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Article

Evaluation of plasterboard partition wall sections in terms of requirements for noise control

Zeynep SAVCI ÖZGÜVEN*, Neşe YÜĞRÜK AKDAĞ

Department of Architecture, Faculty of Architecture, Yıldız Technical University, İstanbul, Türkiye

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ABSTRACT

Building acoustics is known as one of the main indoor environmental conditions which holds utmost importance while considering the design, construction, and operation of buildings. Furthermore, it has gained greater importance together with the growing awareness of the adverse effects of noise on human health and psychology. As a result of these pertinent findings, the "Regulation on Protection of Buildings Against Noise (RPBAN)" was published in the Official Gazette on May 31, 2018, and was officially enforced. Under this regulation, the criteria related to architectural acoustics, such as sound insulation, background noise levels, and reverberation time, are evaluated using an acoustic performance classification system divided into six categories. Newly designed buildings are expected to achieve at least Class C acoustic performance, while existing buildings undergoing renovation are required to meet a minimum of Class D.

Achieving the sound insulation values specified for different acoustic performance classes in buildings is dependent upon various factors such as the inclusion of material properties of different densities and thicknesses, variations in the joint details of building components, and application conditions. Consequently, significant differences often arise between airborne sound insulation values obtained under laboratory conditions and those recorded in the field. Within the scope of this study, 10 different wall variations that were formed into dry wall systems were applied and measured for airborne sound insulation values at the Turkish Standards Institution's Tuzla Building Materials Fire and Acoustic Laboratory. These applications were conducted at various times, using different inner materials, wall types, and gypsum board densities.

To make calculations with the simulation program, the Rw values obtained from laboratory measurements were assigned as the sound transmission loss values of the partition wall sections defined between the rooms. The laboratory-measured results were then simulated within a controlled digital environment under three different scenarios, and the resulting $D_{nT,w}$+C ($D_{nT,A}$) values were compared with the standards outlined under formal regulations. The results obtained from the three different evaluated hypothetical scenarios showed that as the volume of the receiver room increases, i.e., as the V/S ratio increases, the calculated $D_{nT,w}$+C value rises.

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***Corresponding author**
*E-mail adres: zeynepsavci@gmail.com

INTRODUCTION

The construction sector holds a significant place in our economy and is one of the largest and most dynamic industries in Turkey. In recent years, with the increase in the export of both construction materials and contracting services, the importance of the sector and its direct involvement with international competitiveness has consecutively grown. In order to assist with the improvement of general comfort for indoor usage and amenities of the like, to avoid undesired situations that are directly correlated to the rights of acoustic privacy and the effects of standardized conditions, these new policies came into effect as an official regulation to directly address acoustic requirements in Turkey on May 31, 2018.

The sound insulation classes defined by regulation are crucial criteria for determining the quality of sound insulation provided by the building elements. Neubauer's study, commonly utilized throughout Europe, is used to examine how parameters such as DnT,w and Rw, are used to create sound insulation classes and explores the relationship between these parameters. This study reveals that a difference of approximately ±2 dB may occur between these two measurements dependent on the geometric properties of building elements and rooms. These findings emphasize the importance of considering specific boundary conditions when evaluating the acoustic performance of building elements (Neubauer, 2023).

Another study evaluates the acoustic performance of residential buildings in terms of legislation and its subjective effects by conducting field measurements of acoustic performance. This study also compares the threshold values defined in Turkey's regulations and the evaluation methods of building acoustic performance with socio-acoustic surveys, which helps to determine residential user satisfaction, disturbances caused by other various noise pollution and the levels of negative impact experienced by those affected (Şentop, 2020).

In the process of building acoustics, the design of partition walls and the selection of materials are of great importance, particularly in densely urbanized areas, which help to ensure acoustic privacy. In the study conducted by Uris et al., it was observed that due to the presence of an internal gypsum layer in double-framed partition walls, the sound insulation at low frequencies decreases even if the number of plaster panels in the wall section, the thickness and density of the gypsum panel layer do not change. The study further concludes that placing such layers in the middle of the partition wall decreases sound insulation at additional resonance frequencies, particularly in the 100-200 Hz range. These findings highlight the need for particular selection of material combinations for the purpose of building internal wall systems (Uris et al., 2006).

The sound insulation performance of building elements should be meticulously evaluated, not only in laboratory environments, but also under actual field conditions. Goretti and Cotana's study investigates the variations in sound insulation performance exhibited by the same building elements when constructed in different building designs. This study reveals how design parameters such as wall thickness and surface density lead to differing results in sound insulation, especially in small and irregularly shaped rooms. These findings underscore the importance of considering field conditions in the acoustic design of partition walls (Goretti & Cotana, 2014).

The study by Schäfers and Grethe examines the pros and cons of the KS Schallschutzrechner simulation program, which allows the modeling lateral or separating structural components of multi-layered lightweight structural elements in multi-storey residential buildings where sound insulation is designed in accordance with DIN 4109-2 (Schäfers & Grethe, 2015).

Aksoylu et al. conducted a comparative analysis of sound reduction index models in terms of sound transmission using four different simulation programs (Bastian, Akuzoft, Insul, and dBKAisla). Their analyses calculated the effectiveness and accuracy of the models for the weighted sound reduction index (RW), which reflects the degree of effective performance by the usage of proper materials, based on experimental data. With the usage of 11 materials, the average accuracy of the models was determined as follows: Insul model 90%, dBKAisla model 86%, Bastian model 84%, and Akuzoft model 82% (Aksoylu et al., 2016).

Tan and Sin analyzed the sound transmission values of four different construction materials (autoclaved aerated concrete, laminated glass, expanded polystyrene, and rock wool) using an impedance tube. These results can suggest that autoclaved aerated concrete provides more sound insulation than other materials. The sound insulation values of various combinations of these materials were also examined, with the combination of autoclaved aerated concrete and expanded polystyrene which proved to be more efficient than other alternative materials (Tan and Sin, 2018).

