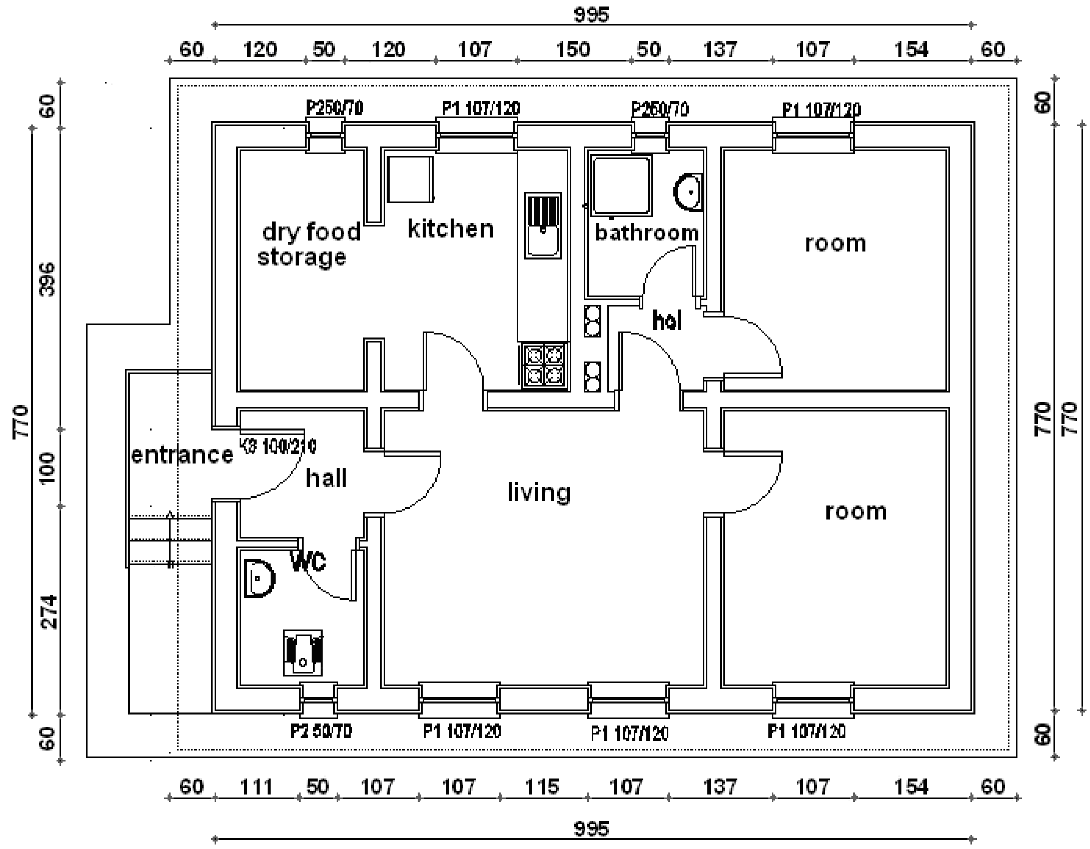

Figure 1. Post- Disaster House Plan

Reference: Archives of the Ministry of Public Works of the Republic of Turkey.

The TS 825 Thermal Insulation Standard in Buildings states that Turkey has a total of four different degree day zones, and consequently there are different heating loads for buildings in each zone [3]. For the four different degree day zones in the standard, the U-values that are to be provided for the walls, ceiling, floors and window systems have been determined. According to these Standards, the recommended U-values for buildings constructed in Dinar, which falls in the third degree day zone, are presented in the table below (Table1).

Table 1 U-values recommended in the TS 825 Thermal Insulation Standard in Buildings

zone	U_{Wall}	$U_{Ceiling}$	U_{Floor}	$U_{Window1}$
1st zone	0.7	0.45	0.7	2.4
2nd zone	0.6	0.4	0.6	2.4
3rd zone	0.5	0.3	0.45	2.4
4th zone	0.4	0.25	0.4	2.4

3.1. First Step

In this part of the study, primarily the U-values of the construction elements have been calculated for the present state. There are two values calculated for the walls due to the presence of a reinforced concrete beam along the length of the building periphery. In the Izoder TS 825 calculator, the construction elements are defined as follows: brick wall as wall 1.1, reinforced concrete beam as wall 1.2, single-glazed window as window 1, and double-glazed window as window 2. Floor finish material has been disregarded, as it is standard for all types of constructions. The orientation of the buildings was not considered in the project in Dinar, and so the larger windows of the buildings face south in some cases, and north in others. For the purpose of this study, the living space is assumed to be south facing, and the resulting U-values calculated for the post-disaster houses can be seen in Table 2.

Table 2 U-values calculated for the present state of the building.

