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# DETERMINING THE EFFECT OF LEVEL OF FLOOR, EXTERNAL WALL THICKNESS AND JACKETING ON ACOUSTIC COMFORT IN EXISTING RESIDENTIAL BUILDINGS IN TURKEY

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**Keywords**

*Noise Comfort,*
*Noise Standart,*
*Insulation,*
*Construction.*

**Abstract**

Since people spend most of their time in the residences especially during the pandemic, acoustic comfort has come into prominence. Many studies were conducted to improve acoustic comfort. Notwithstanding the fruitful existing studies, there is no study detecting the correlation of building elements with acoustic comfort. Therefore, in this study, the correlation of floor levels, wall thickness and the availability of jacketing with the acoustic performances of existing residential buildings constructed before 2017 were investigated according to Regulation on the Protection Against Noise in Buildings entering into force on 31st May 2017 with Official Gazette. The noise levels of 155 residences in residential buildings were investigated and correlations of the level of the floor, exterior wall thicknesses and jacketing with the noise comfort were detected with the help of Pearson Correlation computed via SPSS software. It is believed that this study will improve practical implementations of existing standards in the construction industry.

# TURKİYE'DE MEVCUT KONUT BİNALARINDA KAT SEVİYESİNİN, DIŞ DUVAR KALINLIĞININ VE MANTOLAMANIN AKUSTİK KONFOR ÜZERİNE ETKİSİNİN BELİRLENMESİ

**Anahtar Kelimeler**

*Ses Konforu,*
*Ses Standardı,*
*Yalıtım,*
*İnşaat.*

**Öz**

Özellikle pandemi döneminde insanlar zamanlarının çoğunu mekanlarda geçirdiği için; akustik konfor ön plana çıkmıştır. Akustik konforu iyileştirmek için birçok çalışma yapılmıştır. Mevcut verimli çalışmalara rağmen, yapı elemanlarının akustik konfor ile ilişkisini tespit eden bir çalışma bulunmamaktadır. Bu nedenle, bu çalışmada, 2017 yılından önce inşa edilmiş mevcut konut binalarının kat seviyeleri, duvar kalınlığı ve mantolama mevcudiyetinin akustik performansları ile ilişkisi , 31 Mayıs 2017 tarihinde Resmi Gazete'de yürürlüğe giren Binalarda Gürültüden Korunma Yönetmeliği'ne göre araştırılmıştır. Konut binalarındaki 155 mekanın gürültü seviyeleri incelenmiş ve kat seviyesi, dış duvar kalınlığı ve mantolamanın gürültü konforu ile korelasyonları SPSS yazılımı ile hesaplanan Pearson Correlation yöntemi yardımı ile tespit edilmiştir. Bu çalışmanın inşaat sektöründe mevcut standartların pratik uygulamalarını iyileştireceği düşünülmektedir.