A similar study evaluated the sound insulation performance of single and double-panel structures using analytical and experimental findings based on mass law. The study calculated and compared sound insulation values using materials such as glass, steel, and concrete. While the analytical model was effective for sound insulation, differences between experimental and analytical results were observed at low frequencies (Tadeu et al., 2003).

In addition to simulation studies, on-site sound insulation measurements hold significant importance. In residential buildings in Macedonia, the sound transmission loss values of different types of partition walls, measured through field studies, were compared by Samardzioska T., and various interventions were implemented to improve these results. Gypsum board cladding combined with mineral wool was applied to perforated brick walls of varying thicknesses. For a 160-mm-thick perforated brick wall, the sound transmission loss value increased by 11 dB, rising from 38 dB to 49 dB. Similarly, for a 250-mm-thick perforated brick wall, the sound transmission loss value increased from 46 dB to 53 dB. (Samardzioska, 2014).

Crispin et al. (2008) examined the efficiency of flexible connectors for sound insulation according to EN ISO 12354-1(2021e). Their study focused on airborne sound insulation in masonry buildings built with brick content. Measurements were conducted on a constructed building using different types of flexible connectors for walls and floors. The results offered solutions for improving sound insulation based on the geometric conditions of the building and the complete separation of walls from the structure using flexible connectors (Crispin, 2023).

This study aims to evaluate the data obtained from sound transmission loss measurements (RW) conducted on 10 different gypsum board partition wall types within the compliance and standards of 10140-2 at the Turkish Standards Institution (TSE) laboratory (International Organization for Standardization [ISO], 2021). The DnT,A values are determined through simulations in modeled spaces and compared with regulatory values. In order to achieve this, the following is applied:

- The variables causing differences in the sound insulation levels of various gypsum board partition wall types obtained in accredited laboratories are identified, and design details to be considered during the planning stage are determined.
- The targeted sound insulation levels for wall types measured in laboratory conditions are compared using simulation software.
- The sound insulation levels of gypsum board partition walls in newly designed buildings are evaluated for compliance with the standards outlined in the regulation.

METHOD

Applications of gypsum board partition walls were conducted using 10 different wall typologies based on two different construction methods with varying density and thickness characteristics. The airborne sound insulation values of these wall types were measured at the Turkish Standards Institution's Tuzla Building Materials Fire and Acoustic Laboratory (TSE) according to the procedures outlined in ISO 10140-2 (2021b). The weighted standardized sound reduction index was calculated in accordance with ISO 717-1 (2013).

The Rw values obtained at the TSE Laboratory based on ISO 717-1 (2013) were converted into $D_{nT,w}$+C values for modeled spaces using the KS-Schallschutzrechner 8.03 Simulation Program. The weighted sound reduction index results ($D_{nT,w}$+C) derived from 10 partition wall types that were placed between a source room and three different receiver rooms were then evaluated under the "Regulation on Protection of Buildings Against Noise," published in the Official Gazette on May 31, 2018 (Ministry of Environment, Urbanization and Climate Change, 2018). As the modeled spaces were designed as office spaces the results were assessed within the office category as defined by the regulation.

The workflow followed by this study are presented below:

- ✓ Identification of gypsum partition wall section options
- ✓ Development of section details
- ✓ Determination of sound transmission loss values (RW) according to the TSE Laboratory
- ✓ Evaluation of results under the regulation are determined by:
- Design of modeled spaces
- Selection of simulation software
- Transfer of section options to the simulation program and obtaining results ($D_{nT,w}$+C)
- Assessment of results within the scope of RPBAN

GYPSUM BOARD PARTITION WALL TYPES EVALUATED WITHIN THE SCOPE OF THE STUDY

This section provides an overview of the material and application details of the gypsum board partition wall types studied, as well as information on the measurement equipment and its relevant standards.

Gypsum Board Partition Wall

The 10 types of gypsum board partition wall systems addressed in the study are divided into two categories based on their application methods.

Single-Frame Gypsum Board Partition Wall Systems

Gypsum board partition wall systems constructed using a single-frame carrier with a C100 galvanized profile were manufactured in the laboratory at various times, incorporating gypsum boards with varying panel densities. The details of the single construction gypsum panel partition wall type are shown in Figure 1.

Double-Frame Gypsum Board Partition Wall Systems

Double-frame gypsum board partition wall systems manufactured with C50 galvanized profiles were produced in the laboratory at various times using gypsum boards with varying panel densities. In the double-frame gypsum board

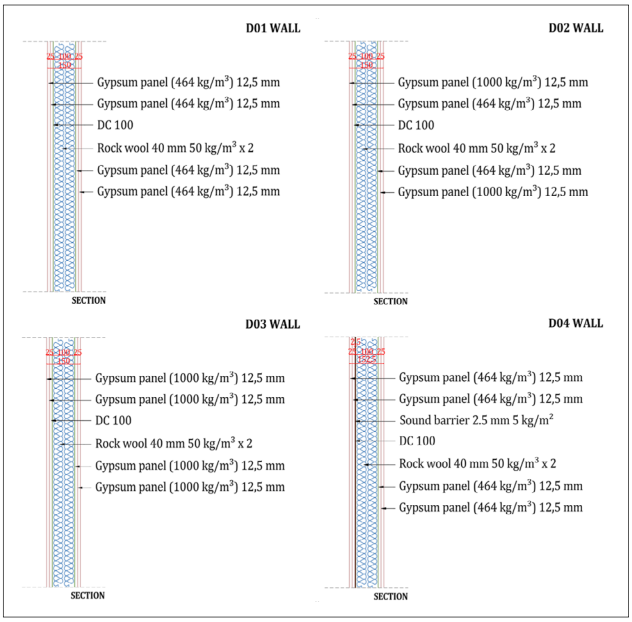


Figure 1. Single-Frame Gypsum Board Partition Wall Systems Manufactured at TSE (Credit to authors).

partition wall application, the air gap between the frames was increased to evaluate its effect on sound transmission loss values. In the double-frame gypsum board partition wall applications, the air gap between the frames was varied, a sound barrier was added to the gypsum board, and a flexible connection profile was utilized. The changes in measured sound transmission loss values were analyzed and compared, as illustrated in Figure 2.

