ATATÜRK ÜNİVERSİTESİ YAYINLARI
ATATURK UNIVERSITY PUBLICATIONS

Araştırma Makalesi *Research Article* DOI: 10.54864/planarch.1456604

Evaluation of Ortahisar Municipality Building Interior Spaces in Terms of Noise Levels

Ortahisar Belediye Binası İç Mekanlarının Gürültü Düzeyleri Açısından Değerlendirilmesi

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ABSTRACT

In the study, the acoustic comfort conditions of the interiors of the Trabzon Ortahisar Municipality Building were evaluated depending on the noise level values. Noise level measurements were made indoors in Ortahisar Municipality of Ortahisar District, the center of Trabzon, and acceptable values and measurement results were compared. First, the current architectural project of Ortahisar Municipality was obtained from the Survey Project Directorate to determine the measurement points. The causes of indoor noise and density conditions in the units were evaluated by making on-site observations. Then, measurement points were determined on the project in line with the data obtained. Four measurements of 15 minutes each between 10.00-11.00 hours at the specified measurement points were completed in 24 working days. The values of the noise level measurement results depending on the frequencies were obtained. In the last stage of the study, the noise level measurement values obtained were compared with the acceptable values specified in the relevant standards. As a result of the study, it was determined that the noise level measurement results were generally above acceptable values in the background at medium and high frequencies.

Keywords: Noise criterion, noise level, office, Ortahisar.

ÖZ

Çalışmada, Trabzon Ortahisar Belediye Binası'nın iç mekanlarının akustik konfor koşulları, gürültü düzey değerlerine bağlı olarak değerlendirilmiştir. Trabzon'un merkezi konumunda olan Ortahisar İlçesi Ortahisar Belediyesi'ndeki iç mekanlarda gürültü düzeyi ölçümleri yapılmış ve kabul edilebilir değerler ile yapılan ölçüm sonuçları karşılaştırılmıştır. Öncelikle ölçüm noktalarını belirlemek için Ortahisar Belediyesi'nin mevcut mimari projesi Etüt Proje Müdürlüğü'nden temin edilmiştir. Yerinde gözlemler yapılarak iç mekân gürültüsünün nedenleri ve birimlerdeki yoğunluk durumları değerlendirilmiştir. Daha sonra elde edilen veriler doğrultusunda proje üzerinde ölçüm noktaları belirlenmiştir. Belirlenen ölçüm noktalarında 10.00-11.00 saatleri aralığında 15'er dakikalık dört ölçüm 24 iş gününde tamamlanmıştır. Frekanslara bağlı gürültü düzeyi ölçüm sonuçlarına ait değerler elde edilmiştir. Çalışmanın son aşamasında, elde edilen gürültü düzeyi ölçüm değerleri ilgili standartlarda belirtilen kabul edilebilir değerler ile karşılaştırılmıştır. Çalışma sonucunda gürültü düzeyi ölçüm sonuçlarının orta ve yüksek frekanslarda genel olarak arka planda kabul edilebilir değerlerin üzerinde olduğu tespit edilmiştir.

Anahtar Kelimeler: Gürültü düzeyi, gürültü ölçütü, ofis, Ortahisar.

Geliş Tarihi/ Received 28.07.2023

Kabul Tarihi/ Accepted 13.02.2024

Yayın Tarihi/ Publication Date 25.03.2024

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Cite this article: Aydın, B., & Kavraz, M. (2024). Evaluation of Ortahisar Municipality Building Interior Spaces in terms of Noise Levels. *PLANARCH - Design and Planning Research, 8*(1), 58-66. DOI: 10.54864/planarch.1456604.

Introduction

As in all buildings, public buildings' interiors are also important regarding room acoustics and noise level. For the auditory communication between users and employees in the work areas to be maintained healthily, the spaces must provide acoustically ergonomic conditions. Having an environmental noise level above 60 dBA leads to focus, communication, and sleep problems in humans (Babisch, 2014). Considering the noise affecting the working areas, it is stated that a working environment with a noise level above 85 dBA causes a serious increase in the blood pressure level of the employee (Vehid, 1995). In this context, it is seen that the noise in the work areas directly and negatively affects the employees.

Acceptable noise levels are an important parameter for acoustic comfort conditions. The quality and quantity of the measures to be taken for noise control in space are determined according to acceptable noise levels (Topalgökçeli, 1995). Since the sensitivity to noise varies according to frequencies, acceptable indoor noise levels are defined by spectra (Şentop, 2013). Criterion curves are used to determine acceptable values in noise control NC and NR criterion curves were used within the scope of the study.

NC Curves (Noise Criteria): The noise criterion (NC-Noise Criteria) curves are used to determine the background noise of a closed area and to evaluate the level that will affect the activities to be performed (Vergili, 2015). The NC curve was first developed by MEP (Mechanical, Electrical, and Plumbing) engineers along with other construction experts and acoustic engineers at the American National Standards Institute (ANSI). Over time, ISO (the International Organization for Standardization) and ASA (Statistical Institute of America) have published similar criteria (Lesson 3: Noise Criteria: A Background Noise Rating Standard (201912A), 2022). The noise criterion (NC) is used to define the noise level in a given area in the frequency range. The NC value represents the curve covering the range of octave band center frequencies from 63 Hz to 8,000 Hz (Cirrus Research plc, 2013). Figure 1 shows frequency-dependent NC curves. The NC curve, which is accepted as a criterion within the scope of the study, is shown in Table 1.

