Research Article GU J Sci, Part B, 11(4): 785-797 (2023)

Gazi University

Journal of Science

PART B: ART, HUMANITIES, DESIGN AND PLANNING

http://dergipark.gov.tr/gujsb

Noise Control in Residential Buildings in the Context of National Regulation and An Example

Ahsen İNCE[1,*], Füsun DEMİREL[2]

[1] 0000-0002-7084-2997, *Gazi University, Faculty of Architecture, Department of Architecture, Ankara/Turkey*
[2] 0000-0002-8217-4797, *Gazi University, Faculty of Architecture, Department of Architecture, Ankara/Turkey*

Article Info

Received: 15/11/2023
Accepted: 22/12/2023

Keywords

Residential Buildings,
Noise,
Acoustic Comfort,
Regulation on the Protection of Buildings Against Noise.

Abstract

Noise in residential buildings has been a problem for users for years. In order to ensure acoustic comfort conditions in these units, noise control is included in the country's regulations. As a result of noise control gaining importance in our country in recent years, the Regulation on the Protection of Buildings Against Noise (2017) and the Regulation on Amending the Regulation on the Protection of Buildings Against Noise (2018) came into force. In this context, the aim of the study is to examine the noise control of an existing residential building and present suggestions for improvement by comparing it with the limit values defined in the regulation. Using the Insul (v9.0.24) simulation program, calculations were made to produce an evaluation of an independent unit of an existing residential structure. According to the results of this study, it has been determined that the sound transmission loss is quite high in the external walls of the composite structure due to the high wall thickness and the use of double-layered structural elements, but the insulation value of the composite system decreases due to the low sound transmission loss of the pvc windows. While sufficient sound insulation is provided in the interior walls, it has been determined that the impact sound limit values are not met due to the lack of adequate sound insulation measures in the floors, as in many residential buildings. For this reason, in the study, suggestions are presented to improve the sound insulation values of building elements that do not meet the limit values.

1. INTRODUCTION AND LITERATURE REVIEW

Since noise pollution is an increasing environmental problem in the world, noise control must first be provided in a livable environment. Especially in these days, the rapidly increasing number of high-rise buildings and lightweight building elements in architectural construction creates acoustic problems that are difficult to solve [1]. One of the necessary conditions to ensure indoor environmental quality is the necessity of acoustic comfort. In places where acoustic comfort is provided, it is possible to personalize conversations by blocking unwanted sounds. In this way, a space can be made a healthier and more productive living space [2].

Noise, which has become an important problem especially in urban areas due to factors such as population growth, dense construction, traffic and changing noise sources in addition to architectural construction, has been the subject of many studies in recent years [3]. In the study prepared by Maschkea and Niemanna (2007), it has been stated that traffic noise is the most dominant source of discomfort for many people living in European countries, followed by neighborly noise. In conclusion of this study, discomfort caused by neighborly noise increases the risk of depression and migraine. Therefore, increased requirements for sound insulation between residences in multi-family residences should be considered mandatory [4]. In the study conducted by Rasmussen and Ekholm (2015), the prevalence and trends over time of the discomfort felt by neighbor noise and traffic noise in the homes of adult Danes were examined. It has been determined that the discomfort felt by traffic noise and neighbor noise has increased over the years, and the discomfort is higher for users in multi-story houses, while the discomfort is less for users in detached houses. It has been found that the discomfort felt by neighborly

* Corresponding author: ahsencorakbas26@gmail.com

noise is highest in young people and that the discomfort decreases with age. According to the results of this study, more attention should be paid to improving the sound insulation between residences [5]. In the study prepared by Park & Lee (2017), the effects of impact sound on psychophysiological responses were investigated. As a result of this study, increases in noise levels cause more discomfort, and physiological responses are affected depending on the type of noise source [6].