$U_{Wall\ 1.1}$	$U_{Wall\ 1.2}$	$U_{Ceiling}$	U_{Floor}	$U_{Window1}$	$U_{Window2}$
1.25	2.976	0.586	3.152	5.1	3.3

A comparison between Table 1 and Table 2 reveals that the U-values of the wall, floor and window 1 are considerably different than the values required by the Standards. Conversely, the U-value determined for the ceiling (0.586 W/m^2.K) is very close to the value required (0.3 W/m^2.K). Should the ceiling be the sole construction element applied with thermal insulation, the effectiveness in minimising the U-value through the installation of insulating materials can be clearly understood. In addition, looking at the U-values determined for Window 1 and Window 2, it can be seen that the U-value of window 2 (3.3 W/m^2.K) is very close to the required value (2.4 W/m^2.K), which is a clear indication of the different effects on the thermal performance of a building offered by single glazing and double glazing.

The maximum permitted annual heating energy value (Q′) for the houses has been calculated as 116.50 kWh/m^2. In their present state, the annual heating energy requirement of the houses (Q_{year}) stands at 412.88 kWh/m^2, which exceeds the maximum permitted annual heating energy consumption. The heat dissipation that occurs as a result of the conductivity of the construction elements (H_T) in this building is 339.9 W/K; and the amount of fuel that will be consumed per unit volume or unit area is 5,757.52 kg. According to the TS 825 Thermal Insulation Standard for Buildings Q_{year} should be less than Q′ (TS 825, 2008). Since Q_{year} is greater than Q′, the building does not comply with the standard. In order to achieve compliance with the new Standards, the thermal conductivity coefficients (U) of the components, that constitute the building envelope of the dwelling, have been decreased thus decreasing the value of Q_{year}.

In order for the houses to satisfy the TS 825 Standard without the application of any thermal insulation, the brick walls would need to be 1.25m thick, the reinforced concrete beams would need to be 5.5 m thick, the ceiling slab would need to be 8.5m thick, and the floor tiling would need to be 4m thick. If all the windows are double glazed, with a U-value of 2.3 W/m^2.K, the annual heating energy requirement can be calculated as 115.35 kWh/m^2, however it is impractical to produce construction elements with these thicknesses.

This shows that a building must be examined as a whole in the design phase, and that all parameters, such as window area, orientation, construction elements and form, must be taken into consideration if one is to achieve maximum energy savings. In this study, attaining the required value in terms of the annual heating energy requirement of a building has been targeted only through the use of thermal insulation, and by minimising the thermal conductivity coefficients of the windows, without changing the features or the thickness of the construction elements.

3.2. Second Step

At this stage, all of the windows are assumed to be double glazed. For the purpose of this study low-e covered wooden frame window with 9 mm hollow space double glazing, which has a U-value of 2.3 W/m^2K, have been chosen. The other materials used in the construction of the sample building remain unchanged in order to allow a clear understanding of the effect of changes made to the windows (Table 3). Accordingly, the acquired annual heating energy need was 401.27 $W/m^2.K$, the heat dissipation that occurred through the conductivity of the construction elements was 331.9 W/K, and the amount of fuel consumed per unit area was 5,595.62 kg.

Table 3 U-values acquired in Step 2

$U_{Wall\ 1.1}$	$U_{Wall\ 1.2}$	$U_{Ceiling}$	U_{Floor}	U_{Window}
1.25	2.976	0.586	3.152	2.3

As the calculated annual heating energy requirement for this building is greater than the permitted maximum annual heating energy figure (401.27>116.50), the building is found to be incompatible with the TS 825 Thermal Insulation Standard for Buildings. However, by reducing only the U-values of the windows in the buildings, a saving of 80.98 kWh/m^2 can be made in the annual heating energy requirement, as heat dissipation occurring through the conductivity of the construction elements reduces by 8 W/K, and the amount of fuel that will be consumed per unit area reduces by 161.9 kg.

3.3. Third Step

In this step, the required U-values for each construction element have been acquired through the use of thermal insulating materials. XPS is a water- and pressure-resistant material. For this reason, it has been recommended in this study to use XPS only on the floor, while using expanded polystyrene foam (EPS) for the walls.

All the windows have been considered as wooden-framed, with 9 mm air gap in low-e coated double glazing. To achieve the required U-values for the walls, ceiling and floor, the insulation being 7cm thick expanded polystyrene foam on the walls; 12cm thick glass wool on the ceiling slab; and 7cm thick extruded polystyrene foam to the slab-on-grade foundation was used. The U-values achieved in this state are shown in Table 4.

Table 4 The U values calculated when heating insulation materials have been used

$U_{Wall\ 1.1}$	$U_{Wall\ 1.2}$	$U_{Ceiling}$	U_{Floor}	U_{Window}
0.392	0.479	0.27	0.418	2.3

In this configuration, the acquired annual heating energy requirement was 120.32 kWh/m^2, heat dissipation through the conductivity of the construction elements was 95.7 W/K, and the amount of fuel that will be consumed per unit area was 1,677.85 kg. As the calculated annual heating energy requirement for this building is greater than the permitted maximum annual heating energy figure (120.32>116.50), the building still does not comply with the Thermal Insulation Standard for Buildings. However, when the ceiling insulation material is increased from 5cm to 12cm, and 7cm thick insulation material is used on the walls and the slab-on-grade foundation, a saving of 292.56 kWh/m² can be made in the annual heating energy requirement, heat dissipation occurring through the conductivity of the elements reduces by 244.2 W/K, and the amount of fuel that will be consumed per unit area reduces by 4,079.67 kg.