Table 1. Recommended NC values for office structures (Uçar, 2019)

Volume	NC Curve
Open Plan Offices	35-40

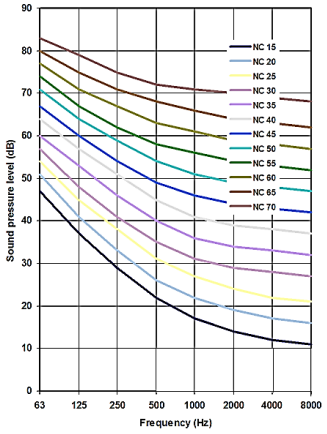

Figure 1. Accepted NC curves (Engineering ToolBox, 2001)

NR Curves (Noise Rating): The International Organization for Standardization (ISO) has developed NR curves to determine the acceptable noise level within the structure (Konuk, 2010). NR curves are widely used in Europe (Cirrus Research plc, 2013). It is similar to NC curves and NR curves focus on high frequencies (Şentop, 2013). The values of NC and NR curves at medium frequencies are quite close to each other (Guide, 2006). The values of NR curves according to frequencies are shown in Figure 2. NR curve values accepted as criteria within the scope of the study are shown in Table 2.

Table 2. Recommended NR values for office structures (Cirrus Research plc, 2013)

Volume	NR Curve
Open Plan Offices	40

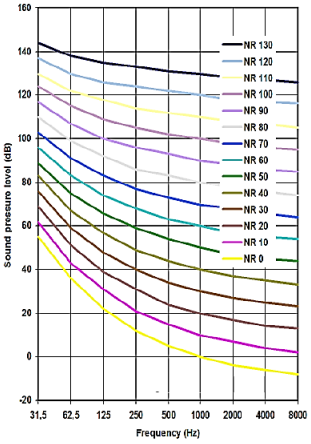

Figure 2. NR curves (Engineering ToolBox, 2001)

Acar (2007) conducted on-site noise level measurements to determine the current situation in two offices in his study titled "Examples of Approach to Providing Workplace Comfort in Open Plan Office Buildings". Measurement points were determined by considering the characteristics of the volumes, and two measurements of 10 minutes were made at each point. According to the results of the measurement, it was determined that the noise level in the volumes exceeded the acceptable values. It has been determined that the main reason for this is the insufficient use of sound-absorbing materials. Evaluations have been made on the measures for appropriate acoustic comfort conditions (Acar, 2007). Ateş (2007), in his study titled "Examination of the Acoustic Problems of the Basilica Cistern, which is our Cultural Heritage", determined the quality of the building, which has a special place in the history of architecture, in terms of acoustics. The noise level was measured according to the standards when the volume was empty. Then, a three-dimensional model of the volume was made and analyzed in the simulation program. A recommendation was created by comparing the results obtained from on-site measurements. The proposal was remodeled in the simulation program and evaluated according to the standards. The results obtained were examined and a recommendation was presented to improve volume acoustic comfort (Ateş, 2007). In the study of Aslan (2009) titled "Noise Measurement and Evaluation in Entertainment Places in Settlement Areas", the environmental noise level of an entertainment center in Samsun was evaluated. Noise level measurements were performed at different points in the selected space, in the entrance areas, and on the upper floor. In addition, measurements were made in two different stages, considering the space's open and closed conditions. It has been determined that the achieved noise level exceeds the standards specified in the regulation. Material suggestions are presented to provide noise control in the space (Aslan, 2009). Within the scope of Özen's (2017) study titled "Konya-Nalçacı Street within the Framework of the Effect of Highway Traffic Noise on Indoor Life Comfort", it is aimed to map the noise levels caused by traffic. Noise level measurements were performed at 14 different points on the intersections and connection roads with heavy traffic on the selected street. Noise level measurements were completed in the time interval determined in the morning, noon, and evening hours. Considering the concentric noise levels at the measurement points, it was determined that there was a decrease in the noise level towards the north of the street. It has been determined that the measurement values obtained exceed the limit values given in the Regulation on the Evaluation and Management of Environmental Noise, up to 30 dBA.

As a result, attention was drawn to the measures that can be taken to reduce the noise levels that adversely affect the comfort conditions (Özen, 2017).

Koranteng et al. (2016) aimed to evaluate the noise exposure levels in public educational institutions in Ghana and to evaluate the satisfaction of building occupants with the noise level, within the scope of their study titled "Environmental Noise Exposure on Occupants in Naturally Ventilated Open-Plan Offices: Case of Selected Offices in Kumasi, Ghana". The study used a survey including interviews to conduct an empirical assessment of noise levels in and around three office buildings and to assess employee satisfaction with noise levels of open-plan offices at Kwame Nkrumah University. Despite the high noise levels, office occupants generally rated the overall noise level in their offices as acceptable (Koranteng et al., 2016). Veliu (2022) evaluated the noise levels around the 'NewCo Ferronikeli' smelter, known as an industrial complex, located in the town of Glogoc in the Pristina region in the central part of the Republic of Kosovo. This study was based on the Directive 2002/49/EC of The European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise. As a result of the study, it was determined that the noise levels in the environment surrounding the facility were at acceptable levels (Veliu, 2022).