Technical Application Details

In accordance with TS EN ISO 10140-5 (2021c), DU profiles were affixed to the floor, ceiling, and wall surfaces of the test frame by gluing 5 mm thick acoustic strips made from recycled rubber to the back and securing them with screws (ISO, 2021). DC profiles were placed within the 3060 mm x 4060 mm test frame at intervals of 60 cm. Double layers of gypsum boards were staggered and applied on both surfaces of the construction. The construction cavity was filled with two layers of stone wool, each 40 mm thick and with a density of 50 kg/m³. The second layer of gypsum boards were patched with mesh tape and joint filler. Fire-resistant sealant was applied around the perimeter of the frame on both sides to ensure airtightness. The installation of the test frame between the source and receiver rooms was carried out by the laboratory team. Relevant technical details can be viewed in Figure 3 through the following photographs:

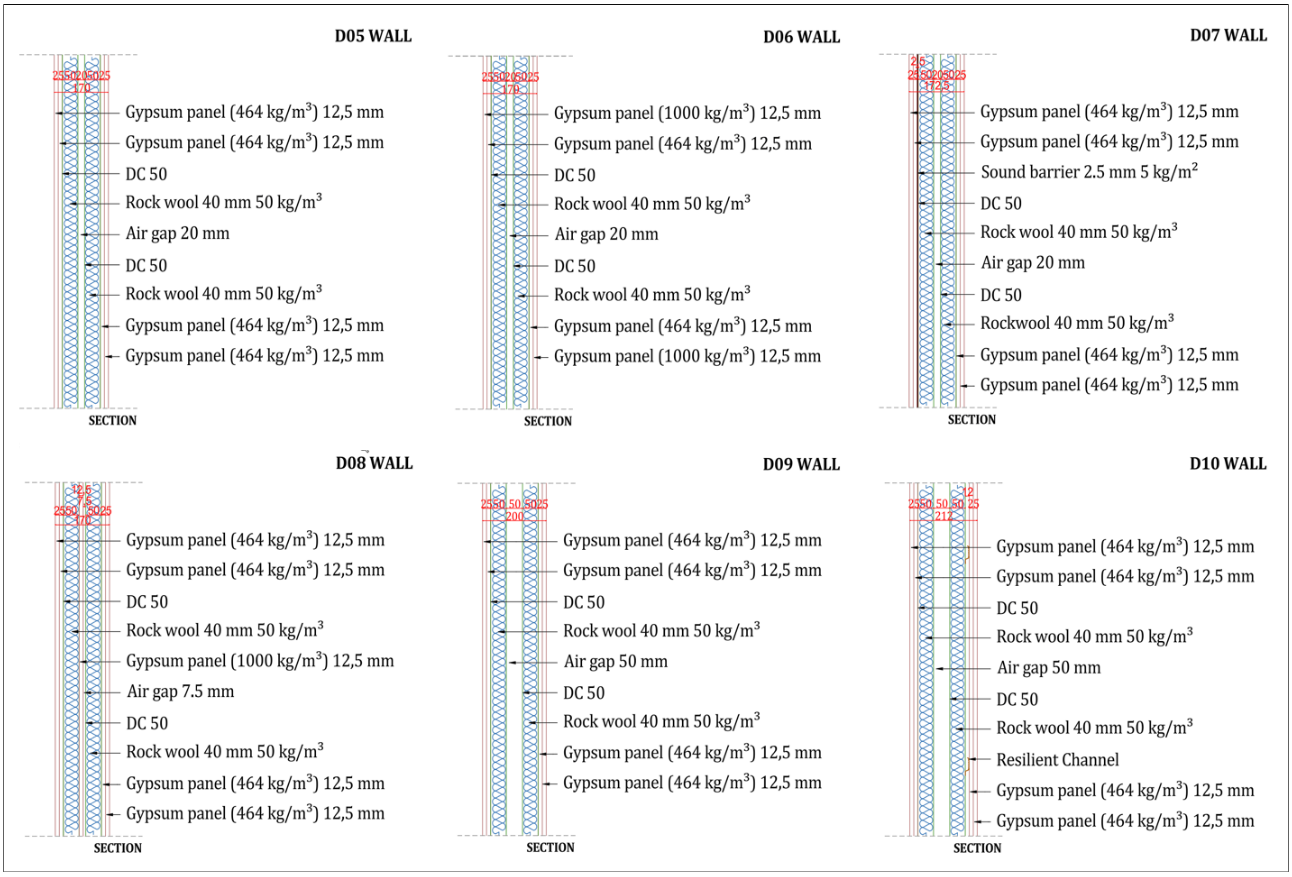


Figure 2. Double-Frame Gypsum Board Partition Wall Systems Manufactured at TSE (Credit to authors).

Figure 3. Gypsum Board Partition Wall Systems Manufactured at TSE.

LABORATORY CONDITIONS AND MEASUREMENT METHODS

Laboratory Conditions

The measurements were conducted at the Turkish Standards Institution (TSE) Testing and Calibration Center Presidency and Building Materials Fire and Acoustic Laboratory Directorate, both of which are located in Tuzla. The dimensions and specifications of the source and receiver rooms, as well as the environmental conditions of the laboratory where the measurements were carried out, are provided in Table 1.

