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Evaluating the aircraft noise level and acoustic performance of the buildings in the vicinity of Dubai International Airport

Naglaa Sami Abdelaziz Mahmoud [a], Chuloh Jung [b,*], Nahla Al Qassimi [b]

[a] Department of Interior Design, College of Architecture, Art and Design, Ajman University, United Arab Emirates
[b] Department of Architecture, College of Architecture, Art and Design, Ajman University, United Arab Emirates

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ABSTRACT

Airports, especially international ones, within the urban context should have a specific consideration so they do not affect human lives. The planes fly a few hundred meters above these urban fabrics, and when they are landing, they fly slightly over 20–40 m above the ground. This paper aims to measure aircraft noise, conduct a survey on the subjective reaction of residents to aircraft noise, and present primary data necessary to secure the acoustic performance of residential buildings neighboring an international airport. The methodology used a field survey for six buildings neighboring Dubai International Airport in the United Arab Emirates, analyzed building/window material, and a subjective reaction survey. The result showed that the average equivalent noise level (L_{eq}) was 66.4 dB(A), and the average maximum noise level (L_{max}) was 73.3 dB(A). The indoor noise of the target buildings was found to be in the range of NC-35 to NC-53, exceeding NC-30, the permissible noise standard. The average noise level difference between indoors and outdoors was 13.6–30.5 dB(A). It was statistically proven that aircraft noise is a significant source of sound pollution and occurs all day throughout the year, regardless of the season. The response rate for loudness and noisiness was found to be very high. Regarding the disturbance in daily life due to annoyance, aircraft noise is significantly affected in the order of telephone calls, conversations, listening to TV and radio, sleep disturbance, concentration disturbance, and rest disturbance. This study will serve as primary data to present basic data necessary to secure an optimum acoustic performance of a residential building against aircraft noise.

1. Introduction

Dubai is a cosmopolitan metropolis of the United Arab Emirates (UAE) that suffered rapid population growth from 34,000 in 1960 to more than 2.92 million in 2021 [1–3]. Dubai has become a global city as a business and cultural hub of the Middle East and the Gulf region [4,5]. It has recently attracted international attention via many innovative mega-scale construction projects and global events. Dubai's economy is becoming more sustainable with tourism, aviation, real estate, and financial services [6–8]. Dubai is also a major transport hub for passengers and cargo [9,10]. Emirates Air is the world's 2nd largest freight and 4th largest passenger carrier airline [11,12]. Dubai's aviation industry has expanded dramatically over the past decades due to unprecedented economic growth [13,14]. The total investment in Dubai International Airport development in the next 20 years is estimated to be over 71 billion AED (19 billion USD) [15,16]. It is in the middle of Dubai and developed rapidly during the past ten years to accommodate the rapid growth of air traffic [17,18]. Dubai International Airport (DXB) is currently the 4th busiest airport in the world, with 193,000 average passengers per day and an average of 979 aircraft landings per day (357,335 aircraft landings per year) [19]. Dubai International Airport was constructed in 1959 in the middle of residential (Mirdif, Al Rashidiya, Muhaisnah, and Al Twar) and commercial areas (Garhoud, Umm Ramool, and Al Muraqqabat) [20]. The planes fly a few hundred meters above these urban fabrics, and when they are landing, they fly slightly over 20–40 m above Mohammed bin Zayed Road, the main highway near the airport [21–23].

* Corresponding author.
E-mail address: c.jung@ajman.ac.ae (C. Jung).

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Environmental pollution is inevitably accompanied by the development of transportation networks such as aviation, roads, and railroads, and noise pollution has a transient characteristic that does not accumulate, unlike other environmental pollution [24–26]. Aircraft noise has a very high noise level and a wide range of damage, causing civil complaints from most residents around the airport [27–29]. To reduce the impact and damage of aircraft noise, the acoustic performance of a building is fundamentally essential [30,31]. A survey of the acoustic performance of an existing building becomes the basis [32]. In addition, it is necessary to investigate the subjective reactions of residents living in existing buildings, such as the sense of damage to aircraft noise and the degree of disturbance in life, as reference data [33,34].