Material and Methods

The study aims to evaluate the current acoustic comfort conditions of the interiors of the Ortahisar Municipality Building in Trabzon City depending on the noise levels. The Municipality Building was included in the research within the scope of the study because it is a building that was built recently in the city center of Trabzon and attracts attention with its architecture, is important due to its location, is generally visited by the people living in the city for official purposes, and has a large number of employees. For this purpose, firstly, noise level values were obtained by making on-site measurements, then these values were compared with acceptable values in the relevant standards, and analyses were carried out. First of all, the measurement points were decided by considering the on-site observations in the floor plans of the building. In this context, 24 measurement points have been determined in the building under the guidance of the Environmental Noise Measurement and Evaluation Guide (General Directorate of Environmental Management, 2011). At the specified measurement points, noise level measurements were carried out between 10.00-11.00 hours (four measurements at 15-minute intervals) when working hours were the busiest. In the study, NC Curves (Noise Criteria) and NR Curves (Noise Rating) were taken into account in the acoustic evaluation of the study areas of the Ortahisar Municipality Building, and the values obtained as a result of the measurement processes were analyzed.

Ortahisar Municipality Building

Ortahisar Municipality Building, located in Pazarkapı Neighborhood and on Kahramanmaraş Street, is also adjacent to Ortahisar District Governorship and is located in a region between the city center and Trabzon Metropolitan Municipality Building and Varlıbaş Shopping Center (Figure 3). Near the building, there is the Kadınlar Bazaar, which contributes to the high density of people in this area, and the Trabzon Chamber of Commerce and Industry. The building is visited by an average of 2000 people per day.

Figure 3. Relationship of Ortahisar Municipality with its immediate surroundings (Google Earth, 2023)

The building was built with a reinforced concrete structural system. Aluminum composite panels and glass materials were used in the curtain wall system of the building. Additionally, solar shading elements were added to provide mobility on the façade. In interior spaces, ceramic coating material was preferred over reinforced concrete flooring. Plasterboard and MDF panels were used in the partition walls between the spaces. For suspended ceilings, an aluminum suspended ceiling system without insulation material was preferred.

Determination of Points to Measure in the Building

In determining the noise level measurement places made inside the building, the situations where the noise from the outside environment is effective and the situations where the noise occurs indoors are considered. In this context, as shown in Figure 4, three axes were created in the horizontal plane in the floor plan and the points to be measured on these axes were determined.

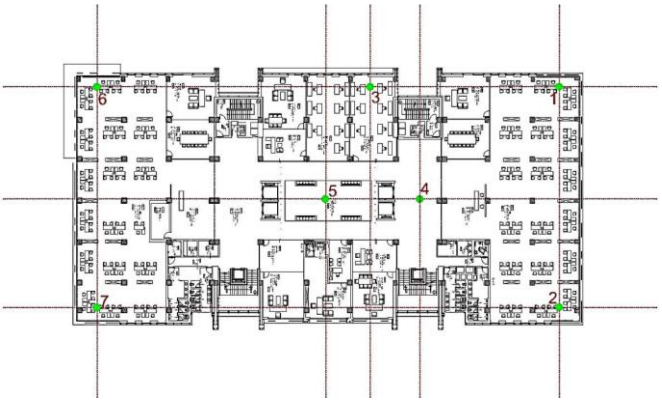

Figure 4. Measurement locations determined by axles created on the third-floor plan (Trabzon Ortahisar Belediyesi, 2022)

Measurement was carried out on six floors in the building. Measurement was carried out at a total of 24 points including 7 points on 3rd the floor, 3 points on the 2nd floor, 4 points on the 1st floor, 3 points on the ground floor, 3 points on the 1st basement floor, and 4 points on the 2nd basement floor. Measurements were performed with SVAN-957 Type 1 and values were obtained at 1/1 octave band frequencies in the range of 20 Hz – 20 kHz. Measurements were made by TS ISO 1996-1:2020.

Results

The noise level values obtained from the measurements were compared with acceptable values. NC Curves (Noise Criteria) and NR Curves (Noise Rating) were used as evaluation criteria within the scope of the study. As a result of the measurements, the noise levels obtained in the octave band range of 63 Hz-8000 Hz were evaluated by comparing them with the NR 40 and NC 40 curves.

Noise Level Measurement Results on the Third Floor

There is the Directorate of Zoning and Urbanization and the Directorate of Building Control on the third floor. On this floor, there are two open office work areas for directorship, private rooms for managers, and common toilets. Measurements were made at seven points due to the high number of personnel and visitors working in the units on this floor with an open office system (Figure 4). Noise level values in the frequency range of 63 Hz-8000 Hz were compared with acceptable values. The noise levels in Table 3 were determined by taking the logarithmic average of the values obtained in four 15-minute measures performed at each measurement point. The frequency-dependent noise values obtained at the points measured on this floor and the values of NC 40 and NR 40 curves at the relevant frequencies are given in Table 3.