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## 1. Introduction

The quality of interaction between occupants and residences determines the livability standards of the residences. (Brooker, Stone, & Uçar (çevirmen), 2012). In this context, the sound comfort of residences affects people physiologically and psychologically. Strong correlations were observed between the sound comfort and quality of occupants' interactions in the residences (Maraş, Alkış, & Maraş, 2010). By the same token, noise intensity has a detrimental effect on living beings (Chen & Kang, 2011). Additionally, when mechanical sound - which is dominantly perceived - skyrockets the disturbance, natural sound – which is dominantly perceived increases the relaxation of human beings (Zhang, Ba, Kang, & Meng, 2018). For this reason, to ensure the sound comfort of occupants, it is essential to determine and apply the acoustic criteria correctly during the design phase of new buildings, and it is also vital to maintain noise standards in the existing buildings (Şentop, 2013). Many researchers have contributed to acoustic comfort for new and existing buildings, and numerous effects of community noise have also been examined (Yang & Kang, 2005). Demirel (2006) conducted a study concerning indoor noise measurements for the living rooms and bedrooms in one of the apartment blocks constructed via tunnel formwork in Ankara. Obtained data were evaluated by comparing them with the Noise Control Regulation and Noise Control Criteria, and it was determined that there was noise which was above the acceptable level in these rooms, and necessary precautions were recommended. Acar and Akdag Yugruk (2008) introduced the requirements to be accomplished for open-plan offices during the architectural design phase in order to satisfy auditory comfort. In this context, with the help of Odeon 8.0 program, parameters such as "heights of different partition" and "absorption of different surface " were evaluated and the most suitable conditions were determined to provide auditory comfort. Morgül and Dal (2012) conducted a study in which maximum noise levels of important places in the city center of Sakarya were measured and compared with the related noise regulations. Certain locations such as noise-sensitive areas and areas with high traffic were selected to measure in different periods during a month. It was detected that the noise levels of most of the locations were higher than the maximum noise level. It was determined that the entire city center of Sakarya was noisy and bothers people psychologically and physiologically. Özçetin and Demirel (2012) compared the noise regulations of the UK, the US, Germany and Turkey for conservatory buildings. It was emphasized that our country's regulation was insufficient for educational buildings. Similarly, Tüzel (2013) played two audios in a noisy classroom and a noiseless soundproof classroom environment, made up of a group of 146 students who were in 5th grade, and this study emphasized how much the environment affects the students' comprehension and remembering skills. It was determined that students recall at a higher rate in the noiseless environment. Özer (2014) determined that Aziziye Park in the city center of Erzurum exceeded the noise limit set by the regulation for the evening, and solutions were proposed to reduce noise pollution in the park. Also, Bayramoğlu et al. (2014) made noise measurements in Meydan Park and Fatih Park in Trabzon city center. As a result of this study, it was concluded that the intensity of the noise changes depending on the vehicle traffic. It was concluded that it would be appropriate to use natural and artificial elements in the parks in order to provide acoustic comfort and reduce the noise level to the values specified by the regulation. Next, Kavraz (2015) observed environmental-based noise in the KTÜ Kanuni Campus. The observations and measurements were made and the obtained data were compared with the noise limits specified in the regulation. It was concluded that the measured locations were highly affected by noise. Suggestions were made to minimize the existing noise. Furthermore, Özçetin et al. (2015) assessed the current situation in terms of acoustic comfort conditions in the classes at the Department of Architecture at Bozok University. As a result of the measurements and analyses via Insul 6.4 simulation program in accordance with the TS EN ISO 16283-1 standard, it was concluded that the insulation performance against airborne sound did not meet the values recommended in the regulation due to the acoustic performance of the materials used on the walls. As a result of the evaluations made with the Insul program, appropriate results were obtained in terms of the sound insulation during the sound transmission in the educational buildings by proposing the different building materials having sound insulation. Bulunuz et al. (2017) evaluated the level, reasons, and effects of noise with the help of sound measurement gauge, and surveying data were obtained from teachers and administrators for acoustically improved schools. According to the survey results, the noise level of the school is considered as low and medium level. This study highlighted that the necessary acoustic precautions should be taken by carrying out precautions concerning noise pollution and providing noise awareness training in all schools. Moreover, Untuç and Yüğrük Akdağ (2017) conducted a study concerning the conservatory buildings, the thickness values of the envelope and interior partition elements were determined with the help of the acoustic simulation program. Thus, as a result of the calculations which consider the region, volume, function and features of the area, an exemplary application in terms of noise control was put forward for the development of the regulation concerning "Protection of Buildings Against Noise". With respect to the Multi-Purpose Hall of Cultural Center in Sivas, their acoustic designs which were developed for conference, concert, opera and theater functions were analyzed and evaluated by Demirel et al. (2018). Suggestions were made for the acoustic comfort recommended by the national and international standards as well as literature. In the study conducted by Cansever (2019), the level of noise pollution was determined by measuring the noise pollution in certain regions of Amasya. The effects of noise level on human and environmental health were examined and fruitful suggestions were made.

Regulation concerning Assessment and Management of Environmental Noise was enacted on 25.06.2002, 07.03.2008 and 04.06.2010 with the regulation numbers of 2002/49/EC, 26809 and 27601 respectively. Regulation concerning Protection of Employees from Risks Related to Noise came into force on 28.07.2013. The issue of noise control in buildings has been taken under legal control by the "Regulation on the Protection Against Noise in Buildings", which was published in the Official Gazette on 31.05.2017. The implementation of this entered into force on 1 June 2018 in order to provide auditory comfort in buildings.

By considering the regulation and existing studies, it was brought to light that there is no study detecting the correlation of floor levels, exterior wall thickness and availability of jacketing with acoustic comfort of the existing residential buildings in Turkey. Thus, in this study, the correlation of the level of floor, wall thickness and the availability of the jacketing in the existing residential buildings in Turkey constructed before 2017 with the acoustic performances were detected according to regulation concerning "Regulation on the Protection Against Noise in Buildings". 155 residences in different buildings having sides to the main streets were investigated in Isparta in Turkey. The obtained data were evaluated to detect the correlation of sound performance with the level of the floor, the thickness of the wall and the existence of the jacketing via Pearson correlation computed by SPSS software. This study detected strong correlations of noise performance with structural factors such as the thickness of the wall and the existence of the jacketing.