Two adjacent rooms, one designated as the source room and the other as the receiver room, were used for the measurements. Loudspeakers and microphones were positioned at predetermined measurement points in accordance with TS EN ISO 10140-2 (2021b) and TS EN ISO 10140-5 (2021c) standards, which prepared the system for measurement (ISO, 2021). Before and after the measurement, calibration of the microphones was performed. For measurements using a mobile microphone, the sound pressure levels were recorded with a measurement duration and a full rotation time of the moving microphone set to 60 seconds. According to TS EN ISO 3382 (2021d), 12 measurements were performed for each frequency band to determine the reverberation time in the receiver room (ISO, 2021). Background noise was measured in the receiver room, and necessary corrections were made to the sound pressure level calculations. The section and plan views of the test rooms are provided in Figure 4:

Images of the test rooms containing specimens measured at varying times are presented in Figure 5. The laboratory tests were conducted using the following equipment:

- Power amplifier used specifically for the sound source, Norsonic, Nor280

Table 1. Environmental Characteristics of the Measurement Setup at TSE

Room name	Length (m)	Width (m)	Height (m)	Volume (m³)	Test wall area (m²)
Source room	6.39	5.29	3.56	114.90	12.40
Receiver room	7.75	5.48	4.30	174.42	
Room Name	**Temperature °C**	**Pressure (kPa)**	**Moisture %**		
Source room	21.4±0,8	102.5±1	34.9±5		
Receiver room	21.9±0,8	102.3±1	32.2±5		

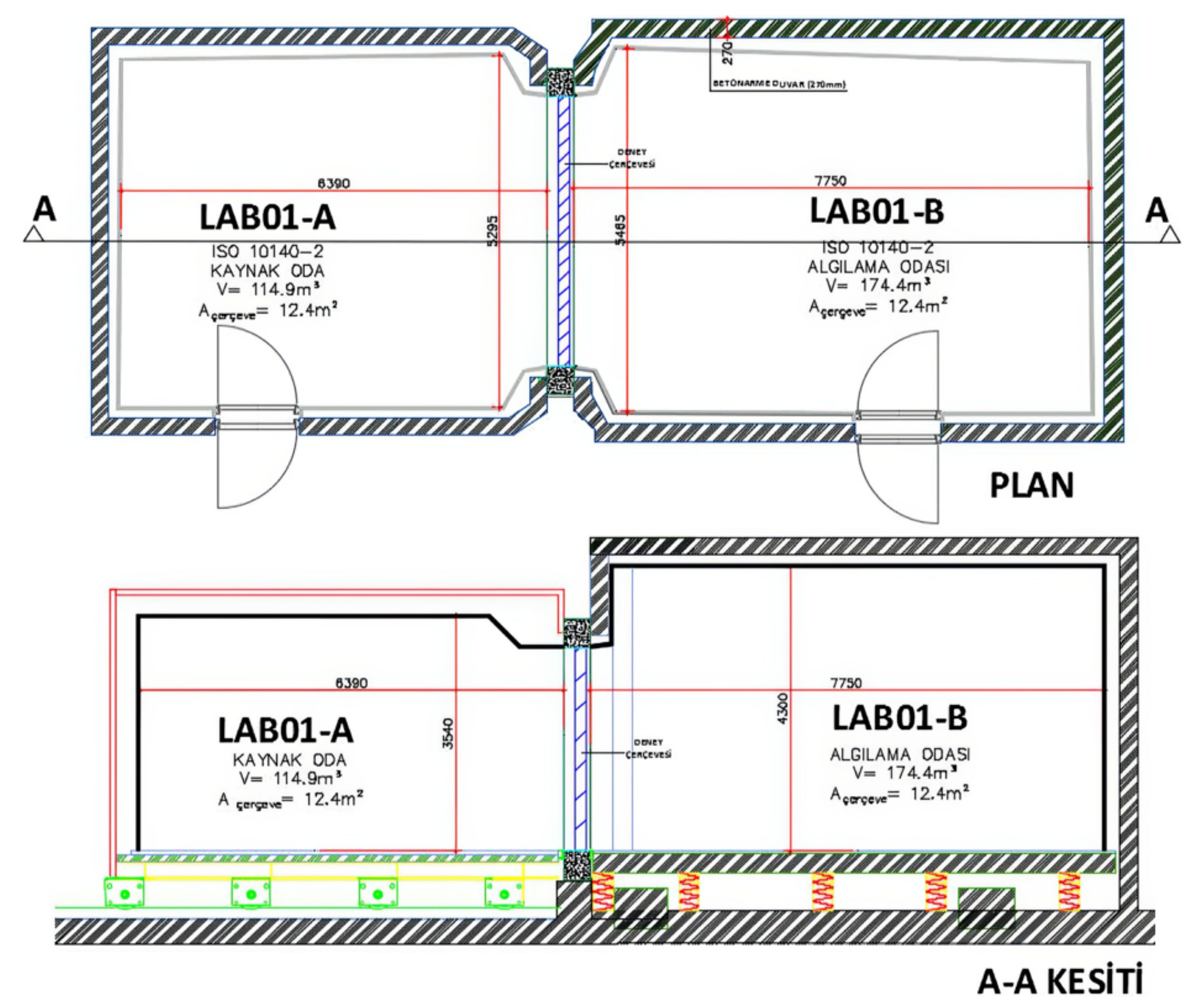


Figure 4. Section and Plan Views of the Test Room.

Figure 5. Measurement of the Test Specimen Under Laboratory Conditions.

- 12-faced omnidirectional sound source, Norsonic, Nor276
- 10-channel sound level analyzer
- ½-inch diffuse field microphone, Gras, Gras40ar
- Microphone boom and accessories
- Subwoofer, Davinci, Code 12S
- Calibrator, Norsonic, Nor1255

Measurement Method

To determine the Rw values of the wall sections, sound transmission loss measurements were conducted as a function of frequency in accordance with the TS EN ISO 10140-2:2021b standard. The results were calculated using the following Formula 1. The Rw values were obtained through single-number evaluation as per the TS EN ISO 717-1 standard (2013).