Figure 5 shows the comparison of the noise level results at seven points measured on the third floor with the NC 40 Curve. It has been determined that the average noise level values at the measured points are below the acceptable values at 1/1 octave band frequencies below 250 Hz and above the acceptable values at 1/1 octave band frequencies of 500 Hz and above. It was determined that the results closest to the acceptable values were at Point 7. While the values obtained at this point are above 3 dBA on average at 1/1 octave band frequencies of 250 Hz and above, they are below 5 dBA at 8000 Hz frequency. The highest noise level measurement results on this floor are given in Point 4. It is seen that the sound pressure levels at this point are above the acceptable values starting from the 250 Hz frequency, and the difference reaches up to 28 dBA at the 8000 Hz frequency. In addition, it was determined that the values at all points except Point 1 and Point 4 at a frequency of 8000 Hz were below the acceptable value (Figure 5). Figure 5 also shows the comparison of the noise level results at seven points with the NR 40 Curve. It has been determined that the average noise level values at the measured points are below the acceptable values at 1/1 octave band frequencies below 250 Hz and above the acceptable values at 1/1 octave band frequencies of 500 Hz and above. It was determined that the results closest to the acceptable values were at Point 7. It is seen that the values obtained at this point are above 4 dBA on average at 1/1 octave band frequencies of 250 Hz and above, and reach the same value as NR 40 at 8000 Hz frequency. The highest noise level measurement results on this floor are given in Point 4. It is seen that the sound pressure level at this point is above the acceptable value starting from the 500 Hz frequency, and the difference reaches up to 32 dBA at the 8000 Hz frequency (Figure 5).

Table 3. Noise level values obtained at 1/1 octave band frequencies at measurement points on the third floor

3rd Floor	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Point1	23,70	38,10	46,84	56,46	54,66	51,66	48,79	41,99
Point2	23,49	32,35	41,10	49,99	45,21	47,71	43,35	36,06
Point3	30,34	36,88	45,01	49,99	47,38	44,86	41,88	33,48
Point4	24,98	34,70	50,44	61,48	67,49	63,30	57,96	65,22
Point5	30,0	34,86	45,56	51,43	50,16	47,42	44,33	34,58
Point6	33,76	40,85	47,83	55,46	51,34	48,22	45,17	36,68
Point7	27,08	34,04	41,80	48,87	44,86	42,62	40,11	32,23
NC 40	64	56	50	45	41	39	38	37
NR 40	67	57	49	44	40	37	35	33

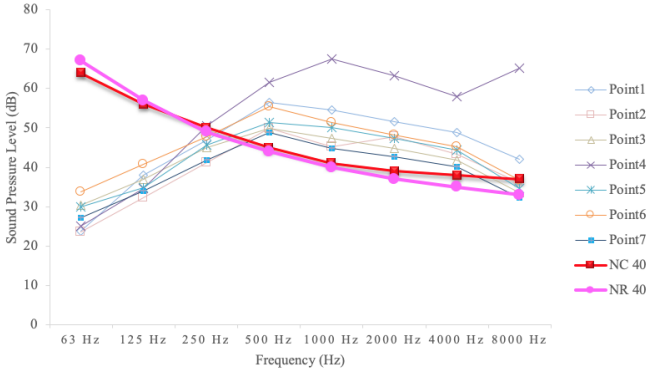

Figure 5. Noise levels and criterion values obtained at measurement points on the third floor

The noise level measurement results made at point 7 contain the results above the NC 40 and NR 40 curves at medium and high frequencies but closest to these values. It is thought that this is because the point where the measurement is made is the place with the least personnel on the floor and that there is no person other than the personnel in the environment during the measurement. At point 4, the highest noise level measurement results on the floor were obtained. Excessive circulation in the elevator and stair area has been determined to affect the sound pressure level values. Frequency-dependent noise level measurement results were generally above acceptable values at medium and high frequencies.

Noise Level Measurement Results on the Second Floor

On the second floor, there are private working areas and office areas belonging to the mayor, three vice-mayor rooms, three meeting rooms, office areas belonging to the directorates, and common toilets. Noise level measurements were carried out at three points in the personnel room and common area of the Survey Project Directorate with the vice president's room on this floor. Noise level values in the frequency range of 63 Hz-8000 Hz were compared with acceptable values. The noise levels in Table 4 were determined by taking the logarithmic average of the values obtained in four 15-minute measures performed at each measurement point. The frequency-dependent noise values obtained at the points measured on this floor are given in Table 4.