## 2. Classification of Acoustic Standards as per Regulation on the Protection Against Noise in Buildings

According to this regulation, the background noise of the existing buildings and acoustic performance classes in the regulation are compared to detect whether these residences satisfy the acoustic comfort or not. Background noise (for buildings) is defined as the remaining total sound measured at the same location when the noise source in the environment is deactivated (Çevre ve Şehircilik Başkanlığı, 2017). Acoustic performance classes - which are identified as A, B, C, D, E or F in the regulation - are determined by considering the internal noise, the insulation values of the building elements, the internal noise levels arising from service equipment and the reverberation times. While A represents the highest performance, F stands for the lowest performance (Çevre ve Şehircilik Başkanlığı, 2017). At least C and D classes should be met for new buildings and existing buildings respectively. Permitted noise levels in the residence depending on the acoustic performance class are illustrated in Table 1 below.

**Table 1.** Permitted noise levels in the residence depending on the acoustic performance class (Çevre ve Şehircilik Başkanlığı, 2017)

| Function of Building | Location | Time Period | Internal noise level, $L_{Aeq}^2$ | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Night (23.00 –07.00) | | | | | | |
| | | Evening (19.00-23.00) | Acoustic Performance Class | | | | | |
| | | Morning (07.00-19.00) | **A** | **B** | **C** | **D** | **E** | **F** |
| Residential Buildings | Bedrooms | Night | 26 | 30 | 34 | 38 | 42 | 46 |
| | Living Spaces | 24 hours | 31 | 35 | 39 | 43 | 47 | 51 |
| | Kitchens | 24 hours | 31 | 35 | 39 | 43 | 47 | 51 |

## 3. Proposed Method

In this study, in order to define how to improve the acoustic standards in existing structures, the correlation of the floor levels, wall thickness and the existence of the jacketing in the existing residential buildings constructed before 2017 with the acoustic performances were investigated in accordance with "Regulation on the Protection Against Noise in Buildings" published in the Official Gazette on 31st May 2017. In order to achieve the objective of this study, background noises of 155 residential buildings which have side to the main road and are located in Isparta in Turkey were measured and the level of floors, exterior wall thicknesses and the existence of the jacketing were determined. The obtained data were compared with the highest value permitted in the standard concerning "Regulation on the Protection Against Noise in Buildings" for the existing spaces of buildings in order to determine the acoustic comfort of the measured spaces. Then, the correlations of the level of floors, wall thickness and jacketing with the acoustic comfort values in the buildings were determined. Considering TS ISO 1996-2 standards (Turkish Standard, 2009), 465 measurements were conducted in 155 residences with a volume less than 300 m$^3$ in different regions via a device named Testo 816-1. Measured buildings were constructed before the "Regulation on the Protection Against Noise in Buildings" entering into force in 2017. According to TS ISO 1996-2 standards (Turkish Standard, 2009) , at least three different microphone positions - which are evenly located - should be used in a room where sound-affected people spend time. If low-frequency noise is considered to be dominant, one of the three microphone positions should be in the corner of the room. The location of the corner microphone should be located at a distance of at least 0.5 meters from the nearest wall. Other microphones should be positioned at least 0.5 meters from walls, ceiling or floor. It should also be positioned 1 meter away from prominent sound-conducting elements such as windows or air intakes. The distance between two neighboring microphones should be at least 0.7 meters. The processes in this article are mainly designed for rooms with a volume of less than 300 m3. The data obtained from the existing structures were compared with the C and D acoustic performance classes defined in the regulation, and thus the acoustic comforts of the existing structures were determined according to this standard. Then, the correlation of sound performance with the level of the floor, the thickness of the wall and the existence of the jacketing in existing buildings were determined by using SPSS software. Since the sample size is greater than 30 and the normal distribution is valid, Pearson correlation was adopted for this study.

## 4. Findings

In order to achieve the objective of this study, 155 spaces in residential buildings that had the side to the main street were selected. Permissions from the residents to conduct the noise measurements were requested. 3 measurements from different points as depicted in the regulation were made for each space and a total of 155 measurements were carried out. The results obtained from the residences measured during the day hours are depicted in Table 2 below.