Additionally, there are some studies that evaluate noise disturbances within the scope of national regulations. To illustrate, as a result of the research conducted by Şentop Dümen and Tamer Bayazıt (2019), regulation data were applied to existing buildings, and acoustic performance evaluation was examined within the framework of acoustic measurements and surveys. Acoustic performance classes were determined by comparing the measurement results taken from the building elements with the limit values. In addition to the measurement data, a survey was conducted, the noise disturbances of the users were examined, and the measurement results were compared with the noise disturbance data. As a result of this comparison, the reliability of field studies has been identified [7]. According to research data conducted by Şentop Dümen and Şaher (2020), while it was found that the discomfort caused by traffic noise decreased after COVID-19, it was also determined that users were disturbed by the sounds in their own apartments. During this period, the discomfort caused by neighborly noise generally did not change. In accordance with the result, it was observed that users were more affected by environmental noise. Additionally, some users stated that their noise awareness has increased and precautions should be taken. For this reason, it is suggested in the study that improved arrangements be addressed through acoustic classification [8]. As a result of the research conducted by Şentop Dümen, Şaher, and Kurra (2022), it has been stated that the discomfort of users due to outdoor noise has decreased due to the decrease in traffic noise after COVID-19. However, it has been determined that the use of private vehicles, which is preferred due to the pandemic, will create environmental noise. As the time spent at home increases, the lack of sound insulation in residential buildings has caused noise problems, and in addition, it has been identified that noise affects the comfort and productivity of users [9]. As a result of these studies, the aim is to create healthier environments by protecting users from unwanted sounds in buildings. Although the perception of noise and the discomfort felt by it vary from person to person, place and time, it can cause discomfort and different reactions in many users. In this context, it is necessary to ensure noise control in neighboring and adjacent spaces and to control environmental noise [10].

To this end, the limit values specified in the Regulation on the Protection of Buildings Against Noise (2017), which came into force in our country, vary according to acoustic performance classes. According to the mentioned regulation, acoustic performance class is an evaluation method that can be applied to independent sections or the entire building depending on sound insulation limit values, internal noise level, internal noise level caused by installation and service equipment, and reverberation time. While class A represents the highest quality, class F defines the lowest quality [11]. In this context, the aim of the study is the examination of the noise control of an existing residential building, the determination of its performance by comparing it with the limit values defined in the regulation, and, if necessary, the presentation of suggestions for improvement.

2. METHOD

In this study, performance criteria developed in the context of national regulation for residential buildings were evaluated on a sample. In line with this determined method, the sound insulation limit values of the structural elements in an existing residential building were calculated with the Insul (v9.0.24) simulation program, and the values are in accordance with the Regulation on the Protection of Buildings against Noise (2017) and the Regulation on Amendments to the Regulation on the Protection of Buildings against Noise (2018) was compared with the limit values defined for class D [11] [12] [13].

In converting the Rw (Ctr) and Lnw (CI) values obtained with the Insul program into regulation values, the confidence interval and simple method data specified in the Acoustical Design, Installation, and Inspection of Buildings Guide were used [16]. As a result of this evaluation, improvement suggestions for building elements that do not meet the limit values are presented in Section 5 of the study. In the study, since the limit values of building elements are determined by the simulation method, indoor noise, installation noise, and reverberation time limit values are excluded from the scope of the study.

3. NATIONAL REGULATION AND NOISE CONTROL LIMIT VALUES IN RESIDENTIAL BUILDINGS

Residential buildings are stated as very sensitive buildings to noise according to Article 4-rr of the regulation [11]. For this reason, residential buildings need to be protected against internal and external noise, and a comfortable space must be created for users. Limit values that must be met for comfort conditions are defined in the regulation. The limit values to be met in residential buildings are as follows: Regulation (2017) Annex-3 Table 3.1 for the lowest airborne sound insulation values on facade elements; if the neighborhood relationship is defined, it is necessary to use the data in Regulation (2017) Annex-3 Table 3.4 for the lowest airborne sound insulation values in interior partition elements and in Regulation (2018) Annex-3 Table 3.5 for the highest impact sound insulation values in floors [11] [13].

4. AN EXAMPLE: A RESIDENTIAL BUILDING IN ANKARA

In this study, the evaluation of an independent unit of an existing residential building within the scope of the Regulation on the Protection of Buildings Against Noise was created by making calculations with the Insul (v 9.0.24) simulation program [12].

4.1 General Information About Residential Building

The selected residential building is located in Emek neighborhood, Çankaya district, Ankara province. Figure 1 shows the location of the residential building.