Regarding aircraft noise, some studies are being conducted on the actual condition of aircraft noise around airports, evaluation indicators of aircraft noise, and regulatory standards [35,36]. However, there are no concrete research cases or primary data on the acoustic performance of houses for sound insulation in the UAE [37]. There is no accumulation of primary design data for improving the acoustic performance of residential buildings in the United Arab Emirates [38]. Along with measuring aircraft noise, a survey is conducted on the subjective reaction of residents to aircraft noise. In addition, measuring the acoustic performance of a residential building against aircraft noise is intended to present primary data necessary to secure the acoustic performance of a residential building in Dubai. This study will contribute in:

- Measure the average equivalent noise level outside the residential buildings.
- Measure the indoor noise of the houses.
- Determine the average noise level difference between indoor and outdoor of the residential buildings.
- Define the level of annoyance/disturbance affecting the residents' daily activities at a specific time.

2. Materials and methods

2.1. The characteristics of aircraft noise

Aircraft noise is distinguished from ground traffic noise, such as from automobiles and railroads because it can freely and far propagate into the air without interference from artificial or natural obstacles [39,40]. Aircraft noise sources can be broadly classified into propulsion system noise and aerodynamic noise [41]. The primary sources of propulsion system noise are mechanical noise and primary ejection noise [42]. Machine noise is generated from the engine driving parts, such as a fan, compressor, and turbine [43]. Jet noise is caused by mixing the air around the aircraft with the high-speed jet gas from the engine [44]. These two sources' relative contributions and noise characteristics differ according to aircraft operation patterns, such as take-off, landing, and flight [45]. In terms of environmental noise around airports, where noise during take-off and landing is the main target rather than during flight, noise from the propulsion system is a significant concern [46]. Since noise from the propulsion system is more dominant than the aerodynamics of the aircraft, it is reasonable to reduce the noise from the propulsion system to reduce the effect of noise on the vicinity of the airport [47].

2.2. Aircraft noise assessment methods

The evaluation of aircraft noise is divided into noise evaluation for individual aircraft and noise evaluation for residential areas around the airports [48]. The noise evaluation of each aircraft is used as the standard for the aircraft's noise certificate, and all characteristics of the aircraft such as frequency characteristics, duration, direction and distribution of noise as well as the size of the noise must be considered [49]. In addition, noise generated during take-off and landing is a problem in the noise evaluation for residential areas around the airport, so the number of take-offs and landings of aircraft and the time of take-off and landing are to be considered together [50]. Since aircraft noise affects a large area around the airport, it is necessary to evaluate the data for land use planning and human impact accurately [51,52]. Aircraft noise evaluation indicators, used internationally, are NEF (Noise Exposure Forecast), NNI (Noise and Number Index), PNL (Effective PNL), WECPNL (Weighted Equivalent Continuous Perceived Noise Level), and L_{dn} (Day-Night Equivalent Noise Level) [53,54]. WECPNL has the advantage of being appropriate for noise evaluation around airports because it can objectively represent the reaction of residents to aircraft noise, but the following problems have recently been raised [55]. First, compared to dB(A) or L_{eq}, it is more complex and difficult for ordinary people to understand. Second, since most international airports are in areas where road noise and other environmental noises are complexly mixed, it is meaningless to treat aircraft noise separately from other environmental noises [56]. Therefore, foreign countries are gradually reviewing the integration and unification into L_{eq} [57].

2.3. Target buildings for aircraft noise assessment

In order to measure aircraft noise and to understand the acoustic performance, 6 buildings in the vicinity of Dubai International Airport that are affected by aircraft noise were selected as the measurement points for field survey. Table 1 shows the outline of the surveyed building to determine the acoustic performance of the building against aircraft noise. The wall structure of the target buildings was a lightweight panel structure using sandwich panels, masonry, reinforced concrete & masonry, and wood. The windows and doors, which are weak areas of sound insulation performance, are made of synthetic resin and aluminum chassis single windows, synthetic resin chassis double-glazed windows, synthetic resin and FRP chassis & Aluminum. The structure of the chassis double-glazed window is composed of 3 mm, 5 mm and 6 mm thick glass and 18 mm double glazing. Shorooq townhouse and Ghoroob apartment (Fig. 1) have structures of masonry and reinforced concrete + masonry, which show relatively high sound insulation performance. Villain Muhaisnah, which appears to have moderate sound insulation performance, is masonry (cement block), and Al Wasl Equestrian Stables is made from wood. House A, which seems to have low sound insulation performance, is a warehouse with a lightweight panel structure using sandwich panels, and house E is an old villa of masonry (cement block).