R = L1 - L2 + 10log(S/A) (1)

A = 0.16V/T

L1: Energy-averaged sound pressure level in the source room, dB

L2: Average sound pressure level in the receiver room, dB

S: Area of the free test opening where the test element is placed, m^2

A: Equivalent sound absorption area in the receiver room, m^2

V: Volume of the receiver room, m^3

T: Reverberation time in the receiver room, s

LABORATORY MEASUREMENT RESULTS AND EVALUATIONS IN TERMS OF THE RELEVANT REGULATION

Laboratory Results

The first wall construction, featuring a C100 single-frame structure, double-layer Intreme Fit® panels on both sides, and double-layer stone wool with a density of 50 kg/m^3, was carried out on January 22, 2024, under standard-compliant conditions in the laboratory of the Turkish Standards Institution (TSE) in Tuzla. Following this, all constructions were sequentially performed using different construction types and panels of varying densities, covering 10 walls in total, and were completed on September 5, 2024. The sound reduction index values (RW), measured in the frequency range of 100-3150 and 50-5000 Hz in 1/3 octave bands, along with the technical specifications of the wall types, are provided in Table 2.

In the RPBAN Regulation, requirements for insulation based on room function are provided using the weighted standardized level difference ($D_{nT,A}$), which takes into account factors such as the area of the receiver room, the surface area of the partition element, and lateral transmissions (ISO, 2021). Therefore, the Rw value determined through laboratory measurements is required to be converted into the DnT,A metric. The measurement values of the wall types tested in the laboratory indicate the Rw (C;C_{tr}) values belonging to the sound reduction class, which considers only direct sound transmission and excludes lateral transmission. In field applications of these wall types, factors such as lateral transmissions, the volume of the room, the surface area of the applied wall, and the reverberation time of the environment become critical. This is due to the fact that the regulation evaluates values based on $D_{nT,A}$. Using the Formula 2 and Formula 3 provided below, the weighted standardized level difference ($D_{nT,w}$) value can be calculated by substituting R'W.

The formulas from TS EN ISO 12354-1(2021e) which enable the conversion of Rw to DnT,A, are provided below as Formula 2 and Formula 3 (ISO, 2021):

$$D_{nT,W} + R'_w + 10\log\left(\frac{0.16V}{T_0 S_s}\right) = R'_w + 10\log\left(\frac{0.32V}{S_s}\right)\ dB \quad (2)$$

DnT,A = $D_{nT,w}$+C (3)

C: Correction Factor

T0: Reference Time

R'w: Weighted Sound Reduction Index

V: Volume of the receiver room (m^3)

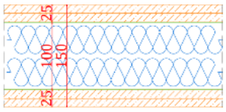
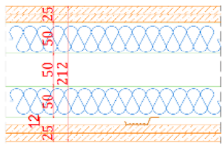
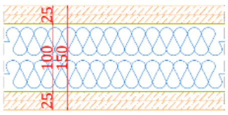
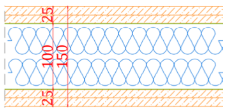
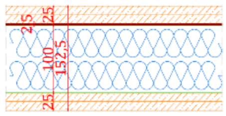
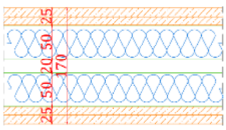
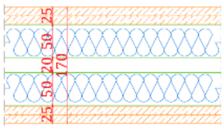
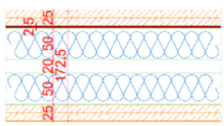
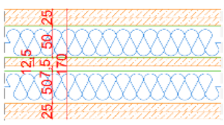
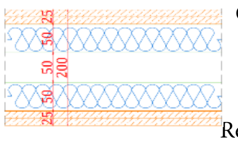
Ss: Surface area (m^2)

For the 10 wall sections with determined Rw values, three different hypothetical room sizes were created to determine which acoustic performance class was most useful according to the specified regulations. These sections were considered as partition walls for office meeting rooms. The hypothetical rooms were modeled in the KS-Schallschutzrechner 8.03 acoustic simulation program, which performs $D_{nT,A}$ value calculations in accordance with the TS EN ISO 12354-1 (2021e) standard. These values were then calculated for each wall section in three different hypothetical room configurations.

To input data into the KS-Schallschutzrechner 8.03 simulation program, it was assumed that side walls were constructed using 19.5 cm horizontally perforated bricks (800 kg/m^3) with 2 cm plaster on both surfaces (1600 kg/m^3). Additionally, the ceiling and floor slabs were modeled as 25 cm reinforced concrete slabs (2400 kg/m^3). The surface area of each gypsum board wall was constant at 15.75 m^2. These walls were evaluated for three different scenarios, where only the receiver room volume varied, and their corresponding DnT,A values were determined using the simulation program. Figure 6 presents the relevant plans of the hypothetical room configurations:

The 10 types of gypsum board partition walls measured under laboratory conditions were evaluated for three different receiver room volumes while keeping the partition

Table 2. Wall Section Specifications and Measurement Results (RW) of the Test Specimen

