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Investigating the Level of Acoustic Comfort in Contemporary Apartments based on Standards and the Existing Situation
(Case Study: Tabriz City)

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ABSTRACT: The extant study aimed to analyze the acoustic comfort situation in contemporary apartments based on urban spaces in Tabriz, Iran. This study was conducted using a quantitative method within the field survey at two levels of the questionnaire (perceptual situation) and field measurements (acoustical condition). The researcher-made questionnaire was used to collect data in the first step. Architecture experts approved the validity of the questionnaire; its reliability was examined using Cronbach's alpha (0.926). All experiments associated with airborne noise field measurements (background sound and sound pressure level) were done using 2260Investigator. First, background noise was measured in two open and closed windows inside the considered residential units. In the next step, sound pressure level (SPL) Figures were plotted using level rate and sound standard in different plan spaces. Ultimately, the authors assessed noise criteria and their difference with sound levels. The results indicated the undeniable effect of traffic, among other variables of acoustic comfort, on dissatisfaction caused by noise in urban areas of Tabriz. This effect was not only definite but also so significant that there was no change in patterns emerging in noise level, even based on the SPL measurements.

Keywords: *Acoustical Comfort, Apartment, Noise, Urban Space, Tabriz.*

INTRODUCTION

Despite the recorded knowledge of the acoustic field, acoustical comfort has remained unknown. Although there has been an increasing interest in this context among academic communities and a growing number of analyzed buildings, further studies are required. Despite the high importance of acoustic comfort in this area of knowledge, this factor has not been considered a priority in building design.

Various sound sources inside and outside residential buildings disturb acoustic comfort. Some of the mentioned sources include external traffic, the noises from neighborhood units in the apartment, or internal sources, such as individuals' voices, TV, conversations, or sounds caused by walking in the house. The mentioned triple sources for annoyance have always been debatable issues among experts. In other words, residents living in apartments complain about different noises in neighboring units, external traffic noise, and noises from internal appliances. The main concern is adapting the residents' feelings about sound measurements and describing sound insulation characteristics in buildings. Therefore, sound sensation or annoyance caused by noise is still a popular topic among researchers. However, the current research results are insufficient, so there is a growing demand for further studies. Accordingly, it is essential to compare audio perception and technical sound data.

Subjective noise responses are considered annoyance depending on the type of sound. According to conducted studies, the airborne and percussion sound from the floor negatively affect the day and night in the building. External traffic sounds have constituted a minor part of the annoyance. It is essential to consider a guideline for sound insulation performance in the house. It is necessary to examine the rate and sense of hearing a particular sound to find its effect on a person (living in their residence) hearing that internal sound.

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The purpose of the present study was to provide a report on the analysis of acoustic comfort in apartments based on urban spaces. This study used the field method and valid devices based on internal standards.

Many studies have been conducted on acoustical comfort in housing. There are various optimization solutions regarding different sound sources. This part of the study presents the previous studies on acoustic comfort regarding other annoyance indicators and noise sources in neighboring apartment units (Table.1).

Noise is defined as unwanted sound; in other words, it is known as extra noise and an annoyance in the living and work environment. The ambient noise must be controlled as much as possible and reduced to an acceptable level since high-level noise is disturbing and leaves countless harm. Therefore, the noise must be minimized or removed (Low et al., 2008). Despite the importance of acoustic comfort in engineering sciences, this concept has remained vague. The first attempts at defining and identifying the idea of acoustic comfort go back to 1978 (Commins, 1978). (Table 2) Studying acoustic quality can be affected by different factors: building location (location of building in urban fabric), city design, building design, vegetation included on the building façade, construction type, balcony type, and choice of material and elements (Zalejska-Jonsson, 2019).