Figure 1. *Location of the residential building in Çankaya (Yandex Map*)

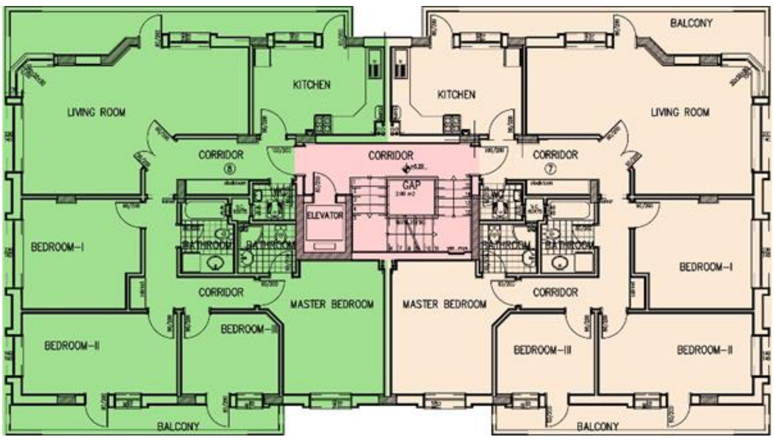


Figure 2. *The plan and section of the flat chosen as an example*

The selected residential building consists of two basement floors, a ground floor, three floor plans, and an attic floor plan. In this study, the second floor plan was taken as a sample. The plan and section of the flat chosen as a sample are given in Figure 2.

The selected flat is of the 4+1 plan type, and only the master bedroom and kitchen units are adjacent to the side flat. Wet volumes and circulation units are positioned in the center of the floor plan. While the wet areas act as a buffer zone for the residential building, the elevator and stairs use the same structural elements as the bedroom. However, it is seen that there is no sound insulation in the sections of the architectural project.

4.2 Environmental Noise Analysis

The environmental noise level for this residential building was provided by strategic noise maps obtained from Ankara Metropolitan Municipality [15]. Information about the noise level is given in Table 1.

Table 1. *Determination of noise level with a strategic noise map (2015)*

<table>
<tr><th>Level</th><th>Situation plan</th><th>Legend</th></tr>
<tr><td>Lden, dB(A)</td><td>Current data for 2015

Location of the building</td><td>


</td></tr>
</table>

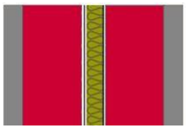
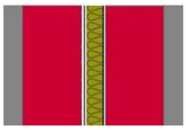
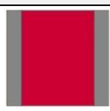
The examined residential example is located in the back streets of Mevlana Boulevard, which creates a high noise level. There are mostly residential buildings around the residential building, and there are two schools a few streets away. Since the existing environmental noise sources cause discomfort in the residential building, 59, which is the upper value of the limit value (55–59), was taken into consideration.

4.3 Determination of Building Element Types

When the architectural project was examined, it was seen that there was a heat-insulated reinforced concrete wall above the window, while a double-layer brick wall was used under the window. In the interior walls, it was determined that there was a reinforced concrete wall around the elevator, and the other walls were brick walls.

The existing structural element types used in the residential building are arranged from outside to inside, according to the data included in the project of the residential building, as indicated in Table 2. In this table, the components, structural element details, and insulation values of the building element types are included according to the project.