**Table 2.** The results of the spaces measured during the day hours

| Number | Floor # | Type of the space | Location (Isparta, Turkey) | Noise Level (dB) | Corresponding Acoustic Performance Class | Exterior Wall Thickness (cm) | Jacketing |
|---|---|---|---|---|---|---|---|
| 1 | 3 | Bedroom | Süleyman Demirel Street, Çünur District | 41.2 | E | 20 | No |
| 2 | 3 | Bedroom | Süleyman Demirel Street, Çünur District | 39.8 | E | 20 | No |
| 3 | 3 | Bedroom | Süleyman Demirel Street, Çünur District | 49.3 | F | 20 | No |
| 4 | 3 | Living Spaces | Süleyman Demirel Street, Çünur District | 40.9 | D | 21 | No |
| 4 | 3 | Kitchen | Süleyman Demirel Street, Çünur District | 50 | F | 20 | No |
| 5 | 2 | Bedroom | Süleyman Demirel Street, Çünur District | 42.1 | F | 20 | No |
| 6 | 2 | Bedroom | Süleyman Demirel Street, Çünur District | 39 | E | 20 | No |
| 7 | 2 | Bedroom | Süleyman Demirel Street, Çünur District | 35.4 | D | 21 | No |
| 7 | 2 | Living Spaces | Süleyman Demirel Street, Çünur District | 40.3 | D | 21 | No |
| 7 | 2 | Kitchen | Süleyman Demirel Street, Çünur District | 49.3 | F | 20 | No |
| 8 | 2 | Bedroom | Süleyman Demirel Street, Çünur District | 30.1 | C | 25 | Yes |
| 9 | 2 | Bedroom | Süleyman Demirel Street, Çünur District | 30.6 | C | 25 | Yes |
| 10 | 2 | Bedroom | Süleyman Demirel Street, Çünur District | 30.4 | C | 25 | Yes |
| 11 | 2 | Living Spaces | Süleyman Demirel Street, Çünur District | 37.6 | C | 25 | Yes |
| 11 | 2 | Kitchen | Süleyman Demirel Street, Çünur District | 34.7 | C | 25 | Yes |
| 12 | 3 | Bedroom | Süleyman Demirel Street, Çünur District | 31.8 | C | 25 | Yes |
| 13 | 3 | Bedroom | Süleyman Demirel Street, Çünur District | 31.7 | C | 25 | Yes |
| 14 | 3 | Bedroom | Süleyman Demirel Street, Çünur District | 28.3 | C | 25 | Yes |
| 14 | 3 | Living Spaces | Süleyman Demirel Street, Çünur District | 37.2 | C | 25 | Yes |

| Number | Floor # | Type of the space | Location (Isparta, Turkey) | Noise Level (dB) | Corresponding Acoustic Performance Class | Exterior Wall Thickness (cm) | Jacketing |
|---|---|---|---|---|---|---|---|
| 15 | 3 | Kitchen | Süleyman Demirel Street, Çünur District | 37.2 | C | 25 | Yes |
| 16 | 3 | Living Spaces | 202 Street, Zafer District | 40.4 | D | 21 | Yes |
| 16 | 3 | Kitchen | 202 Street, Zafer District | 31.4 | C | 21 | Yes |
| 17 | 3 | Bedroom | 202 Street, Zafer District | 33 | C | 21 | Yes |
| 18 | 4 | Living Spaces | 202 Street, Zafer District | 45.2 | E | 20 | No |
| 18 | 4 | Kitchen | 202 Street, Zafer District | 40.3 | D | 21 | No |
| 19 | 4 | Bedroom | 202 Street, Zafer District | 38.3 | E | 20 | No |
| 20 | 3 | Living Spaces | 202 Street, Zafer District | 47.9 | F | 20 | No |
| 20 | 3 | Kitchen | 202 Street, Zafer District | 41.6 | D | 21 | No |
| 21 | 3 | Bedroom | 202 Street, Zafer District | 38.7 | E | 20 | No |
| 22 | GL | Living Spaces | 202 Street, Zafer District | 46.6 | D | 21 | No |
| 22 | GL | Kitchen | 202 Street, Zafer District | 46.2 | E | 20 | No |
| 22 | GL | Bedroom | 202 Street, Zafer District | 44.7 | F | 20 | No |
| 23 | 1 | Living Spaces | 202 Street, Zafer District | 39.2 | D | 21 | No |
| 23 | 1 | Kitchen | 202 Street, Zafer District | 40.3 | D | 21 | No |
| 24 | 1 | Bedroom | 202 Street, Zafer District | 35.2 | D | 21 | No |
| 25 | 2 | Living Spaces | 202 Street, Zafer District | 39.1 | D | 21 | No |
| 25 | 2 | Kitchen | 202 Street, Zafer District | 41.2 | D | 21 | No |
| 26 | 2 | Bedroom | 202 Street, Zafer District | 34.4 | D | 21 | No |
| 27 | 3 | Living Spaces | 202 Street, Zafer District | 36.8 | D | 21 | No |
| 28 | 3 | Kitchen | 202 Street, Zafer District | 43 | D | 21 | No |
| 29 | 3 | Bedroom | 202 Street, Zafer District | 34.5 | D | 21 | No |
| 30 | GL | Living Spaces | 202 Street, Zafer District | 43 | D | 27 | Yes |
| 30 | GL | Kitchen | 202 Street, Zafer District | 38,9 | C | 27 | Yes |
| 31 | GL | Bedroom | 202 Street, Zafer District | 38 | D | 27 | Yes |
| 32 | GL | Bedroom | 202 Street, Zafer District | 37,8 | D | 27 | Yes |
| 33 | 1 | Living Spaces | Mimar Sinan Street, İstiklal District | 39,3 | C | 27 | Yes |
| 33 | 1 | Kitchen | Mimar Sinan Street, İstiklal District | 39,5 | D | 27 | Yes |
| 34 | 1 | Bedroom | Mimar Sinan Street, İstiklal District | 33,3 | C | 27 | Yes |
| 35 | 1 | Bedroom | Mimar Sinan Street, İstiklal District | 36,4 | D | 27 | Yes |
| 36 | 2 | Living Spaces | Mimar Sinan Street, İstiklal District | 39,4 | D | 27 | Yes |
| 36 | 2 | Kitchen | Mimar Sinan Street, İstiklal District | 39 | C | 27 | Yes |
| 37 | 2 | Bedroom | Mimar Sinan Street, İstiklal District | 34 | C | 27 | Yes |
| 38 | 2 | Bedroom | Mimar Sinan Street, İstiklal District | 33,4 | C | 27 | Yes |
| 39 | 2 | Living Spaces | Mimar Sinan Street, İstiklal District | 44.6 | E | 20 | No |