Acoustic comfort is affected by some indicators, including human sources (voice, steps, movements, radio, and television), individual equipment (apartment heaters, washing

Table 1: Studies on sound comfort conditions in neighborhood units

Writer	Architectural parameters	Source	Annoyance index	Important statistical results
(Namba et al., 1991)	-	Neighborhood Traffic Building services	America 40% Japan: 18% Germany: 20% Turkey: 40% China: 20%	Neighborhood noise is annoying in all countries. In all countries except Germany, the population tolerated a certain amount of noise rather than complaining to their neighbors.
(Grimwood, 1997)	Type of residential building: Apartment with shared walls	Airborne and percussion sounds	Poor insulation-related annoyance index: 98%	Poor insulation is the main cause of noise dissatisfaction in residential units.
(Bluhm et al., 2004)	Type of construction: Separate buildings in the form of apartments	Traffic	Sleep disorders in units facing the street: 27%	Bedroom windows are the most important factor in causing sleep disturbances due to annoying noises with traffic.
(Gidlöf-Gunnarsson & Öhrström, 2007)	Construction Type: Apartment in urban green areas (distance 200 to 600 meters from (the street	Traffic	The annoyance index is directly related to increasing distance from traffic and .greenery	The degree of access to green space directly affects the response to traffic noise.
(Maschke & Niemann, 2007)	-	Traffic	Annoyance rate: 39%	Symptoms of respiratory problems can be seen in the signs of further irritation.
(Jeon et al., 2010)	Apartment buildings	Drainage and sewage system	Total annoyance index: 50%	Unexpected sources of noise that cause fear of noise.
(Yu & Kang, 2014)	Apartment or detached (villa)	Traffic	Traffic noise has the most negative impact.	The feeling of noise is a function of cultural and social characteristics.
(Hongisto et al., 2015)	Light and heavy structures (concrete)	,Neighbor Building Facilities	Annoyance rate: 56%	Airborne noises have many negative effects in both cases
(Wang et al., 2015)	Apartment, semi-detached, completely separate, adjoining terrace	Traffic, internal sounds of units	The rate of harassment in completely detached houses is 50% lower.	Apartment houses have the highest rate of harassment from neighbors
(Park & Lee, 2017)	Simulated (living space in the house)	Neighbor, percussion sounds	60% of noises above 38 dB directly affect the annoyance index.	Perception of loudness is associated with psychological characteristics in individuals.

machines, etc.), domestic equipment, collective equipment (heaters, lifts, transformers, air conditioner) and outdoor noise (traffic, railway, aircraft noise, industrial noise) (Commins, 1978). Some administrative requirements, including airborne insulation, percussion sounds insulation, and noise level caused by traffic and interior equipment of building to achieve acoustical comfort in building (Rindel, 2002).

Acoustic comfort in residential units is achieved if three conditions exist simultaneously: the absence of unwanted sound, desired and high-quality sounds, and doing acoustic activities without annoying other people. It is unacceptable and dissatisfying for residents if acoustic quality in the house is considered a hidden quality (Rasmussen, 2007). In this case, some features named physical characteristics affect acoustical comfort.

Form complexities are the first features concerning the physical characteristics of each space. Materials have limited talent due to their nature; however, form presents a broader range and domain regarding its aesthetical potential. The formation process is designer-based, and it is impossible to change the essence and behavior of materials. In other words, materials do not have extensive capability, while forms can create extreme facilities and meet aesthetical needs simultaneously (Ghaffari & Gholizadeh, 2018). The second influential variable in acoustic comfort includes materials. A strategy used to reduce interior noise or transmission to other spaces consists of applying acoustic absorbents at one or more levels besides materials used in absorbance (Caballol & Raposo, 2016). One of the leading solutions to reduce space noise is using acoustic absorbents, a costly approach (Sokhandan et al., 2019). In this case, the third essential and influential variable is the effect of physical parameters or architectural elements, such as walls, windows, green coatings, and other separators. The present study assessed the variable above as a core parameter. It is worth noting that architectural elements and physical characteristics undeniably affect noise transmission. For instance, creating air gaps using porous materials, such as glass wool, improves the insulation properties. The sound reduction is an essential indicator of architectural elements with a direct relationship with frequency and superficial mass. In this case, the material of the considered surface is also an influential factor. In other words, the more complex the separator's material, the less the noise transmission will be (Ghiabaklou, 2008, 64). Many studies have been done on the effect of green walls (Davis et al., 2017; Thomazelli et al., 2016; Wong et al., 2010), which have also been pointed out in the present paper. Spatial proportions (volume) are among the space's most critical acoustic assessment parameters and analyses related to the coincidence coefficient. Finally, height is another significant variable used in sound ripening. Height can also be used as a problem-solving strategy by interior and exterior architectures. Nevertheless, there is a severe restriction on applying this variable in solving internal acoustic issues in apartments.