Table 2. *Building element types and properties*

Building Element Code	Building Element Components	Building Element Detail	Insulation Value of the Building Element
Exterior Building Elements *			
dd-1, dd-1a, dd-1b	Above the window: reinforced concrete wall (4 cm plaster - 25cm reinforced concrete – 5 cm thermal insulation – 4 cm plaster) - Rw: 61 (-1,-4) Pvc Window: 4cm glass – 12cm gap – 6 cm glass - Rw: 36 (-3,-6) Under the window: double layer brick wall (4cm plaster – 13,5 cm brick – 8 cm thermal insulation – 8,5 cm brick – 4 cm plaster) - Rw: 60 (-2,-5)	*Wall type above the window:*  *Wall type under the window:* 	Composite on living room, bedroom-1 and bedroom-2 facades *dd-1 wall:* **Rw:39 (-2,-6)** *dd-1a wall:* **Rw:40 (-2,-6)** *dd-1b wall:* **Rw:42 (-3,-6)**
dd-2, dd-2a, dd-2b, dd-2c	Above the window: reinforced concrete wall (4 cm plaster - 25cm reinforced concrete – 5 cm thermal insulation – 4 cm plaster) - Rw: 61 (-1,-4) Pvc Window: 4cm glass – 12cm gap – 6 cm glass - Rw: 36 (-3,-6) Under the window: double layer brick wall (4cm plaster- 18,5 cm brick -8cm thermal insulation- 13,5 cm brick -4 cm plaster) - Rw: 64 (-2,-7)	*Wall type above the window:*  *Wall type under the window:* 	Composite on living room, bedroom-2, bedroom-3 and master bedroom facades *dd-2, dd-2a, dd-2c walls:* **Rw:43 (-2,-6)** *dd-2b wall:* **Rw:41 (-2,-6)**
Interior Building Elements			
di-1,di-1a	* 4 cm plaster * 20cm brick * 4 cm plaster		*Between the walls separating the apartments:* **Rw:55 (-1,-4)**
di-2, di-2 (a,b,c,d,e,f)	* 4 cm plaster * 10cm brick * 4 cm plaster		*On interior walls:* **Rw:49 (-1,-3)**
di-3&di-3a	* 4cm plaster * 25 cm reinforced concrete wall		*Around the elevator:* **Rw: 61 (-1,-5)**

di-4&di- 4(a,b)	* 4cm plaster * 25cm brick * 4cm plaster ** Wooden door (for di-4a wall)		*di-4, di-4b walls around the apartment hall:* **Rw: 58 (-2,-5)** *di-4a composite wall**:* **Rw: 49 (-1,-6)**
Flooring Element			
do-1,do-2	* 3cm laminate flooring * 4cm screed * 12cm reinforced concrete * 4cm plaster		*Throughout the floor slab:* **Rw: 54 (-1,-3)** **Lnw:69 (-6)**
* Coding on external walls is made according to the most sensitive area. For this reason, receiver rooms were determined as volumes that are very sensitive to noise (bedrooms) and volumes that are sensitive to noise (living rooms). The kitchen volume, which is less sensitive to noise, was not evaluated. ** It shows the wall containing the door. For this reason, the sound insulation value of the composite system allowed to be no more than 14 dB lower than the limit values [11].			

The areas where the building elements defined in Table 2 are used in the floor plan are shown in Figure 3, and the airborne and impact sound insulation values of the building elements are shown in the table 3. $R_w(C;C_{tr})$ and $L_{n,w}(CI)$ values obtained with the Insul program correspond to the ($D_{n,T,Atr}$; $D_{n,T,A}$; $L'_{n,T,w}$) values defined in the regulation and as stated in the method of the study. It was transformed using a confidence interval and a simple method. According to these methods:

i. If the source and receiver room volumes are less than 75 m^3, the width and length of the spaces are less than 5 m, and the height is less than 3 m, the confidence interval method can be used. According to the confidence interval method:

* $D_{nT,A,tr} = R_w\ (C;C_{tr}) - 4$ * $D_{nT,A} = R_w\ (C;C_{tr}) - 3$ * $L'_{nT,w} = L_{n,w}\ (C_I) + 3$
Calculations can be made using formulas [16].

In the study, the confidence interval method was used in all spaces except the living room volume and the apartment hall, which do not meet these conditions. Simple method was used in the living room and apartment hall volumes.

ii. For airborne sound insulation, the Rw value must first be converted to the R'_w value, and this value to the D_{nTw} value.

iii. For impact sound insulation, both airborne sound ($D_{n,T,A}$) and impact sound ($L'_{nT,w}$) are taken into account. These transformations are stated in detail in the Acoustical Design, Installation, and Inspection of Buildings Guide [14]. The values converted according to these methods are given in Figure 3. Values that meet the limit value are shown in green, and values that do not meet the limit value are shown in red.