| Number | Floor # | Type of the space | Location (Isparta, Turkey) | Noise Level (dB) | Corresponding Acoustic Performance Class | Exterior Wall Thickness (cm) | Jacketing |
|---|---|---|---|---|---|---|---|
| 40 | 2 | Kitchen | Mimar Sinan Street, İstiklal District | 43.6 | E | 20 | No |
| 40 | 2 | Bedroom | Mimar Sinan Street, İstiklal District | 39.1 | E | 20 | No |
| 41 | 4 | Living Spaces | Mimar Sinan Street, İstiklal District | 48.3 | F | 20 | No |
| 41 | 4 | Kitchen | Mimar Sinan Street, İstiklal District | 52.8 | F | 20 | No |
| 42 | 4 | Bedroom | Mimar Sinan Street, İstiklal District | 43.6 | F | 20 | No |
| 43 | 1 | Living Spaces | Mimar Sinan Street, İstiklal District | 44.4 | E | 20 | No |
| 43 | 1 | Kitchen | Mimar Sinan Street, İstiklal District | 47.5 | F | 20 | No |
| 44 | 1 | Bedroom | Mimar Sinan Street, İstiklal District | 38.1 | E | 20 | No |
| 45 | 2 | Living Spaces | Mimar Sinan Street, İstiklal District | 38,1 | C | 25 | Yes |
| 45 | 2 | Kitchen | Mimar Sinan Street, İstiklal District | 40,7 | D | 25 | Yes |
| 46 | 2 | Bedroom | Mimar Sinan Street, İstiklal District | 38 | D | 25 | Yes |
| 47 | 1 | Living Spaces | Mimar Sinan Street, İstiklal District | 39.3 | D | 20 | Yes |
| 47 | 1 | Kitchen | Mimar Sinan Street, İstiklal District | 41.6 | D | 20 | Yes |
| 48 | 1 | Bedroom | Mimar Sinan Street, İstiklal District | 37.9 | D | 20 | Yes |
| 49 | 4 | Living Spaces | İstasyon Street, İstiklal District | 48.7 | F | 20 | No |
| 49 | 4 | Kitchen | İstasyon Street, İstiklal District | 42.6 | D | 21 | No |
| 50 | 4 | Bedroom | İstasyon Street, İstiklal District | 36.1 | D | 21 | No |
| 51 | 4 | Bedroom | İstasyon Street, İstiklal District | 39 | E | 20 | No |
| 52 | 1 | Living Spaces | İstasyon Street, İstiklal District | 39.1 | D | 21 | No |
| 52 | 1 | Kitchen | İstasyon Street, İstiklal District | 43.4 | E | 20 | No |
| 53 | 1 | Bedroom | İstasyon Street, İstiklal District | 38.1 | E | 20 | No |
| 54 | 2 | Living Spaces | İstasyon Street, İstiklal District | 46.4 | E | 20 | No |
| 54 | 2 | Bedroom | İstasyon Street, İstiklal District | 37.7 | D | 21 | No |
| 55 | 2 | Bedroom | İstasyon Street, İstiklal District | 41.8 | E | 20 | No |
| 56 | 5 | Living Spaces | İstasyon Street, İstiklal District | 39 | C | 27 | Yes |
| 56 | 5 | Kitchen | İstasyon Street, İstiklal District | 40 | D | 27 | Yes |
| 56 | 5 | Bedroom | İstasyon Street, İstiklal District | 33,8 | C | 27 | Yes |
| 57 | 3 | Living Spaces | İstasyon Street, İstiklal District | 44.8 | E | 20 | No |
| 57 | 3 | Bedroom | İstasyon Street, İstiklal District | 41.3 | E | 20 | No |
| 58 | 5 | Living Spaces | İstasyon Street, İstiklal District | 45.2 | E | 19 | No |
| 58 | 5 | Kitchen | İstasyon Street, İstiklal District | 49 | F | 19 | No |
| 58 | 5 | Bedroom | İstasyon Street, İstiklal District | 42.4 | F | 19 | No |
| 59 | 5 | Bedroom | İstasyon Street, İstiklal District | 40.1 | E | 19 | No |
| 60 | 2 | Living Spaces | İstasyon Street, İstiklal District | 44.9 | E | 20 | No |