MATERIALS AND METHODS

The extant study was applied in terms of purpose and was descriptive-analytical research in terms of nature. The authors used two bibliographic and field methods in this study. The authors reviewed foreign and Iranian references in the bibliographic part to identify variables and suitable data collection and analysis instruments. The field study was conducted at two levels. In the first level, the statistical population was examined using a questionnaire. The authors measured the acoustic situation of the studied subjects through suitable sound measurement tools in the second level. A researcher-made questionnaire was used in the first level to collect data. The validity and reliability of this questionnaire were examined and approved based on the opinion of architecture experts and Cronbach's alpha (0.926), respectively. There are different standards in terms of acoustic

Table 2: Summary of definitions provided on the "Acoustic comfort"

“.Definition of the concept of “acoustic comfort	Source	Title
Ability to have the right sound conditions for a specific activity in a particular location	(Vardaxis et al., 2017)	On the definition of acoustic comfort in residential buildings
The capacity protects residents from noise and creates the .optimal conditions for which the building is designed	-	Greek national standard
Formation of a sense of satisfaction in certain sound conditions	(Navai & Veitch, 2003)	Acoustic satisfaction in open-plan offices: review and recommendations
Sound comfort is a concept that can be defined by the absence of unwanted noises and the ability to do things without disturbing others in the environment	(Rindel, 2002)	Acoustical comfort as a design criterion for dwellings in the future
No unwanted noises, hearing the right sounds at the right level and quality, performing audio activities without being heard or annoyed by others	(Rasmussen, 2007)	Sound Insulation of Residential Housing — Building Codes and Classification Schemes in Europe
Satisfaction with the existing acoustic conditions	Wang et al., 2015,) (681	Noise annoyance and loudness: Acoustic performance of residential buildings in tropics

Table 3: Dimensions, variables, and sources related to each of the parameters affecting sound comfort

Dimensions	Variables	Source
Acoustic characteristics	External nuisance noise (traffic noise) and internal noise sources include three categories of common spaces (facilities, elevator noises, stairwells, etc.), neighborhood unit spaces (neighbor noise) as well as spaces inside the .residential unit	Ayr et al., 2003; Botteldooren et al., 2011; Guarnac-) cia, 2013; LeCe et al., 2015; Ottoz et al., 2018; Peters, (2013 (Scholl et al, 2015)
Physical characteristics	Form, materials, architectural elements (including partition wall, green cover), spatial proportions, and height	Hurrell et al., 2018; Sadouki, 2018; Samani et al.,) (2015; Schiavoni et al., 2016 (Dien & Woloszyn, 2005) Anoop et al., 2018; Davis et al., 2017; Pérez et al.,) (2016; Thomazelli et al., 2016
Social characteristics	Age, gender, education, number of living households, and home attendance	Guski, 1999; Öhrström, 2004; Schultz, 1978; Whittle) (et al., 2015

measurements, including ISO booklets. ISO is the World Federation of International Standards, and this measure is performed by members of the technical team in ISO technical committees. The considered ISO 16283-1 was the prior version of the standard related to field measurement of airborne sounds designed by the Acoustic Technical Association in the International Organization for Standardization. the authors did all sizes based on the sound pressure measurement. All frequencies considered in this standard covered the range of human hearing. In the first step, background noise in receiving room is measured while the sound source is passive. In measurements, it is recommended to assess background noise in each of the spaces within two modes of closed and opened windows. In the second step, the sound produced by amplifiers located at different points is played and measured in the receiving room. It is worth noting that all experiments associated with airborne noise field measurement (background sound and acoustic measurement of sound pressure) were done using 2260 investigators manufactured by B&K company in Denmark, as shown in the Figure 1.

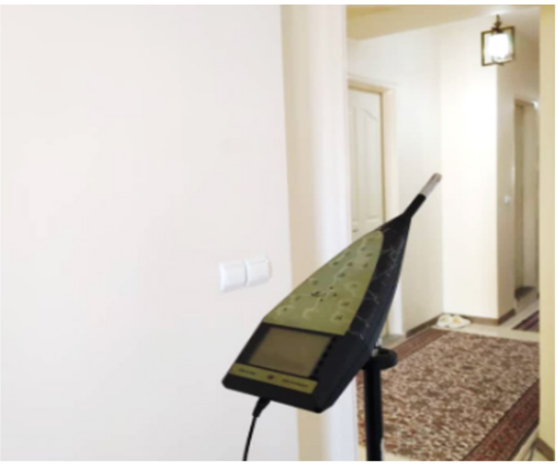

Fig. 1: An example of a 2260 sound analyzer while performing sound tests inside a residential unit.