Table 4. Noise levels obtained at 1/1 octave band frequencies at measurement points on the second floor								
2nd Floor	**63 Hz**	**125 Hz**	**250 Hz**	**500 Hz**	**1000 Hz**	**2000 Hz**	**4000 Hz**	**8000 Hz**
Point8	20,99	25,01	33,19	41,00	35,85	35,97	31,74	27,22
Point 9	26,15	30,60	40,56	48,07	43,90	42,52	38,06	30,12
Point10	24,32	30,73	43,11	50,45	47,06	46,82	41,44	35,05

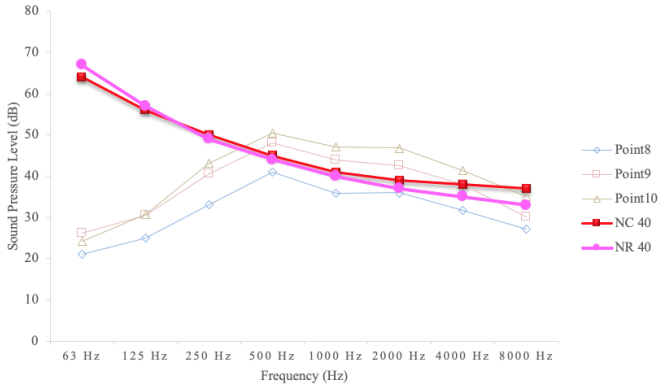

Figure 6. Noise levels and criterion values obtained at measurement points on the second floor

Figure 6 shows the comparison of the noise level results at three points measured on the second floor with the NC 40 Curve. It has been determined that the average noise level values at Point 9 and Point 10 are below acceptable values at 1/1 octave band frequencies below 500 Hz and above acceptable values at 1/1 octave band frequencies between 500 Hz and 4000 Hz. It was determined that the results closest to the acceptable values were at Point 8. It is seen that the values obtained at this point are below acceptable values at 1/1 octave band frequencies between 63 Hz-8000 Hz. The highest noise level measurement results on this floor are given in Point 10. It is seen that the sound pressure level at this point is above the acceptable values starting from the 500 Hz frequency, and the difference reaches up to 8 dBA at the 2000 Hz frequency. In addition, it was determined that the values at all points at a frequency of 8000 Hz were below the acceptable value (Figure 6). Figure 6 also shows the comparison of the noise level results at three points measured on the second floor with the NR 40 curve. It has been determined that the average noise level values at Point 9 and Point 10 are below acceptable values at 1/1 octave band frequencies below 500 Hz and above acceptable values at 1/1 octave band frequencies between 500 Hz and 4000 Hz. It was determined that the results closest to the acceptable values were at Point 8. It is seen that the values obtained at this point are below acceptable values at 1/1 octave band frequencies between 63 Hz-8000 Hz (Figure 6). The highest noise level measurement results on this floor are given in Point 10. It is seen that the sound pressure levels at this point are above the acceptable values from the 500 Hz frequency, and the difference reaches up to 10 dB at the 2000 Hz frequency.

It was determined that the noise level measurement results made at point 8 included results below the NC 40 and NR 40 curves. The reason for this is that the measurement was made in the chamber of the deputy mayor and it is thought that it was because there was only a president in the environment during the measurement. At point 10, the highest noise level measurement results on the floor were obtained. Excessive circulation in the elevator and stair area has been determined to affect the sound pressure level values. In Point 9 and Point 10, it was determined that the frequency-dependent noise level measurement results were generally above acceptable values at medium and high frequencies.

Noise Level Measurement Results on the First Floor

On the first floor, there are working areas and common toilets belonging to the directorates. Measurements were carried out on this floor at four points: The Registrar's Office, the Legal Affairs Office, the common area, and the entrance. Noise level values in the frequency range of 63 Hz-8000 Hz were compared with acceptable values. The noise levels in Table 5 were determined by taking the logarithmic average of the values obtained in four 15-minute measures performed at each measurement point.

Table 5. Noise levels obtained at 1/1 octave band frequencies at measurement points on the first floor								
1st Floor	**63 Hz**	**125 Hz**	**250 Hz**	**500 Hz**	**1000 Hz**	**2000 Hz**	**4000 Hz**	**8000 Hz**
Point11	25,10	33,24	43,82	52,44	47,44	44,67	42,24	33,72
Point12	23,89	32,85	42,49	51,49	45,96	47,93	44,02	35,50
Point13	26,02	35,95	52,53	61,18	66,01	60,16	54,68	65,21

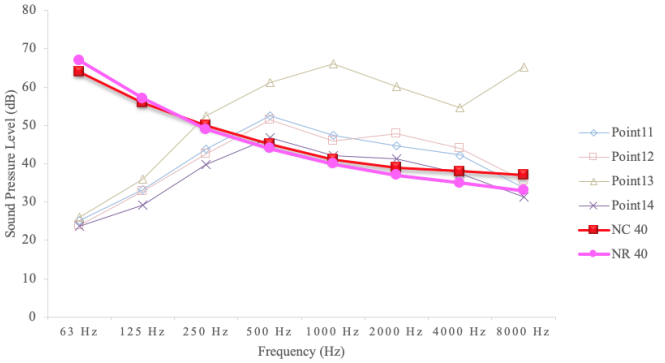

Figure 7. Noise levels and criterion values obtained at measurement points on the first floor

Figure 7 shows the comparison of the noise level results at four points measured on the first floor with the NC 40 curve. It has been determined that the average noise level values at the measured points are below acceptable values at 1/1 octave band frequencies below 250 Hz and above acceptable values at 1/1 octave band frequencies between 500-4000 Hz. It was determined that the results closest to the acceptable values were at Point 14. At this point, it is seen that the values obtained are above 2 dBA on average at 1/1 octave band frequencies of 250 Hz and above, and reach the same value as NC 40 at 4000 Hz. The highest noise level measurement results on this floor are located at Point 13. It is seen that the sound pressure levels at this point are above the acceptable values starting from the 250 Hz frequency, and the difference reaches up to 28 dBA at the 8000 Hz frequency. In addition, it was determined that the values at all points except