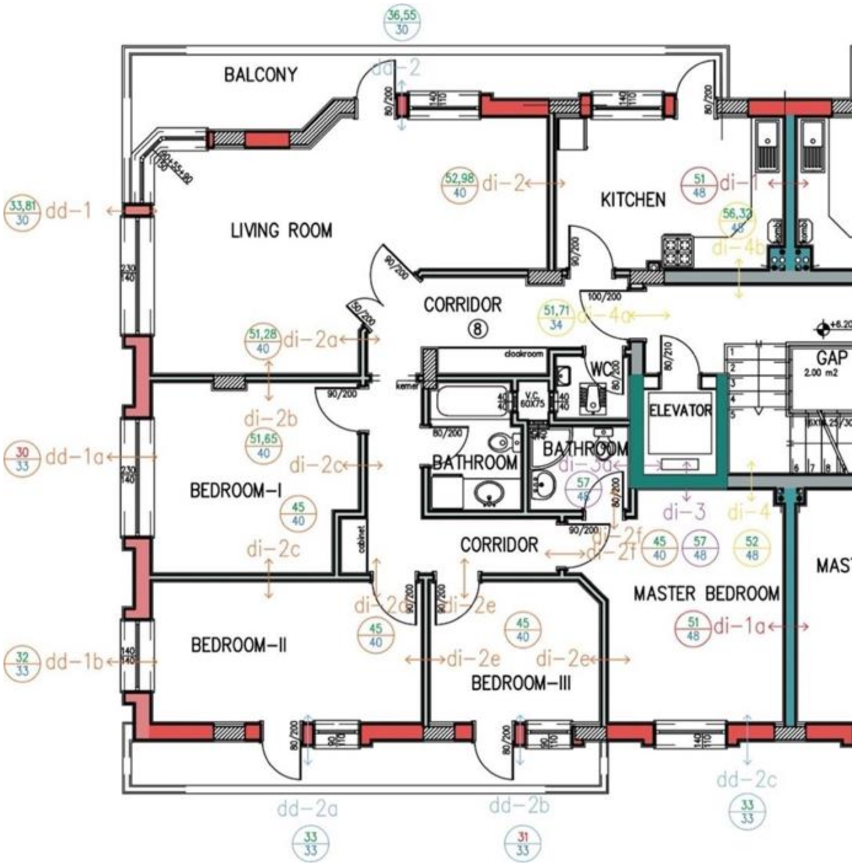


Figure 3. *Airborne sound pressure levels requested from and provided by building elements*

4.4 Comparison of Limit Values of Building Elements with the Values in the Regulation

A comparative table of the values of the residential building selected as a sample is given in Table 3, taking the table prepared by Bayazıt, Kurra, Şentop & Özbilen (2015) as a reference [17]. Values obtained for building elements: if it does not meet the limit values in the regulation, it is shown in dark color.

Table 3. *Comparison of limit values*

Target Acoustic Performance Class: D												
Building Element Code	**Places**		**Desired Value**		**Airborne Sound Transmission Performance of the Element**			**Impact Sound Transmission Performance of the Element**			**Calculation Results**	
	Source	**Receiver**	**$D_{nT,A}$**	**L'_{nTw}**	**$R_w(C;C_{tr})$**	**Cf**	**R'_w**	**$L_{nw}(CI)$**	**K**	**Hd**	**$D_{nT,A}$**	**L'_{nTw}**
Exterior Building Elements												
dd-1	Environmental Noise	Living room	**30**	**-**	39(-2,-6)	2,00	31,00	-	-	-	**33,81**	**-**
dd-1a	Environmental Noise	Bedroom -1	**33**	**-**	40(-2,-6)	Confidence Interval Method		-	-	-	**30**	**-**
dd-1b	Environmental Noise	Bedroom -2	**33**	**-**	42(-3,-6)	Confidence Interval Method		-	-	-	**32**	**-**
dd-2	Environmental Noise	Living room	**30**	**-**	43(-2,-6)	2,00	35,00	-	-	-	**36,55**	**-**