2.4. Measurement methods

In order to understand the effect of aircraft noise on acoustic performance, aircraft noise was simultaneously measured indoors and outdoors in the target buildings for seven days (Fig. 2) [58]. The measurement point was set – 2 m away from the facade wall center from the outside and at the center of the bedroom indoors [45]. The maximum noise level (L_{max}) and equivalent noise level (L_{eq}) of aircraft noise from the inside and outside of the target house were measured for 5 min at each measurement [59]. The indoor noise level was compared and analyzed with the allowable indoor noise level [60]. Additionally, in order to understand the noise reduction effect of each building, the difference between indoor and outdoor noise levels was calculated and compared, and reviewed [61]. The equipment used for noise measurement is shown in Table 2. The microphone was installed at 1.2 m – 1.5 m height from the floor in the noise source direction [62]. The duration of noise generated during aircraft passage was more

Table 1
Surveyed Buildings for Aircraft Noise around Dubai International Airport.

Target Buildings	Location	Structure	Floor Area	Wall Thickness	Window
Al Yousef Warehouse	Umm Ramool	Light Weight Panel Structure	16.4 m^2 (4.6 m × 3.5 m)	80 mm (Sandwich Panel)	FRP Sash & Single Glass (6 mm)
Muhaisnah1-&A Villa	Muhaisnah	Cement Block Masonry	11.8 m^2 (4.1 m × 2.9 m)	210 mm (1.0B Cement Block)	FRP Sash & Double Glass (6 mm + 6 mm)
Shorooq 04–302	Mirdif	Reinforced Concrete & Block	12.2 m^2 (3.6 m × 3.4 m)	350 mm (2.0B Brick)	FRP + Aluminum Sash & Double Glass (6 mm + 6 mm)
Ghoroob 12A-402	Mirdif	Reinforced Concrete & Block	14.0 m^2 (3.9 m × 3.6 m)	350 mm (2.0B Brick)	FRP + Aluminum Sash & Double Glass (18 mm Pair Glass + 12 mm Air + 3 mm Glass)
Al Twar 3-26A Villa	Al Twar	Cement Block Masonry	21.6 m^2 (4.0 m × 5.4 m)	200 mm (1.0B Cement Block)	Aluminum Sash & Single Glass (5 mm)
Al Wasl Equestrian Stables	Al Khawaneej	Wooden Structure	8.4 m^2 (2.1 m × 4.1 m)	300 mm (Wood & Clay)	N/A

Fig. 1. Ghoroob Apartment (Left) and Shorooq Townhouse (Right).

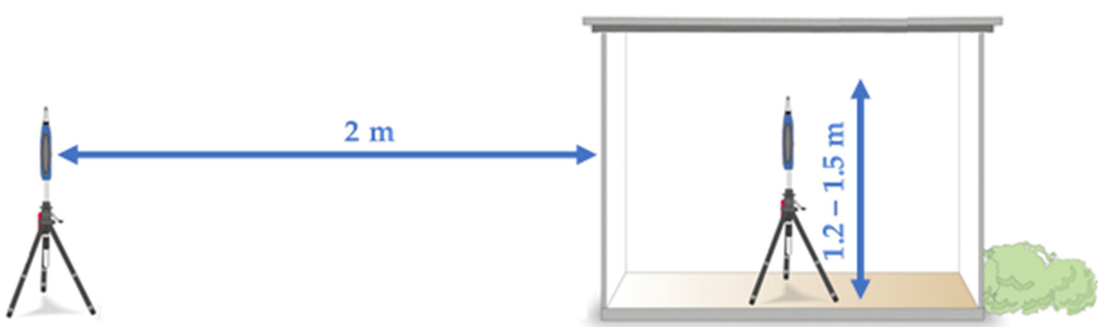

Fig. 2. Measuring positions indoors and outside the residential buildings.

than 10 s, and the noise level was measured every time an aircraft passed, and among the indicated values, a measurement value that was 10 dB(A) higher than background noise was selected [63].