Point 13 at a frequency of 8000 Hz were below the acceptable value (Figure 7). Figure 7 also shows the comparison of the noise level results at four points measured on the first floor with the NR 40 curve. It has been determined that the average noise level values at the measured points are below the acceptable values at 1/1 octave band frequencies below 250 Hz and above the acceptable values at 1/1 octave band frequencies of 500 Hz and above. It was determined that the results closest to the acceptable values were at Point 14. While the values obtained at this point are 2 dBA above the acceptable values at 1/1 octave band frequencies of 250 Hz and above, they are 2 dBA below the acceptable value at 8000 Hz frequency. The highest noise level measurement results on this floor are located at Point 13. It is seen that the sound pressure levels at this point are above the acceptable values starting from the 250 Hz frequency, and the difference reaches up to 32 dBA at the 8000 Hz frequency. In addition, it was determined that Point 11 reached the same value as NC 40 at a frequency of 8000 Hz (Figure 7).

It is thought that the noise level measurement results made at point 14 contain the closest results to the values of the NC 40 and NR 40 curves at medium and high frequencies because there is no non-personnel person in the environment during the measurement. At point 13, the highest noise level measurement results on the floor were obtained. It has been determined that excessive circulation in the common area of the floor affects the sound pressure level values. It was determined that the frequency-dependent noise level measurement results were generally above acceptable values at medium and high frequencies.

Noise Level Measurement Results on the Ground Floor

On the ground floor, there are open office work areas belonging to the directorates. Measurements on this floor were carried out at three points in common areas. Noise level values in the frequency range of 63 Hz-8000 Hz were compared with acceptable values. The noise levels in Table 6 were determined by taking the logarithmic average of the values obtained in four 15-minute measures performed at each measurement point.

Table 6. Noise levels obtained at 1/1 octave band frequencies at measurement points on the ground floor

Ground Floor	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Point15	23,66	30,58	44,41	51,04	45,16	43,76	40,22	32,45
Point16	27,28	35,69	50,14	55,09	51,63	48,61	45,14	35,88
Point17	34,47	39,80	45,72	54,03	51,67	48,48	45,15	35,41

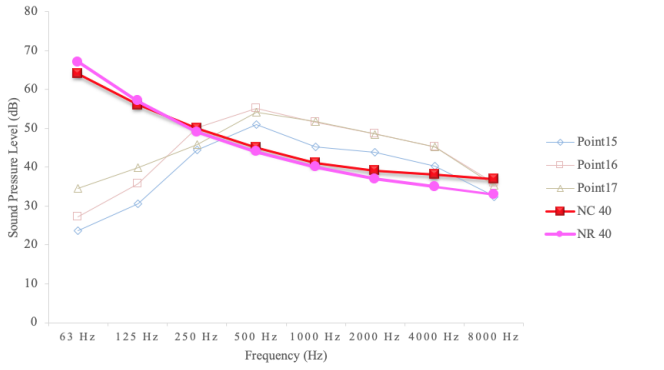

Figure 8. Noise levels and criterion values obtained at measurement points on the ground floor

Figure 8 shows the comparison of the noise level results at three points measured on the ground floor with the NC 40 curve. It has been determined that the average noise level values at the measured points are below acceptable values at 1/1 octave band frequencies below 250 Hz and above acceptable values at 1/1 octave band frequencies between 500-4000 Hz. It was determined that the results closest to the acceptable values were at Point 15. While the values obtained at this point are above 4 dBA on average at 1/1 octave band frequencies of 500 Hz and above, they are below 5 dBA at 8000 Hz frequency. The highest noise level measurement results on this floor are given in Point 16. It is seen that the sound pressure levels at this point are above the acceptable values starting from the 250 Hz frequency, and the difference in the 8000 Hz frequency decreases by 2 dBA. In addition, it was determined that the values at all points at a frequency of 8000 Hz were below the acceptable value (Figure 8). Figure 8 also shows the comparison of the noise level results at three points measured on the ground floor with the NC 40 curve. It has been determined that the average noise level values at the measured points are below acceptable values at 1/1 octave band frequencies below 250 Hz and above acceptable values at 1/1 octave band frequencies above 500 Hz. It was determined that the results closest to the acceptable values were at Point 15. At this point, it is seen that the acceptable value is above 5 dBA at 1/1 octave band frequencies of 500 Hz and above, while it reaches the same value with NR 40 at 8000 Hz frequency. The highest noise level measurement results on this floor are given in Point 16. It is seen that the sound pressure levels at this point are above the acceptable values starting from the 250 Hz frequency, and the difference reaches up to 3 dBA at the 8000 Hz frequency (Figure 8).