dd-2a	Environmental Noise	Bedroom-2	**33**	**-**	43(-2,-6)	Confidence Interval Method		-	-	-	**33**	**-**
dd-2b	Environmental Noise	Bedroom-3	**33**	**-**	41(-2,-6)	Confidence Interval Method		-	-	-	**31**	**-**
dd-2c	Environmental Noise	Master Bedroom	**33**	**-**	43(-2,-6)	Confidence Interval Method		-	-	-	**33**	**-**
Interior Building Elements												
di-1	Neighbour kitchen	Kitchen	**48**	**-**	55(-1,-4)	Confidence Interval Method		-	-	-	**51**	**-**
di-1a	Neighbour bedroom	Bedroom	**48**	**-**	55(-1,-4)	Confidence Interval Method		-	-	-	**51**	**-**
di-2	Kitchen	Living room	**40**	**-**	49 (-1,-3)	0,00	48,00	-	-	-	**52,98**	**-**
di-2a	Corridor	Living room	**40**	**-**	49 (-1,-3)	0,00	48,00	-	-	-	**51,28**	**-**
di-2b	Living room	Bedroom	**40**	**-**	49 (-1,-3)	0,00	48,00	-	-	-	**51,65**	**-**
di-2c	Corridor / Bedroom	Bedroom	**40**	**-**	49 (-1,-3)	Confidence Interval Method		-	-	-	**45**	**-**
di-2d	Corridor	Bedroom	**40**	**-**	49 (-1,-3)	Confidence Interval Method		-	-	-	**45**	**-**
di-2e	Bedroom/ Corridor	Bedroom	**40**	**-**	49 (-1,-3)	Confidence Interval Method		-	-	-	**45**	**-**
di-2f	Corridor/ Master Bedroom Bathroom	Master Bedroom	**40**	**-**	49 (-1,-3)	Confidence Interval Method		-	-	-	**45**	**-**
di-3	Elevator	Bedroom	**48**	**-**	61(-1,-5)	Confidence Interval Method		-	-	-	**57**	**-**
di-3a	Elevator	Bathroom	**48**	**-**	61(-1,-5)	Confidence Interval Method		-	-	-	**57**	**-**
di-4	Circulation	Master Bedroom	**48**	**-**	58(-2,-5)	Confidence Interval Method		-	-	-	**53**	**-**
di-4a*	Circulation	Corridor	**34**	**-**	49(-1,-6)	2,00	46,00	-	-	-	**51,71**	**-**
di-4b	Circulation	Kitchen	**48**	**-**	58(-2,-5)	2,00	54,00	-	-	-	**56,32**	**-**
Flooring Elements												
do-1	Bedroom	Bedroom	**48**	**58**	54(-1,-3)	Confidence Interval Method		69(-6)	Confidence Interval Method		**50**	**66**
do-2	Living room	Living room	**48**	**58**	54(-1,-3)	0,00	53,00	69(-6)	0,00	-2,00	**52,19**	**61**

5. SUGGESTIONS

When the data in Table 3 is examined, it has been determined that the airborne sound insulation values in some composite structure exterior walls of the residential building and the impact sound insulation values in the floors cannot be achieved. For this reason, suggestions have been presented to improve the sound insulation values of these building elements.

i. Suggestions for providing sound insulation on walls;

While the brick walls used as internal dividers in residential buildings are above the Class D limit value defined in the regulation, some external walls in composite structures cannot meet the sound insulation limit value. Although the sound insulation of the reinforced concrete wall and double-layer brick walls in the external wall component is quite high, the R_w value of the composite component remains below the limit value due to the low R_w value of the pvc windows. Therefore, in order to ensure noise control in the existing building, it is necessary to improve the pvc windows by widening the gap between the glasses or by using laminated glass, which is not preferred due to cost. These suggestions are stated in Table 4.