Wall Code	Wall Sections	WALL TYPES					Laboratory Result Rw (C;Ctr)
		Layering			Physical Properties		
		Material	Thickness (mm)	*Qty	Density (kg/m³)	Weight (kg/m²)	
D01		Gypsum panel	12,5 mm	4	464 kg/m³	5,8 ±0,2 kg/m²	49,50 (-4; -11)
		Rock wool	40 mm	2	50 kg/m³	1,44 kg	
		DC100	47/99/47	8	-	-	
		DU100	38/100/38	2	-	-	
D02		Gypsum panel	12,5 mm	2	1000 kg/m³	12,5 ±0,5 kg/m²	51,30 (-2; -6)
		Gypsum panel	12,5 mm	2	464 kg/m³	5,8 ±0,2 kg/m²	
		Rock wool	40 mm	2	50 kg/m³	2 kg/m²	
		DC100	47/99/47	8	-	-	
		DU100	38/100/38	2	-	-	
D03		Gypsum panel	12,5 mm	4	1000 kg/m³	12,5 ±0,5 kg/m²	59,00 (-3; -9)
		Rock wool	40 mm	2	50 kg/m³	2 kg/m²	
		DC100	47/99/47	8	-	-	
		DU100	38/100/38	2	-	-	
D04		Gypsum panel	12,5 mm	4	464 kg/m³	5,8 ±0,2 kg/m²	47,60 (-1; -6)
		Rock wool	40 mm	2	50 kg/m³	2 kg/m²	
		Sound barrier	2,5 mm	1	50 kg/m³	5 kg/m²	
		DC100	47/99/47	8	-	-	
		DU100	38/100/38	2	-	-	
D05		Gypsum panel	12,5 mm	4	464 kg/m³	5,8 ±0,2 kg/m²	55,60 (-5; -12)
		Rock wool	40 mm	2	50 kg/m³	1,44 kg	
		DC50	47/49/47	16	-	-	
		DU50	38/50/38	4	-	-	
		Air gap	20	1	-	-	
D06		Gypsum panel	12.5 mm	2	1000 kg/m³	12.5 ±0.5 kg/m²	64,20 (-5; -12)
		Gypsum panel	12.5 mm	2	464 kg/m³	5.8 ±0.2 kg/m²	
		Rock wool	40 mm	2	50 kg/m³	2 kg/m²	
		DC50	47/49/47	16	-	-	
		DU50	38/50/38	4	-	-	
		Air gap	20	1	-	-	
D07		Gypsum panel	12.5 mm	4	464 kg/m³	5.8 ±0.2 kg/m²	58,60 (-4; -11)
		Rock wool	40 mm	2	50 kg/m³	2 kg/m²	
		Sound barrier	2.5 mm	1	2000 kg/m³	5 kg/m²	
		DC50	47/49/47	16	-	-	
		DU50	38/50/38	4	-	-	
		Air gap	20	1	-	-	
D08		Gypsum panel	12.5 mm	4	464 kg/m³	5.8 ±0.2 kg/m²	53,50 (-6; -14)
		Gypsum panel	12,5 mm	1	1000 kg/m³	12,5 ±0,5 kg/m²	
		Rock wool	40 mm	2	50 kg/m³	2 kg/m²	
		DC50	47/49/47	16	-	-	
		DU50	38/50/38	4	-	-	
		Air gap	7,5	1	-	-	
D09		Gypsum panel	12,5 mm	4	464 kg/m³	5,8 ±0,2 kg/m²	57,30 (-5; -12)
		Rock wool	40 mm	2	50 kg/m³	1,44 kg	
		DC50	47/49/47	16	-	-	
		DU50	38/50/38	4	-	-	
		Air gap	50	1	-	-	
D10		Gypsum panel	12,5 mm	4	464 kg/m³	5,8 ±0,2 kg/m²	57,50 (-4; -11)
		Rock wool	40 mm	2	50 kg/m³	1,44 kg	
		DC50	47/49/47	16	-	-	
		DU50	38/50/38	4	-	-	
		Resilient Channel	-	5	-	-	
		Air gap	50	1	-	-	

*Qty: Quantity.

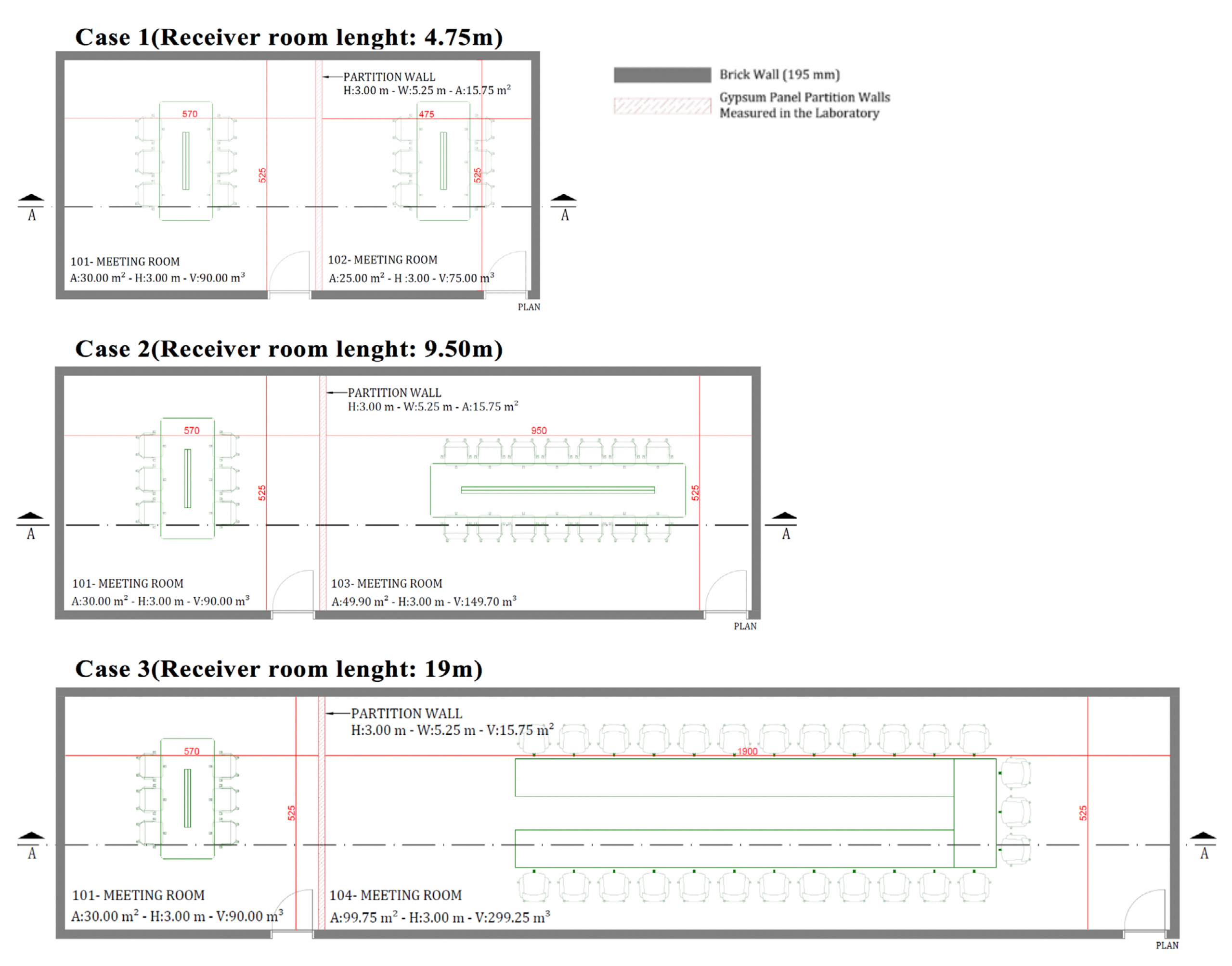


Figure 6. Plans of Hypothetical Room Configurations (Credit to authors).