It is thought that the noise level measurement results made at point 15 are above the NC 40 and NR 40 curves at medium and high frequencies, but the closest results to these values are because the measured point is the place with the least staff on the floor and there is no non-staff person in the environment during the measurement. At point 16, the highest noise level measurement results on the floor were obtained. It has been determined that the high circulation in the building entrance area and the presence of an average of 20 people in the environment during the measurement affect the sound pressure level values. It was determined that the frequency-dependent noise level measurement results were generally above acceptable values at medium and high frequencies.

First Basement Floor Noise Level Measurement Results

On the first basement floor, there are open office work areas, manager rooms and common toilets belonging to the directorates. Noise level measurements were carried out at three points in the Real Estate Directorate and building entrance and accounting unit on this floor. Noise level values in the frequency range of 63 Hz-8000 Hz were compared with acceptable values. The noise levels in Table 7 were determined by taking the logarithmic average of the values obtained in four 15-minute measures performed at each measurement point.

Table 7. Noise levels obtained at 1/1 octave band frequencies at measurement points in the first basement floor

1st basement	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Point18	31,54	36,89	48,04	56,57	52,18	50,11	46,69	36,50
Point19	33,18	37,34	45,45	53,47	49,98	47,64	44,29	35,23
Point20	28,06	33,39	43,83	51,36	47,43	45,28	41,83	32,59

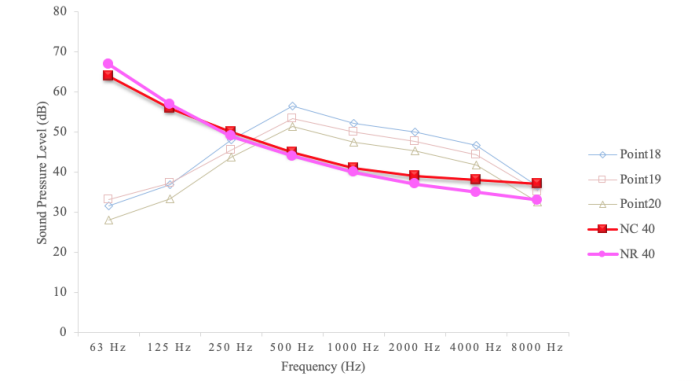

Figure 9. Noise levels and criterion values obtained at measurement points in the first basement

Figure 9 shows the comparison of the noise level results at three points measured on the first basement floor with the NC 40 curve. It has been determined that the average noise level values at the measured points are below the acceptable values at 1/1 octave band frequencies below 250 Hz and above the acceptable values at 1/1 octave band frequencies of 500 Hz and above. It was determined that the results closest to the acceptable values were at Point 20. While the values obtained at this point are 6 dBA above the acceptable values at 1/1 octave band frequencies of 500 Hz and above, they are 4 dBA below the acceptable value at 8000 Hz frequency. This floor's highest noise level measurement results are located at Point 18. While the sound pressure levels at this point are above the acceptable values from the 250 Hz frequency, it is seen that the difference reaches up to 12 dBA at the 500 Hz frequency and the same value as NC 40 at the 8000 Hz frequency. In addition, it was determined that the values at all points at a frequency of 8000 Hz were below the acceptable value (Figure 9). Figure 9 also shows the comparison of the noise level results at three points measured in the first basement floor with the NR 40 curve. It has been determined that the average noise level values at the measured points are below acceptable values at 1/1 octave band frequencies below 250 Hz and above acceptable values at 1/1 octave band frequencies of 500 Hz and above. It was determined that the results closest to the acceptable value were at Point 20. At this point, it is seen that the values obtained are above 6 dBA on average at 1/1 octave band frequencies of 500 Hz and above, while they reach the same value with NR 40 at 8000 Hz frequency. This floor's highest noise level measurement results are located at Point 18. It is seen that the sound pressure levels at this point are above the acceptable values starting from the 250 Hz frequency, and the difference reaches up to 13 dBA at the 2000 Hz frequency (Figure 9).

The noise level measurement results made at point 20 include the results above the NC 40 and NR 40 curves at medium and high frequencies, but closest to these values. It is thought that this is because the point where the measurement is made is the place with the least personnel on the floor and that there is no person other than the personnel in the environment during the measurement. At point 18, the highest noise level measurement results on the floor were obtained. It has been determined that the high number of personnel and visitors in the working area in the open office system affects the sound pressure level values. It was determined that the frequency-dependent noise level measurement results were generally above acceptable values at medium and high frequencies.

Second Basement Floor Noise Level Measurement Results

On the second basement floor, there are open office work areas belonging to the directorates, two multi-purpose halls, a foyer area, a prayer room, and a common toilet. Noise level measurements were carried out at four points in the unit where the cash desks on this floor are located, at the entrance of the building, and at the Police Department. Noise level values in the frequency range of 63 Hz-8000 Hz were compared with acceptable values. The noise levels in Table 8 were determined by taking the logarithmic average of the values obtained in four 15-minute measures performed at each measurement point.