| Number | Floor # | Type of the space | Location (Isparta, Turkey) | Noise Level (dB) | Corresponding Acoustic Performance Class | Exterior Wall Thickness (cm) | Jacketing |
|---|---|---|---|---|---|---|---|
| 60 | 2 | Kitchen | İstasyon Street, İstiklal District | 45.6 | E | 20 | No |
| 61 | 2 | Bedroom | İstasyon Street, İstiklal District | 43.7 | F | 20 | No |
| 62 | GL | Living Spaces | Alparslan Türkeş Street, Davraz District | 47.3 | F | 20 | No |
| 62 | GL | Bedroom | Alparslan Türkeş Street, Davraz District | 39.8 | E | 20 | No |
| 63 | 4 | Living Spaces | Alparslan Türkeş Street, Davraz District | 43.5 | E | 20 | No |
| 63 | 4 | Kitchen | Alparslan Türkeş Street, Davraz District | 45.9 | E | 20 | No |
| 64 | 4 | Bedroom | Alparslan Türkeş Street, Davraz District | 38.8 | E | 20 | No |
| 65 | 1 | Living Spaces | Alparslan Türkeş Street, Davraz District | 39.1 | D | 20 | Yes |
| 66 | 1 | Kitchen | Alparslan Türkeş Street, Davraz District | 43 | D | 20 | Yes |
| 66 | 1 | Bedroom | Alparslan Türkeş Street, Davraz District | 36.4 | D | 20 | Yes |
| 67 | 1 | Living Spaces | Alparslan Türkeş Street, Davraz District | 39.9 | D | 20 | Yes |
| 67 | 1 | Bedroom | Alparslan Türkeş Street, Davraz District | 34.3 | D | 20 | Yes |
| 68 | GL | Living Spaces | Alparslan Türkeş Street, Davraz District | 48 | F | 19 | No |
| 68 | GL | Bedroom | Alparslan Türkeş Street, Davraz District | 41.8 | E | 19 | No |
| 69 | 2 | Living Spaces | Alparslan Türkeş Street, Davraz District | 42,2 | D | 23 | Yes |
| 69 | 2 | Kitchen | Alparslan Türkeş Street, Davraz District | 40,4 | D | 23 | Yes |
| 70 | 2 | Bedroom | Alparslan Türkeş Street, Davraz District | 32,6 | C | 23 | Yes |
| 71 | 2 | Bedroom | Alparslan Türkeş Street, Davraz District | 33,5 | C | 23 | Yes |
| 71 | 2 | Living Spaces | Alparslan Türkeş Street, Davraz District | 40.2 | D | 25 | Yes |
| 72 | 2 | Kitchen | Alparslan Türkeş Street, Davraz District | 41.1 | D | 25 | Yes |
| 73 | 2 | Bedroom | Alparslan Türkeş Street, Davraz District | 37.3 | D | 25 | Yes |
| 74 | 2 | Bedroom | Alparslan Türkeş Street, Davraz District | 34.9 | D | 25 | Yes |
| 74 | 2 | Living Spaces | Alparslan Türkeş Street, Davraz District | 45.1 | E | 20 | No |
| 75 | 2 | Bedroom | Alparslan Türkeş Street, Davraz District | 39.4 | E | 20 | No |
| 76 | 3 | Living Spaces | Alparslan Türkeş Street, Davraz District | 44.2 | E | 20 | No |
| 76 | 3 | Bedroom | Alparslan Türkeş Street, Davraz District | 38.4 | E | 20 | No |
| 77 | 1 | Living Spaces | Alparslan Türkeş Street, Davraz District | 49.4 | F | 20 | No |
| 77 | 1 | Kitchen | Alparslan Türkeş Street, Davraz District | 48.9 | F | 20 | No |
| 78 | 1 | Bedroom | Alparslan Türkeş Street, Davraz District | 43 | F | 20 | No |
| 79 | 1 | Bedroom | Alparslan Türkeş Street, Davraz District | 44.2 | F | 20 | No |
| 80 | 1 | Living Spaces | Alparslan Türkeş Street, Davraz District | 43.1 | E | 20 | No |