The statistical population comprised all residents (N=270) in 11 case studies (residential apartments located in different urban areas in Tabriz). Because it was possible to study the whole statistical society, questionnaires were distributed among residents based on the census method. The studied variables included 14 associated architectural-physical dimensions, noise sources (acoustical characteristics), and sociodemographic features.

Analytical Pearson correlation, linear regression, and one-way ANOVA were used. The authors employed the last one to compare case studies. Research variables have been evaluated within the following parts (Table 3).

RESULTS AND DISCUSSIONS

A) Assessment of perceptual situation:

1. Pearson correlation test: results indicated a significant correlation between all variables except for age, gender, education, stay-at-home duration, and acoustic comfort. Findings have been reported in Table 4.

2. Linear regression test: linear regression test was used to analyze the effect rate of factors influencing noise and acoustic comfort. According to the results, all variables, except for age, gender, education, and stay-at-home duration, had a significant relationship with acoustical comfort. The findings indicated the highest association between variables, e.g., materials, height, traffic, noise coming from neighbors, and shared spaces. Moreover, results showed that all 14 studied variables could explain 87.1% of variations in acoustic comfort. In addition, column "Beta" implied that many other factors besides the studied ones influenced acoustical comfort (Table 5).

3. One-way ANOVA: this test examined the significant difference between studied groups (triple districts). Findings indicated significant differences within and between groups. In other words, there was a substantial difference between acoustic comfort (Mean±SD), physical characteristics (architecture), acoustical characteristics (noise source), and demographic variables (Table 6).

Table 4: Pearson correlation test results

Variable	Parameters	Acoustic comfort	Variable	Parameters	Acoustic comfort
Space layout	N	270	Noise caused by interior spaces	N	270
	Sig	0/000		Sig	0/000
	P	0/356		P	-0/425
Material	N	270	Noise caused by common spaces	N	270
	Sig	0/000		Sig	0/000
	P	0/512		P	-0/504
Height	N	270	Number of residents	N	270
	Sig	0/000		Sig	0/000
	P	0/397		P	-0/214
Space proportion	N	270	Age	N	270
	Sig	0/002		Sig	0/000
	P	0/113		P	-0/108
Form	N	270	Gender	N	270
	Sig	0/002		Sig	0/002
	P	0/189		P	0/008
Noise caused by traffic	N	270	education	N	270
	Sig	0/002		Sig	0/002
	P	-0/797		P	0/095
Noise caused by neighbors	N	270	Duration of stay at home	N	270
	Sig	0/002		Sig	0/002
	P	-0/699		P	-0/082

Table 5: Regression test results regarding the relationship between factors affecting sound comfort

Variables	R	R2	Justified R2	F	Beta	T	p
Space layout	0/414	0/389	0/364	7/63	0/135	2/58	0/000
Material	0/539	**0/499**	0/471	6/85	0/361	3/88	0/000
Height	0/500	0/489	0/461	6/90	0/411	5/59	0/000
Space proportion	0/135	0/120	0/119	5/54	0/045	1/75	0/000
Form	0/210	0/180	0/171	5/88	0/101	2/69	0/000
Traffic noise	-0/841	**-0/789**	-0/770	5/84	0/132	2/52	0/000
Noise caused by neighbors	-0/715	**-0/678**	-0/631	4/98	0/474	4/68	0/000
Noise caused by interior spaces	-0/487	-0/442	-0/399	4/12	0/030	1/63	0/000
Noise caused by common spaces	-0/588	-0/532	-0/498	3/85	0/057	1/87	0/000
Number of residents	-0/283	-0/155	-0/139	3/55	0/052	1/95	0/001
Age	0/101	0/098	0/080	2/63	0/041	1/76	0/007
Gender	0/103	0/098	0/082	2/69	0/098	1/58	0/007
Education	0/089	0/070	0/058	2/02	0/015	1/52	0/007
Duration of stay at home	-0/055	0/041	0/034	1/33	0/496	2/21	0/009