3.4. Fourth Step

In the last part of the study, the thickness of the expanded polystyrene foam applied to the walls was increased from 7cm to 8cm; while the other construction materials and thicknesses were retained from the previous step. The acquired U-values in step 4 are shown in the table below:

Table 5 The calculated U-values in step 4

$U_{Wall\ 1.1}$	$U_{Wall\ 1.2}$	$U_{Ceiling}$	U_{Floor}	U_{Window}
0.357	0.428	0.27	0.418	2.3

At this stage, the calculated annual heating energy requirement was 116.20 kWh/m², heat dissipation occurring through the conductivity of the construction elements was 92.1 W/K and the amount of fuel consumed per unit volume or unit area was 1,620.44 kg. For this configuration, as the calculated annual heating energy need is lower than the maximum permitted annual heating energy need (116.20<116.50), the building complies with the Thermal Insulation Standard for Buildings.

4. Discussion of Results

In this study, the post-disaster housing project implemented in the villages of Dinar has been examined to assess the compatibility of the dwellings built after the 1995 earthquake according to the TS 825 Thermal Insulation Standard for Buildings. In Table 6, the steps carried out in the course of the study have been summarised, and the calculated annual heating energy requirement for each step has been determined. The maximum permitted annual heating energy requirement for the building type has been calculated as 116.50 kWh/m². The annual heating energy requirement for the post-disaster houses in their current state is 412.88 kWh/m², which is far greater than the permitted value; meaning that the building is not in compliance with the Thermal Insulation Standard for Buildings. As such, the window systems have been changed and heating insulation materials have been used on the walls, ceiling and floor in order to make the building compatible with the standard; and as a result the U-values of the construction elements have come close to the recommended values according to the TS 825 Thermal Insulation Standard in Buildings; however, although the required U-values have been attained in this step, the annual heating energy need has been calculated as 120.32 kWh/m², in other words, the building does not comply with the standard. This means that the annual heating energy requirement needs to be decreased to 116.20 kWh/m² by increasing the thickness of the insulation material applied to the walls by 1cm in the last step.

Table 6 Changes made to the building and the acquired annual heating energy requirement values

	Phase 1		Phase 2		Phase 3		Phase 4	
	Insulation material as built and its thickness	U value of building element	Insulation material as built and its thickness	U value of building element	Insulation material as built and its thickness	U value of building element	Insulation material as built and its thickness	U value of building element
Wall 1.1	-	1.25	-	1.25	7cm EPS	0.392	8cm EPS	0.357
Wall 1.2	-	2.976	-	2.976	7cm EPS	0.479	8c m. EPS	0.428
Ceiling	5cm glass wool	0.586	5cm glass wool	0.586	12cm glass wool	0.27	0.12 m. glass wool	0.27
Floor	-	3.152	-	3.152	7cm XPS	0.418	7cm XPS	0.418
Window 1	-	5.1	-	2.3	-	2.3	-	2.3
Window 2	-	3.3	-	-	-		-	-
Q (kWh/m^2)	412.88		401.27		120.32		116.20	
Q' (kWh/m^2)	116.50							

In Table 7, changes to the annual heating energy requirement, heat dissipation occurring through the conductivity of the construction elements and the amount of fuel that will be consumed per unit volume or unit area, which was acquired in the four steps of the study, have been achieved. To sum up, when the glass wool used on the ceiling is increased from 5cm to 12cm; 8cm of expanded polystyrene foam is used on the walls, and 7cm thick extruded polystyrene foam is used on the slab-on-grade floor, the annual heating energy requirement of the building reduces by 296.68 kWh/m^2, dissipation occurring through the conductivity of the construction elements reduces by 247.8 W/K and a saving of 4,137.08 kg in the amount of fuel that will be consumed per unit area is achieved.

Table 7 The annual heating energy requirement acquired in different steps of the study, heat dissipation occurred through the conductivity of the construction elements and fuel amounts that will be consumed per unit volume or unit area.

	Phase 1	Phase 2	Phase 3	Phase 4
Q (kWh/m^2)	412.88	401.27	120.32	116.20
H_T	339.9	331.9	95.7	92.1
Amount of fuel	5,757.52	5,595.62	1,677.85	1,620.44

5. Conclusion

As a result of the addition of thermal insulation to the building envelope, the decrease in the amount of fuel per unit area provides an approximate yearly fuel saving of 316,942 kg in a 76.61 m^2 dwelling, and a total of 391,106.056 kg in the 1,234 post-disaster houses built in the area. This fuel saving achieved through the use of thermal insulation also contributes greatly to the prevention of environmental pollution, and thus the protection of public health. Furthermore, by decreasing the energy spent for heating purposes in the buildings, positive results are achieved in forming the necessary comfort requirements within the buildings, besides providing economic benefit.

6. Acknowledgement

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