Table 4. *Suggestions for sound insulation on external walls*

SUGGESTIONS FOR SOUND INSULATION ON EXTERIOR WALLS					
Building Element Code	**DnTA value defined in the regulation**	**The current situation**	**Suggestion(s)**	**Obtained DnTA value**	**Analysis of current situation**
dd-1a (Bedroom -1)	***33***	**30**	Expanding the glass thickness and the gap between the pvc windows (8-16-8)	**33***	**SUITABLE**
	33	**30**	Using laminated glass (6cm laminated glass - 12 cm gap - 6cm laminated glass)	**35**	**SUITABLE**
dd-1b (Bedroom -2)	***33***	**32**	Expanding the glass thickness and the gap between the pvc windows (8-16-8)	**34**	**SUITABLE**
	33	**32**	Using laminated glass (6cm laminated glass - 12 cm gap - 6cm laminated glass)	**36**	**SUITABLE**
dd-2b (Bedroom -3)	***33***	**31**	Expanding the glass thickness and the gap between the pvc windows (8-16-8)	**34**	**SUITABLE**
	33	**31**	Using laminated glass (6cm laminated glass - 12 cm gap - 6cm laminated glass)	**36**	**SUITABLE**

* If Lgag (55-59) is accepted as the maximum value (59), the limit value will be maximum 33. Since it is assumed that the limit value will remain below 33 (according to the noise map and the location of the residential building), it was accepted appropriate to be equal to the limit value.

ii. Suggestions for providing sound insulation in floors;

When look at the analyses made with the Insul (v9.0.24) program for the flooring in the residential building under consideration, it can be seen that the solid/impact sound insulation values obtained in the flooring are well above the limit values defined in the regulation. When the project of the residential building is examined, it is seen that no sound insulation measures were taken in the project, and impact absorbing material, suspended ceiling, and leak-proof mattress materials were not used.

In order to improve sound insulation in floors, the use of impact absorbing material and suspended ceiling will reduce noise-related discomfort by preventing lateral transmission of sound. Suggestions are included in Table 5.

Table 5. *Suggestions for sound insulation in floors*

SUGGESTIONS FOR SOUND INSULATION IN FLOORINGS (do-1 & do-2)

SUGGESTION-1: USE OF IMPACT ABSORBING MATERIAL UNDER SCREED

Airborne Sound Insulation: Rw: 52 (0,-3)

* Panel 1:1x120 mm concrete
1x40 mm SandCement render (plaster)

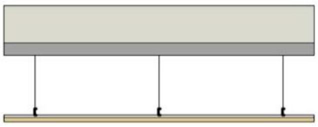
Impact Sound Insulation:$L_{n,w}$: 54 (0)

* Panel 1:1x120 mm concrete
1x40 mm SandCement render (plaster)
* Floor cover: impact absorbing material under cement screed

Location	Obtained DnTA value	DnTA value defined in the regulation	Analysis of current situation	Location	Obtained LnTw value	LnTw value defined in the regulation	Analysis of current situation
do-1 Bedroom	**49**	***48***	**SUITABLE**	do-1 Bedroom	**57**	***58***	**SUITABLE**
do-2 Living room	**51,19**	***48***	**SUITABLE**	do-2 Living room	**52**	***58***	**SUITABLE**

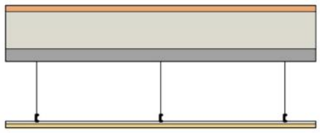
SUGGESTION-2: USE OF SUSPENDED CEILING AND FLOOR COVERING

Airborne Sound Insulation: Rw: 61 (-2,-6)



* Panel 1:1x 120 mm concrete
1x40 mm SandCement render (plaster)
*Suspended Light Steel Grid (200mmx45mm), Stud spacing 600mm; Cavity Width 200mm (Empty Cavity)
* Panel 2: 1x12,5 mm plasterboard

Impact Sound Insulation: $L_{n,w}$: 50 (1)

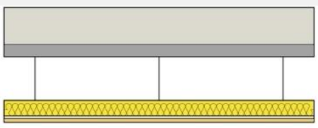


* Panel 1:1x 120 mm concrete
1x40 mm SandCement render (plaster)
*Suspended Light Steel Grid (200mmx45mm), Stud spacing 600mm; Cavity
Width 200mm (Empty Cavity)
* Panel 2: 1x12,5 mm plasterboard
* Floor cover: impact absorbing material under cement screed