Table 6: ANOVA test results regarding differences between regions in terms of variables affecting sound comfort

Research Parameters		Sum of Squares	df	Average of Squares	F	Sig.
Acoustic comfort	Intergroup	31309989304553/000	36	869721925126/000	4928/000	0/000
	Between-group	58760525685/0	300	176458035/092		
	Sum	31368749830238/000	6			
west	Intergroup	83/000	36	2/000	1036/000	0/000
	Between-group	0/0000	300	0/002		
	Sum	84/074	6			
center	Intergroup	95/042	36	2/000	792/000	0/000
	Between-group	1	300	0/003		
	Sum	96/000	6			
east	Intergroup	48/000	36	1/000	911/000	0/000
	Between-group	0/000	300	0/001		
	Sum	49/000	6			

[f(36, 300)=4928.000,1036.000,792.000,911.000].

B) Assessment of acoustical situation:

A specific classification is considered regarding the sound measurement standards. The first case is the height of the supposed story. Following the Standards of National Building Regulations of Iran, the decks above 23m are considered high-risk, while the lower floors are classified as low-rise. Another case is interior volume, which the authors can adjust to the building area due to the same height as most residential spaces. According to field observations, authors can consider two more significant petite types than 150m2 regions. Another parameter depends on the location of the building position in the city. This classification can be done geographically in Tabriz, considering east-west elongation. Finally, three eastern, western, and central parts were considered. According to measurements, the economic value of a building (land value, quality of materials, and insulation of building) becomes more significant from west to east. Authors must examine the mentioned hypothesis in the research process. The case studies have been reported in Table 7.

According to Table 7, the authors examined four case studies in the eastern part of Tabriz, three cases in the west, and four cases in the central part of the city based on the field assessment. The scattering diagram of case studies in Tabriz is illustrated in Figure 2.

First, background noise was measured within two modes of opened and closed windows inside the residential units.

As seen in Figure 3 of acoustic measurement in the east part of the studied area, the sound level diagram has better quality due to lower sound pressure levels in urban areas than central

Table 7: general data of case studies

Case studies	Location	Position		area		height	
		Bypass	Main street	Less than 150m²	More than 150m²	Low-rise	High-rise
No.1	East						
No.2	East						
No.3	East						
No.4	East						
No.5	West						
No.6	West						
No.7	West						
No.8	Center						
No.9	Center						
No.10	Center						
No.11	Center						

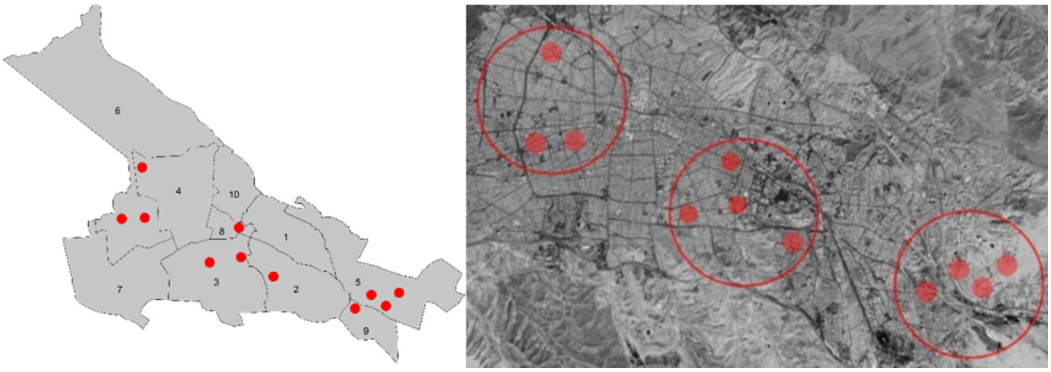

Fig 2: Location of case samples in the aerial map (Google map) and map of Tabriz Municipality (Tabriz Municipality)