wall section properties constant. The room specifications are provided in Table 3. In the first scenario, the longest dimension of the receiver room was set at 4.75 m. For the second scenario, the length was doubled to 9.50 m. In the third scenario, the length was doubled again to 19.00 m. Using the wall width as a reference, the $D_{nT,w}$+C values were calculated in the simulation program based on the following ratios: V/S = 75/15.75, V/S = 149.70/15.75, and V/S = 299.25/15.75.

Simulation results for all other walls across the three different hypothetical room configurations are provided in Table 4. As the V/S ratio increases, it is observed that the DnT,A value also increases. For instance, the Rw value of 49.5 (C-4; Ctr-11) obtained from the laboratory measurement for the first wall corresponds to a $D_{nT,w}$+C value of 46.9 dB while the V/S ratio is 4.76. Additionally, when the V/S ratio increases to 9.50 in the second scenario, the $D_{nT,w}$+C value rises to 49.9 dB. In the final scenario, the

Table 3. Room specifications of hypothetical rooms

Case	Room Name	Length (m)	Width (m)	Heigth (m)	Area (m²)	Volume (m³)	Wall Area (m²)
1	101-Meeting Room (Source Room)	5.70	5.25	3.00	30.00	90.00	15.75
	102- Meeting Room (Receiver Room)	4.75	5.25	3.00	25.00	75.00	
2	101- Meeting Room (Source Room)	5.70	5.25	3.00	30.00	90.00	
	103- Meeting Room (Receiver Room)	9.50	5.25	3.00	49.90	149.70	
3	101- Meeting Room (Source Room)	5.70	5.25	3.00	30.00	90.00	
	104- Meeting Room (Receiver Room)	19.00	5.25	3.00	99.75	299.25	

Table 4. Simulation Results

Wall Code	Sound insulation value, dB			
	Laboratory Results Rw (C;Ctr)	$D_{nT,w}$+C ($D_{nT,A}$)		
		Case 1 V/s = 75.00/15.75	Case 2 V/s = 149.70/15.75	Case 3 V/s = 299.25/15.75
D01	49.50 (-4; -11)	46.9	49.9	52.9
D02	51.30 (-2; -6)	50.1	53.1	56.1
D03	59.00 (-3; -9)	54.4	57.4	60.4
D04	47.60 (-1; -6)	47.8	50.8	53.8
D05	55.60 (-5; -12)	51.1	54.1	57.1
D06	64.20 (-5; -12)	55.6	58.6	61.6
D07	58.60 (-4; -11)	53.7	56.7	59.7
D08	53.50 (-6; -14)	48.6	51.6	54.6
D09	57.30 (-5; -12)	52.3	55.3	58.3
D10	57.50 (-4; -11)	53.1	56.1	59.1

room volume increases approximately fourfold compared to the first room and the V/S ratio reaches 19, the $D_{nT,w}$+C value is calculated as 52.9 dB while using the simulation program.

Comparison of Simulation Calculation Results with the Regulation

Within the scope of the "Regulation on Protection of Buildings Against Noise," published in the Official Gazette on May 31, 2018, an A-F classification system was introduced to determine the acoustic performance classes of buildings. In this classification, A represents the highest acoustic performance, while F represents the lowest. According to the regulation, new buildings must achieve a minimum acoustic performance of Class C, whereas existing buildings are evaluated with a minimum requirement of Class D (Ministry of Environment, Urbanization and Climate Change, 2018).

Table 5 presents classifications based on noise levels and sensitivity grades for office and administrative building spaces, considering source and receiver room scenarios (Ministry of Environment, Urbanization and Climate Change, 2019). In the hypothetical setup examined in this study, the configuration involves two adjacent meeting rooms in an office building. When one room is considered the source, it is categorized as medium-noise (MG), while the other room, as the receiver, falls under the first sensitivity grade. This classification has been verified based on the regulation's criteria outlined in the following Table 5:

Table 5. Noise Sensitivity/Noise Levels for Various Building and Space Functions

Building scale			Spatial scale		
Building function	Source situation Noise rating	Receiver situation Sensitivity rating	Room	Source situation Noise rating	Receiver situation Sensitivity rating
Office and administration buildings	MG	III	Private rooms	MG	I
			Open-plan areas	MG	II
			Meeting rooms	MG	I
			Teleconferance rooms	MG	I
			Recreational areas	MG	II
			Circulation areas1	MG	III
			Technical centers	HG	III
			Courtrooms	MG	II

I: Building and uses that are very sensitive to noise; II: Building and uses that are sensitive to noise; III: Building and uses that are less sensitive to noise; HG: High level noise generation; MG: Moderate noise generation; LG: Low level noise generation.

The minimum airborne sound insulation values to be achieved for the hypothetical rooms with defined noise levels and receiver sensitivity, based on the source and receiver room characteristics, are provided in Table 6 (Ministry of Environment, Urbanization and Climate Change, 2018).

The studies conducted across three different hypothetical scenarios are summarized in Table 7, alongside the regulatory values. The color coding in the table, taken from the original regulation, represents the acoustic performance classes. This table includes 10 different wall types and are identified by their respective wall codes. The laboratory results are presented as Rw(C;Ctr), while the simulation results for the three hypothetical scenarios are based on the three different receiver room volumes, as determined by the formula D_{nTw}+C ($D_{nT,A}$, dB).