| Number | Floor # | Type of the space | Location (Isparta, Turkey) | Noise Level (dB) | Corresponding Acoustic Performance Class | Exterior Wall Thickness (cm) | Jacketing |
|---|---|---|---|---|---|---|---|
| 80 | 1 | Bedroom | Alparslan Türkeş Street, Davraz District | 38.7 | E | 20 | No |
| 81 | 2 | Living Spaces | Alparslan Türkeş Street, Davraz District | 40.2 | D | 21 | No |
| 81 | 2 | Kitchen | Alparslan Türkeş Street, Davraz District | 44.2 | E | 20 | No |
| 82 | 2 | Bedroom | Alparslan Türkeş Street, Davraz District | 34.3 | D | 21 | No |
| 83 | 2 | Bedroom | Alparslan Türkeş Street, Davraz District | 38 | D | 21 | No |
| 84 | 7 | Living Spaces | Alparslan Türkeş Street, Davraz District | 44.7 | E | 20 | No |
| 84 | 7 | Kitchen | Alparslan Türkeş Street, Davraz District | 41.4 | D | 21 | No |
| 84 | 7 | Bedroom | Alparslan Türkeş Street, Davraz District | 36.8 | D | 21 | No |
| 85 | 4 | Living Spaces | Alparslan Türkeş Street, Davraz District | 44.7 | E | 19 | No |
| 85 | 4 | Kitchen | Alparslan Türkeş Street, Davraz District | 44.6 | E | 19 | No |
| 85 | 4 | Bedroom | Alparslan Türkeş Street, Davraz District | 41 | E | 19 | No |
| 86 | 4 | Bedroom | Alparslan Türkeş Street, Davraz District | 40.3 | E | 19 | No |
| 87 | GL | Living Spaces | Gölcük Street, Gülistan District | 38,5 | C | 20 | Yes |
| 87 | GL | Kitchen | Gölcük Street, Gülistan District | 37,7 | C | 20 | Yes |
| 87 | GL | Bedroom | Gölcük Street, Gülistan District | 34,8 | D | 20 | Yes |
| 88 | 1 | Living Spaces | Gölcük Street, Gülistan District | 41.9 | D | 21 | No |
| 88 | 1 | Kitchen | Gölcük Street, Gülistan District | 44 | E | 20 | No |
| 89 | 1 | Bedroom | Gölcük Street, Gülistan District | 39.1 | E | 20 | No |
| 90 | 2 | Living Spaces | Gölcük Street, Gülistan District | 44.6 | E | 20 | No |
| 90 | 2 | Bedroom | Gölcük Street, Gülistan District | 40.7 | D | 21 | No |
| 91 | 3 | Living Spaces | Gölcük Street, Gülistan District | 40.8 | D | 21 | No |
| 91 | 3 | Bedroom | Gölcük Street, Gülistan District | 38.1 | E | 20 | No |
| 92 | 1 | Living Spaces | Gölcük Street, Gülistan District | 45 | E | 20 | No |
| 92 | 1 | Kitchen | Gölcük Street, Gülistan District | 47.4 | F | 20 | No |
| 93 | 1 | Bedroom | Gölcük Street, Gülistan District | 40.4 | E | 20 | No |
| 94 | 1 | Bedroom | Gölcük Street, Gülistan District | 42.4 | F | 20 | No |
| 95 | 5 | Living Spaces | Gölcük Street, Gülistan District | 42.9 | D | 21 | No |
| 95 | 5 | Bedroom | Gölcük Street, Gülistan District | 38.1 | E | 20 | No |
| 96 | 6 | Living Spaces | Gölcük Street, Gülistan District | 42.3 | D | 21 | No |
| 96 | 6 | Bedroom | Gölcük Street, Gülistan District | 39 | E | 20 | No |
| 97 | 7 | Living Spaces | Gölcük Street, Gülistan District | 39.9 | D | 21 | No |
| 97 | 7 | Bedroom | Gölcük Street, Gülistan District | 36.8 | D | 21 | No |
| 98 | 1 | Living Spaces | Gölcük Street, Gülistan District | 45.3 | E | 20 | No |
| 98 | 1 | Kitchen | Gölcük Street, Gülistan District | 43.4 | E | 20 | No |

| Numb er | Floor # | Type of the space | Location (Isparta, Turkey) | Noise Level (dB) | Correspondin g Acoustic Performance Class | Exterior Wall Thickness (cm) | Jacketin g |
|---|---|---|---|---|---|---|---|
| 99 | 1 | Bedroom | Gölcük Street, Gülistan District | 40.3 | E | 20 | No |
| 100 | 1 | Bedroom | Gölcük Street, Gülistan District | 40.9 | E | 20 | No |