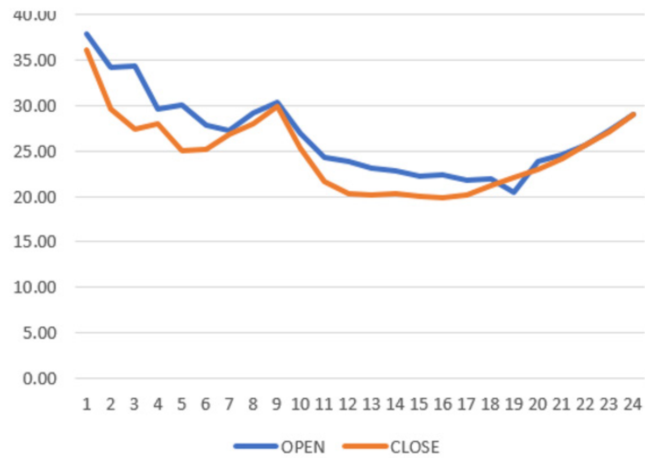

Fig. 3: Average background noise in both open and closed window modes in the East of Tabriz

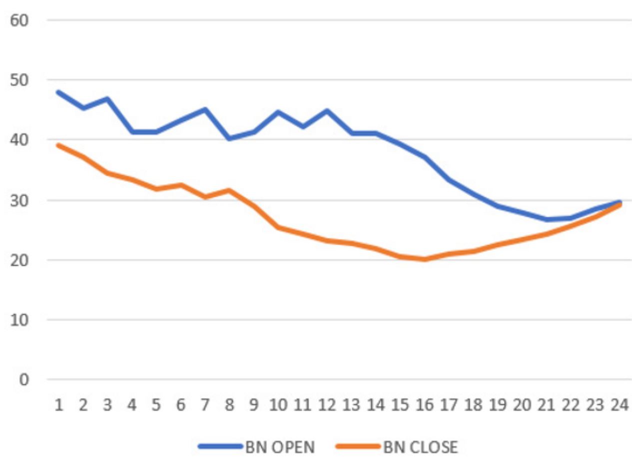

Fig. 4: Average background noise in both open and closed window modes in the center of Tabriz

and western fabrics (proximity to Tabriz International Shahid Madani Airport). This figure shows that the sound pressure level has not reached 40dB, indicating standard SPL.

As seen in Figure 4, the average background SPL in the central area of Tabriz is relatively high (about 50dB). However, the unique point in this figure is the high SPL difference between the two modes of open and closed windows, indicating the high quality of buildings constructed in this part of the city. Because the main fabric of the town relatively covers the original neighborhoods, residents living there work in the historical bazaar of Tabriz, so they have a relatively high income, which is reflected in constructions in the middle part of the city (main fabric). In addition, the east part of Tabriz also has a high regional value, so the price of houses and land in this area is above the overall price average of the city. In the east part of Tabriz, construction insulations have received significant attention. The results of the acoustic assessment in the west part of Tabriz have been depicted in the figure below.

Figure 5 illustrates the average background sound in the western area, SPL in this part of the city is high due to its proximity to the airport and heavy traffic in streets leading to this area. The compressed urban fabric is one of the prominent features of the western region of Tabriz. Furthermore, there are no high-quality constructions in this area due to the low price of land, which is illustrated in Figure 5. Apartments in this area do not have double-glazed windows; hence, the open or closed window does not considerably affect the isolation of outside noise and traffic.

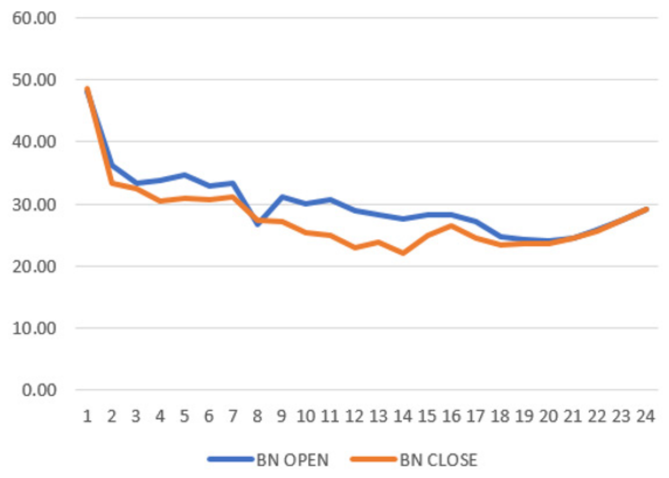

Fig. 5: Average background noise in both open and closed window modes in the west of Tabriz