According to these results, it can be observed in Table 7 that the $D_{nT,A}$ values, which result from three different design configurations, remain at or above the minimum D acoustic performance class. Through the evaluation of the acoustic performance class used for these three design spaces, under the assumption that they are existing structures, all the values presented in the table are within acceptable limits.

If these three rooms would be considered as newly constructed buildings, the D03/D06/D07/D09/D10 walls meet the minimum C acoustic performance class values under all three scenarios.

RESULTS/DISCUSSION

As a part of this study, the Rw values obtained from the laboratory production of 10 different gypsum board partition wall types at the Turkish Standards Institution Tuzla Building Materials Fire and Acoustic Laboratory were applied to three different hypothetical room configurations. The $D_{nT,w}$+C values ($D_{nT,A}$) obtained from the KS-Schallschutzrechner 8.03 simulation program were compared with the target values specified in the current regulation for meeting rooms in office spaces.

The findings can be concisely presented as follows:

Table 6. Minimum Airborne Sound Insulation Values (DnT,A, dB) to be Achieved Based on Source and Receiver Room Characteristics

Source room noise rating	Receiver room sensitivity	Acoustic performance class					
		A	B	C	D	E	F
Moderate level noise (MG)							
75≥ LAF,max >55 dB	I	62	58	52	48	44	40

Table 7. TSE laboratory Rw and DnTw+C Values (DnT,A, dB) of Sections

Wall Code	Laboratory Results Rw (C;Ctr)	Sound insulation value, dB DnT,w+C(DnT,A) Case 1 V/s = 75,00/15,75 K:5.70x5.25x3.00 A:4.75x5.25x3.00 (Length x width x height)	Case 2 V/s = 149,70/15,75 K:5.70x5.25x3.00 A:9.50x5.25x3.00 (Length x width x height)	Case 3 V/s = 299,25/15,75 K:5.70x5.25x3.00 A:19.00x5.25x3.00 (Length x width x height)
D01	49.50 (-4; -11)	46.9 (D Class)	49.9 (D Class)	52.9 (C Class)
D02	51.30 (-2; -6)	50.1 (D Class)	53.1 (C Class)	56.1 (C Class)
D03	59.00 (-3; -9)	54.4 (C Class)	57.4 (C Class)	60.4 (B Class)
D04	47.60 (-1; -6)	47.8 (D Class)	50.8 (D Class)	53.8 (C Class)
D05	55.60 (-5; -12)	51.1 (D Class)	54.1 (C Class)	57.1 (C Class)
D06	64.20 (-5; -12)	55.6 (C Class)	58.6 (B Class)	61.6 (B Class)
D07	58.60 (-4; -11)	53.7 (C Class)	56.7 (C Class)	59.7 (B Class)
D08	53.50 (-6; -14)	48.6 (D Class)	51.6 (D Class)	54.6 (C Class)
D09	57.30 (-5; -12)	52.3 (C Class)	55.3 (C Class)	58.3 (B Class)
D10	57.50 (-4; -11)	53.1 (C Class)	56.1 (C Class)	59.1 (B Class)

- The first four wall applications (D01-D02-D03-D04) were constructed using a single C100 profile. The densities of the panels used in the construction varied among these walls. In the D04 wall, a sound barrier weighing 5 kg/m² and measuring 2.5 mm in thickness was utilized, thus differing from the D01 wall and facilitating a comparison between the two. In D01, low-density panels (464 kg/m³) were applied in four layers, separated by 50 kg/m³ of fibrous material, while in D03, high-density panels (1000 kg/m³) were applied in four layers. Consequently, the higher density of the D03 wall resulted in higher Rw values.
- The Rw value of D04, which differed from D01 only in the inclusion of a sound barrier, was measured at a higher value when adjusted for correction factors (C; Ctr). When $D_{nT,A}$ calculations with correction factors were applied to the wall surfaces in the hypothetical rooms, D04 also demonstrated higher $D_{nT,A}$ values.
- In walls D05, D06, and D07, securely constructed using double C50 profiles with four panels, a 20 mm air gap, and 50 kg/m³ fibrous material. This construction technique was detected to be similar to single-frame applications with sound transmission loss values increasing as the panel density escalated.
- The difference between the D05 and D08 walls was the inclusion of a 12.5 mm thick, 464 kg/m³ density gypsum panel between the profiles in D08. This panel blocked the use of the beneficial air gap, resulting in lower Rw values for D08.
- In the production of double C50 construction walls coded D09, an increase in the air gap from 20 mm to 50 mm has shown positive effects. The findings indicate that the RW sound transmission loss value improves significantly with the increased air gap. Furthermore, these values are higher compared to the D05 wall, which shares the same specifications, aside from the air gap difference.
- In the production of plasterboard using C50 double construction, the D10 wall, which features a flexible connection profile, has demonstrated a positive increase in the Rw sound transmission loss value compared to the D09 wall. The D10 wall consists of 4 plates of the same density with a measurement of 20 cm air gap in between. This design choice highlights the benefits of incorporating flexible connections in wall assemblies, as it contributes to enhanced sound isolation performance.
- D10, which featured the same configuration as D09 aside from including a flexible connection profile, was observed to have a positive increase in the Rw value while demonstrating the effectiveness of the flexible connection in enhancing acoustic performance.
- The laboratory results for the 10 different wall types were constructed with materials of varying thickness and density, and revealed their distinct Rw values for each change. In the hypothetical room configurations prepared to evaluate these Rw values against regulation, it was observed that increasing the V/S ratio led to higher $D_{nT,A}$ values.

As demonstrated in this study, using Rw values determined through measurements in accredited acoustic laboratories, while also taking into consideration the receiver room volume, partition surface area, and lateral transmissions, and lastly verifying whether the required sound transmission loss is achieved, represents the most accurate approach. Therefore, following up with more similar studies will enable the selection of the most appropriate sections for compliance with regulations, particularly for noise control in buildings, and will pave the way for more effective solutions.

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