Location	Obtained DnTA value	DnTA value defined in the regulation	Analysis of current situation	Location	Obtained LnTw value	LnTw value defined in the	Analysis of current situation
do-1 Bedroom	**56**	***48***	**SUITABLE**	do-1 Bedroom	**54**	***58***	**SUITABLE**
do-2 Living room	**58,19**	***48***	**SUITABLE**	do-2 Living room	**49**	***58***	**SUITABLE**

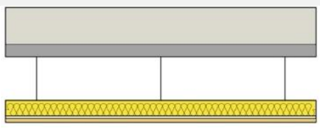
SUGGESTION -3: USE OF SUSPENDED CEILING AND SOUND ABSORBING MATERIALS

Airborne Sound Insulation: Rw: 69(-2,-4)



* Panel 1:1x 120 mm concrete
1x40 mm SandCement render (plaster)
*Suspended Light Steel Grid (200mmx45mm) Cavity Width 200mm + 50 mm Fibreglass(10kg/m^3)
* Panel 2: 1x12,5 mm plasterboard

Impact Sound Insulation: $L_{n,w}$: 60(-10)



* Panel 1:1x 120 mm concrete
1x40 mm SandCement render (plaster)
*Suspended Light Steel Grid (200mmx45mm), Cavity Width 200mm
+50 mm Fibreglass(10kg/m^3)
* Panel 2: 1x12,5 mm plasterboard

Location	Obtained DnTA value	DnTA value defined in the regulation	Analysis of current situation	Location	Obtained LnTw value	LnTw value defined in the	Analysis of current situation
do-1 Bedroom	**64**	***48***	**SUITABLE**	do-1 Bedroom	**53**	***58***	**SUITABLE**
do-2 Living room	**66,19**	***48***	**SUITABLE**	do-2 Living room	**48**	***58***	**SUITABLE**

Values were obtained with the Insul (v9.0.24) simulation program.

According to these data,

* In the first suggestion, the use of impact-absorbing material under the screed for the floors in the existing building provides sufficient sound insulation by meeting the limit values for class D. Suspended ceiling and floor coverings are recommended to achieve better sound insulation.

* In the second suggestion, if only the suspended ceiling is used (20 cm), the impact sound is calculated as Lnw: 62 (-3). Since this value is above the limit value of 58 defined for class D, floor covering is recommended in addition to the suspended ceiling.

* In the third suggestion, when using suspended ceilings (20 cm) and sound-absorbing materials, values that were well above the desired limit value for airborne sounds and well below the desired limit value for impact sounds could be obtained. It was possible to obtain better sound insulation by using floor coverings in this system. This can be especially recommended for noise-sensitive rooms located below the noise source.

Floating flooring is not recommended since floating flooring is not generally preferred in residential buildings except for wet areas.

6. CONCLUSION

In the example considered, the sound insulation values of the building elements were calculated with the Insul (v9.0.24) simulation program, and the results are presented in Table 3 in comparison with the limit values of class D defined in the regulation. As a result of this comparison, the current situation was evaluated, and improvement suggestions were presented to optimize noise control in the residential building. These suggestions are given in Table 4 for external structural elements and Table 5 for floors.

In addition to the suggestions in Table 4 and Table 5, balconies can be designed as acoustic barriers in order to reduce the environmental noise level in existing residential buildings and new residential buildings. The use of rigid materials without gaps in the balcony barrier increases the acoustic shading effect of the balcony [18]. By covering the lower surfaces of the balconies with sound-absorbing material as indicated in Figure 4, a reduction in the sound level reaching the facade can be achieved. In bedrooms that have neighborly relations with stairs and elevators, to prevent lateral transmission caused by impact sound, sealed mats and porous absorbers should be used at stair and floor joints [14].

As in the residential building considered as an example, in many building types, noise originating from outside and inside the building causes discomfort for building users. To minimize discomfort, this can be achieved by considering the necessary precautions at the design stage and applying them correctly during the construction process. In a building where noise control is neglected, it will be much more costly to take sound insulation measures later. For this reason, first of all, for architects and engineers in new buildings, it is necessary to select materials that will meet the limit values in the regulation, to apply the combination details of the building elements correctly, and to prevent the formation of sound bridges due to faulty workmanship during the application phase. Therefore, it will be possible to create more livable and comfortable environments by reducing noise-related disturbances.

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