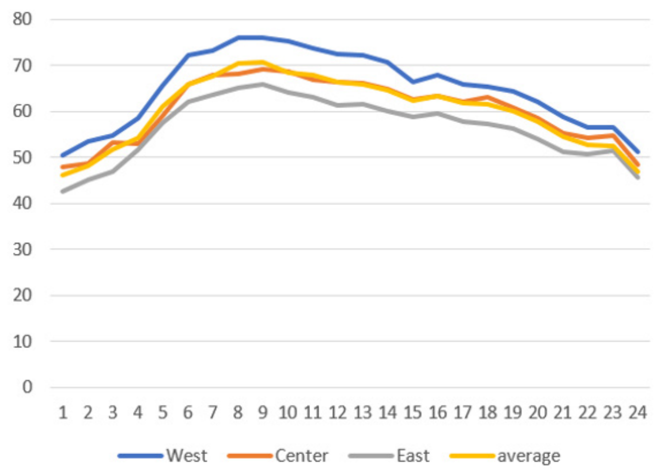

Fig. 6: Comparative study of sound pressure level diagrams among case samples of the central city, west and east of Tabriz with the total average of case samples

In the next step, the authors evaluated acoustical measurements inside the apartment by using SPL diagrams and creating standard decibels in different plan spaces. The obtained results have been reported based on urban districts. It is worth noting that the authors measured the average value of 11 case studies to achieve research results. Then comparative SPL diagrams of three considered urban districts and their mean values were plotted. As seen in Figure 6, the figure of the west area of Tabriz was higher than the average value of 11 case studies, the main fabric was almost consistent with it, and the east area was lower than this figure. The analytical figure indicates that the acoustic status of apartments becomes better when moving from the western parts of the city (with high density and proximity to Tabriz airport) towards the east area of Tabriz. However, Figure 6 indicates the interior acoustical quality of apartments, covering some variables, e.g., form, materials, urban traffic, quality of interior architecture elements (walls, windows, and green walls), quality of interior layout, and design details.

The authors examined the acoustic standard called noise criteria (NC) in the next step. The relevant extracted standards from written references have been described herein. As seen in Table 8, NC has been specified based on different spaces. NC varies between 25 and 35dB in apartments. The mentioned value has been on average for all areas. However, the maximum SPL differs during days and nights equal to 45dB and 35dB, respectively, based on the 18th standard of the National Building Regulations of Iran.

The noise allowed in urban areas has been determined according to the 18th standard of the National Building Regulations of Iran. Some classifications can be considered for the produced noise in urban regions. This table has also mentioned permissible uses, so the maximum SPL based on decibels has been reported in Table 9.

The interesting point in Table 9 is that designers or occupants must take specific measures for external soundproofing if the mentioned permissible uses in urban areas with low and medium noise are constructed in metropolitan areas with high noise. However, in this step, residential services in urban areas are compared with considered standards. Figure 7 indicates the results.

According to Figure 7, all three options have soft acoustical comfort. In other words, there is a significant mismatch between acoustic comfort in these areas and international standards and standard 18 of Iran's national housing and urbanization regulations. The noise coming from neighbors or other sources, such as TV, conversations, phone, music, etc., causes many problems and disturbs acoustic comfort inside the residential apartments.

According to the most prominent point in Figure 7, the effect of urban noise and its combination with SPL measurement has

Table 8: Proposed values of international standard for noise criteria based on different functional spaces (ISO Standard)

Type of room/space type	Recommended NC Level NC Curve	Equivalent sound level dBA
Residence		
Apartment houses	25-35	35-45
Assembly Halls	25-30	35-40
Churches, Synagogues, Mosques	30-35	40-45
Courtrooms	30-40	40-50
Factories	40-65	50-75
Private homes, rural and suburban	20-30	30-38
Private homes, urban	25-30	34-42

Table 9: Urban zoning in terms of environmental noise (National Building Regulation of Iran, 2018)

Type of urban area in terms of noise	Maximum equivalent sound level		Authorized functions
	Day	Night	
Low noise	45	55	Residential, tourism and hospitality centers, health centers, cultural and sports facilities
Moderate noise	55	65	Educational, office, indoor sports clubs, commercial complexes, markets, temporary and permanent exhibitions
High noise	65	75	Terminals, warehouses, parking lots, outdoor sports stadiums, industrial, military, and airports