The thickness of jacketing - which was rigid foam - was detected as 5cm in the measured residences. Measured walls were made by standard Izo-Brick wall and their Loss of Sound Crossings (Rw) were 40 dB according to factory specification. In the light of Table 2, the classification of the spaces according to acoustic performance classes of measured spaces, wall thicknesses and jacketing are tabulated in Table 3 below.

**Table 3.** Wall thicknesses, acoustic performance class and jacketing conditions of residences.

| Exterior Wall Thickness of the Space (cm) | Number of Space | C | | D | | E | | F | |
|---|---|---|---|---|---|---|---|---|---|
| | | Jacketing | | | | | | | |
| | | Yes | No | Yes | No | Yes | No | Yes | No |
| 19 | 10 | | | | | | 7 | | 3 |
| 20 | 75 | 2 | | 9 | | | 45 | | 19 |
| 21 | 34 | 2 | | 1 | 31 | | | | |
| 23 | 4 | 2 | | 2 | | | | | |
| 25 | 17 | 11 | | 6 | | | | | |
| 27 | 15 | 8 | | 7 | | | | | |
| **Total** | **155** | **25** | | **25** | **31** | | **52** | | **22** |

As depicted in Table 3, while A and B acoustic performance classes were not achieved, C, D, E and F acoustic performance classes were met by 25, 56, 52 and 22 residences respectively. Residences meeting the C condition contain both jacketing and exterior walls having thickness above 20 cm. 25 spaces meeting condition D which is the minimum limit of the acoustic comfort were jacketed and their outer wall thicknesses were in the range of 20-27 cm. However, 31 spaces meeting condition D were not jacketed and their exterior wall thickness was 21 cm. The spaces - which were not jacketed and had wall thickness as 20 cm and below - met the E and F conditions. The data were analyzed via SPSS software to determine the correlation of the wall thickness and jacketing with the noise level by using Pearson Correlation. The output is depicted in Table 4 below.

**Table 4.** Correlation of the wall thickness and jacketing with the Noise Level

| **Correlations** | | **Noise Level** |
|---|---|---|
| Noise Level | Pearson Correlation | 1 |
| | Sig. (2-tailed) | |
| | N | 155 |
| Exterior Wall Thickness | Pearson Correlation | -.504** |
| | Sig. (2-tailed) | .000 |
| | N | 155 |
| Floor | Pearson Correlation | .008 |
| | Sig. (2-tailed) | .919 |
| | N | 155 |
| Jacketing | Pearson Correlation | -.556** |
| | Sig. (2-tailed) | .000 |
| | N | 155 |

**. Correlation is significant at the 0.01 level (2-tailed).

The value of the correlation coefficient ranges from +1 to -1 in terms of the strength of the relationship. As the correlation coefficient value approaches 0, the relationship between the two variables weakens. A '+' sign stands for a positive relationship and a '-' sign denotes a negative relationship. As is seen in Table 4, while both Exterior Wall thickness and availability of jacketing have positive correlations which are around 0.5, floor level doesn't have any significant correlation with the noise level.

## 5. Conclusion

In order to provide comfort by diminishing the negative effects of noise on human health, it is necessary to determine the acoustic criteria correctly and to examine and improve the acoustic comforts of existing buildings. Standards concerning the limit values for environmental noise, background noise and sound insulation for buildings elements are specified in the regulations. In this study, a total of 465 measurements were made in three different points of 155 residences with a volume of less than 300 $m^3$ via Testo 816-1 device in accordance with TS ISO 1996-2 standards. These measurements were compared with the highest permitted in-room noise levels defined in the "Regulation on Noise Protection of Buildings" published in the Official Gazette on 31 May 2017. It should provide at least C class for new buildings, at least D class for the existing buildings. Of 81 (52%) residences providing the acoustic performance classes (C, D) in total, 50 (32%) spaces were externally jacketed and had external walls with thicknesses over 25 cm. 31 over 81 spaces providing the acoustic performance classes (D) have external walls with thicknesses of 21 cm without jacketing. However, 74 spaces where the acoustic comforts were not satisfied according to concerning standard have no jacketing and their wall thicknesses were 20cm and below. It is explicitly concluded that the external wall thickness and the existence of jacketing positively affect the acoustic comfort and living standards accordingly.

## Conflict of Interest

No conflict of interest was declared by the author.

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