Table 8. Noise levels obtained at 1/1 octave band frequencies at measurement points in the second basement floor

2nd basement	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Point21	25,99	33,79	46,91	54,64	50,17	48,22	46,22	42,30
Point22	30,30	36,59	52,56	61,12	64,90	59,14	53,25	44,81
Point23	29,52	31,98	40,74	45,45	43,44	41,74	39,79	33,49

Figure 10 shows the comparison of the noise level results at four points measured on the second basement floor with the NC 40 curve. It has been determined that the average noise level values at the measured points are below the acceptable values at 1/1 octave band frequencies below 250 Hz and above the acceptable values at 1/1 octave band frequencies of 500 Hz and above. It was determined that the results closest to the acceptable values were at Point 24. At this point, it was determined that the values obtained were below acceptable values at 1/1 octave band frequencies of 1000 Hz and below, while they reached the same value as NC 40 at 2000 Hz frequency and below acceptable values at 8000 Hz frequency. The highest noise level measurement results on this floor are located at Point 22. While the sound pressure levels at this point are above the acceptable value at 1/1 octave band frequencies of 250 Hz and above, it is seen that the difference reaches up to 24 dBA at 1000 Hz frequency. In addition, it was determined that the values at points other than Point 21 and Point 22 at a frequency of 8000 Hz were below the acceptable value (Figure 10). Figure 10 also shows the comparison of the noise level results at four points measured in the second basement floor with the NR 40 curve. It has been determined that the average noise level values at the measured points are below the acceptable values at 1/1 octave band frequencies below 250 Hz and above the acceptable values at 1/1 octave band frequencies of 500 Hz and above. It was determined that the results closest to the acceptable values were at Point 24.

It is seen that the values obtained at this point are below acceptable values at 1/1 octave band frequencies below 500 Hz, while they reach the same value with NR 40 at 500 Hz frequency. The highest noise level measurement results on this floor are located at Point 22. It is seen that the sound pressure levels at this point are above the acceptable value starting from the frequency of 250 Hz, and the difference reaches up to 25 dBA at the frequency of 1000 Hz. In addition, it was determined that Point 23 at a frequency of 8000 Hz had the same value as NR 40 (Figure 10).

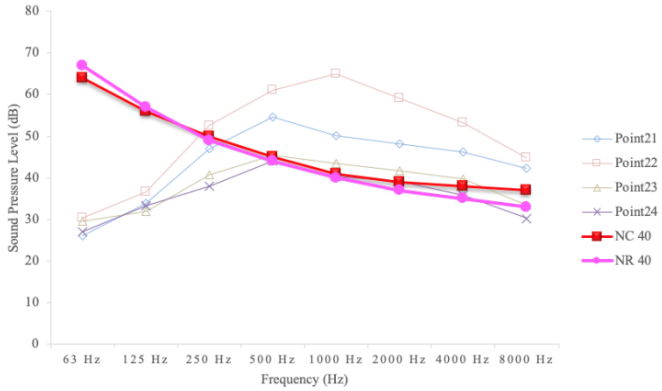

Figure 10. Noise levels and criterion values obtained at measurement points in the second basement

Point 24 contains the results closest to the noise level measurement results' NC 40 and NR 40 curves. It is thought that this is because there is no one other than the personnel in the foyer area while the measurement is made and that the personnel is in working condition. At point 22, the highest noise level measurement results on the floor were obtained. It has been determined that the high number of personnel and visitors in the working area in the open office system affects the sound pressure level values. It was determined that the frequency-dependent noise level measurement results were generally above acceptable values at medium and high frequencies.

Conclusion and Recommendations

In the study, the noise level values of the interiors of Trabzon Ortahisar Municipality Building were analyzed in the range of 63 Hz-8000 Hz in 1/1 octave bands. The interiors of the building are affected by human and traffic noise in the outdoor environment. In addition to people indoors, it has also been affected by the noise emitted by the heating ventilation system and other mechanical, electrical, and electronic devices.

It has been determined that the noise level measurement results (except for Point 8) made in the building's 1/1 octave band frequency range are generally above the acceptable values in the background at medium and high frequencies. It was determined that the reason for this was that there were working areas in the open office system in the building and there was no sound-absorbing material in the environment. In the measurement made in the vice president's room (Point 8), frequency-dependent noise level values were obtained below acceptable values since no other employees were in the space. As a result, when the surface materials in the environment are evaluated, it is seen that the sound absorption properties are insufficient at medium and high frequencies.

It has been determined that the noise level is high due to human voices inside the space rather than environmental sources. In addition, since the acoustic comfort conditions of the volume were not determined at the design stage, sufficient sound-absorbing materials were not used in the space. Since the sound absorption of the materials used in the space is insufficient at medium and high frequencies, choosing materials that will affect these frequencies would be the right approach to improve acoustic comfort conditions.

Note: This study was produced from the Master's Thesis titled "Kamu Yapılarındaki Mekanların Gürültü Düzeyi Açısından Değerlendirilmesi: Trabzon Ortahisar Belediyesi Örneği"

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - B.A.,M.K.; Design- B.A.,M.K.; Supervision- B.A.,M.K.; Resources- B.A.,M.K.; Data Collection and/or Processing- B.A.,M.K.; Analysis and/or Interpretation- B.A.,M.K.; Literature Search- B.A.,M.K.; Writing Manuscript- B.A.,M.K.; Critical Review- B.A.,M.K.

Ethics Committee Approval Certificate: The authors declared that an ethics committee approval certificate is not required.

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

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