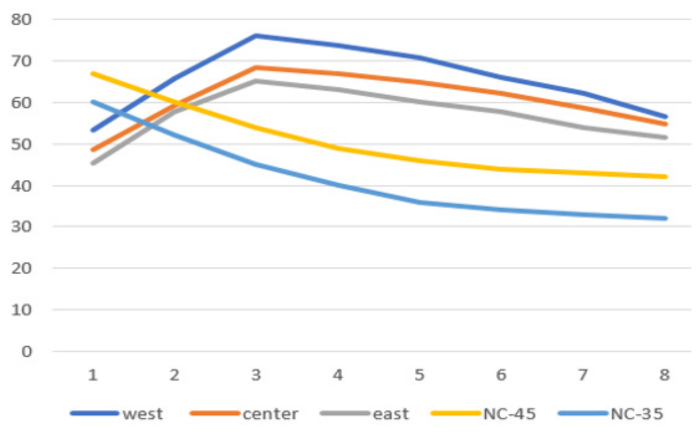

Fig. 7: Comparative comparison of standardized frequencies in three urban areas based on norm noise (NC)

not changed the order of the diagrams' placement. The reason stems from the higher impact of traffic rather than construction quality, form, materials, etc. This case has also been mentioned in questionnaires that experts examined. Suppose there was any change in the order of diagrams of triple urban districts. In that case, it could be claimed that other variables, such as physical characteristics (e.g., form or materials, and interior architecture elements, such as space syntax), had higher effects. Nevertheless, urban traffic had a relatively higher effect.

CONCLUSION

Various sound sources inside and outside residential buildings disturb acoustic comfort. Among these sources, external traffic noise, noise from neighbors, or internal sources, such as people's voices, TV, conversation, or the sound of steps, can be mentioned. The annoyance rate of these triple sources has always been debatable among relevant experts. In other words, residents living in apartments report various noises from neighbors, external traffic, and the noise produced by domestic appliances. The extant study was conducted based on field methods. In terms of the questionnaire, the Pearson correlation and linear regression tests indicated a significant association between acoustical comfort and all variables except for age, gender, education level, and stay-at-home duration. Among auditory features, traffic noise, noise coming from neighbors, and shared spaces had the highest negative effect on acoustic comfort. The linear regression test results indicated that materials-related solutions were more critical, with higher products among physical factors affecting acoustic comfort than other factors.

Moreover, acoustic measurement indicated higher SPL in the western part of Tabriz than in central and east areas due to the proximity of the western region to the airport and heavy traffic leading to streets in this part of the city. Poor construction and old fabric can be named as other reasons. The acoustical status inside the apartment was measured using amplifiers and SPL charts for three considered options (e.g., urban west, east, and center of Tabriz). The results indicated low acoustic comfort of the case studies due to their mismatch with international standards standard 18 of Iran's national housing and urbanization regulations. In other words, the noise from neighbors or other sources, such as TV, conversations, phone, music, etc., causes many problems and disturbs acoustic comfort inside the residential apartments.

On the other hand, space syntax can be an influential factor in this case. An interesting point was no change in the order of background sound diagrams measured in the first mode after measuring the sound pressure level inside the residential apartments, which indicated the importance of the noise outside the apartment, including shared spaces, neighbors, and traffic noise. Since the measurements were done during the day, traffic had the highest effect regarding the annoyance index, so that the measured diagrams might change at night. Therefore, further studies and field measurements should be done inside the apartment at night.

In the end, to compare the present research results with similar research, it can be mentioned that no research has been done about urban noise in Tabriz. For this reason, it is impossible to compare the results, but it is clear that in Tabriz city, there is a big gap in urban noise standards in the world that must be considered.

AUTHOR CONTRIBUTIONS

M.Abbaszadeh performed the literature review and experimental design, analyzed and interpreted the data, and prepared the manuscript text. R. Madani performed the Manuscript edition for final submission.

A. Ghaffari evaluated and measured the city's soundscape and guided the project's experimental parts.

CONFLICT OF INTERESt

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication or falsification, double publication and, or submission, and redundancy, have been completely witnessed by the authors.

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