2.5. Survey

In order to understand the subjective reaction to aircraft noise, a survey was conducted on the residents. By distributing 380 questionnaires, 330 copies were collected, and 296 valid questionnaires were analyzed. The composition of the questionnaire was divided into the general matters of the respondents (including gender, age, essential structure of the building) [64] and the effect of noise (including the noise sources, time of noise per day/per season, and noise loudness and annoyance). For the items of subjective response, a 5-step SD (Semantic Differential) scale was used. In order to comprehensively evaluate the effects of noise, the categories of noise were divided into the properties of noise, Loudness, Noisiness, and Annoyance [65]. The main noise source and the time

Table 2
Measuring Equipment for Aircraft Noise.

Equipment	Model	Range	Frequency	Manufacturer
1/3 Octave Band Real-time Analyzer (Sound Level Meter, Class 1)	NA-28	30 – 130 dB	25 Hz – 10KHz	Rion
Precision Sound Level Meter with 1/3 Octave Band Real Time Analyzer	NL-62	A-weight: 25–138 dB C-weight: 33–138 dB G-weight: 43–138 dB Z-weight: 50–138 dB	1 Hz – 20KHz	Rion
Precision Sound Level Meter with Octave Band Analyzer	Pulsar Nova 46	20 – 140 dB	1 Hz – 20KHz	Pulsar
Level Recorder	LR-07	Recording range 25 or 10 dB: 1 Hz to 100 kHz (tolerance ± 1 dB) Recording range linear: 1 Hz to 100 kHz (±10 % of full-scale point)	N/A	Rion
Pistonphone (Calibrator)	Type 4228	N/A	Calibration Frequencies: 251.2	Brüel & Kjær

of noise generation, the size of the noise, and the type and degree of discomfort and disturbance in life were organized into questions [66]. For questionnaire analysis, IBM SPSS Statistics 25 statistical program for social science was used, and frequency analysis was performed for each questionnaire item.

3. Results

3.1. Noise level in the target area

During the measurement, the noise caused by the take-off, landing, and passing flight lasted about 20 to 60 s, and was observed to occur throughout the day. Fig. 3 shows the comparison of the average maximum noise level and the equivalent noise level measured outside the target building in the measurement area for each measurement point. The average maximum noise level outside the target building for each measurement point is 67.3–79.4 dB(A), and the average maximum noise level for all measurement points is 73.3 dB(A). The average equivalent noise level was in the range of 59.1–74.2 dB(A), and the overall average was 66.4 dB(A). The local order 61/1991 of Dubai and WHO's the equivalent noise level for outdoor living area states that noise level should not exceed 55 dB(A) but the average noise level for all measurement points exceeded this standard [67].

3.2. Frequency characteristics of aircraft noise

Fig. 4 is the frequency analysis result for the aircraft noise. The frequency analysis result is the average of the frequency analysis for each measurement value during the measurement period over the entire measurement period [68,69]. The analysis result of aircraft noise shows a similar pattern across all frequency bands, although there is a slight difference in level. It shows high characteristics in the low and middle-frequency bands of 125–1 kHz. It is necessary to consider these frequency characteristics in order to establish reasonable reduction measures for aircraft noise.

3.3. Acoustic performance of target buildings

By comparing the frequency spectrum of the measured noise level with the NC curves (Noise criteria curves) proposed by L. L. Beranek [70], it is possible to determine the amount of attenuation along with the frequency band that requires noise reduction, so information necessary for sound insulation design (noise prevention design) can be obtained [71]. Therefore, NC is generally used as a design target in sound insulation design and noise evaluation, and in the case of a building, it is suggested that the acceptable indoor noise standard is NC-30 or less.

Fig. 5 shows the noise spectrum obtained by frequency analysis of the aircraft noise measured simultaneously inside and outside of the house to be measured when the window is closed, compared with the allowable indoor noise level. In the case of Al Yousef Warehouse, the frequency band where the indoor noise level exceeds the NC-30 curve was found to be 250–2 kHz. In the case of Muhaisnah1-1A Villa, it was 250–2 kHz; in the case of Shorooq 04–302, it was 500–4 kHz. In the case of Ghoroob 12A-402, the indoor noise level exceeds the NC-30 curve in the 250–1 kHz band. In the case of Al Twar 3-26A Villa and Al Wasl Equestrian Stables, it

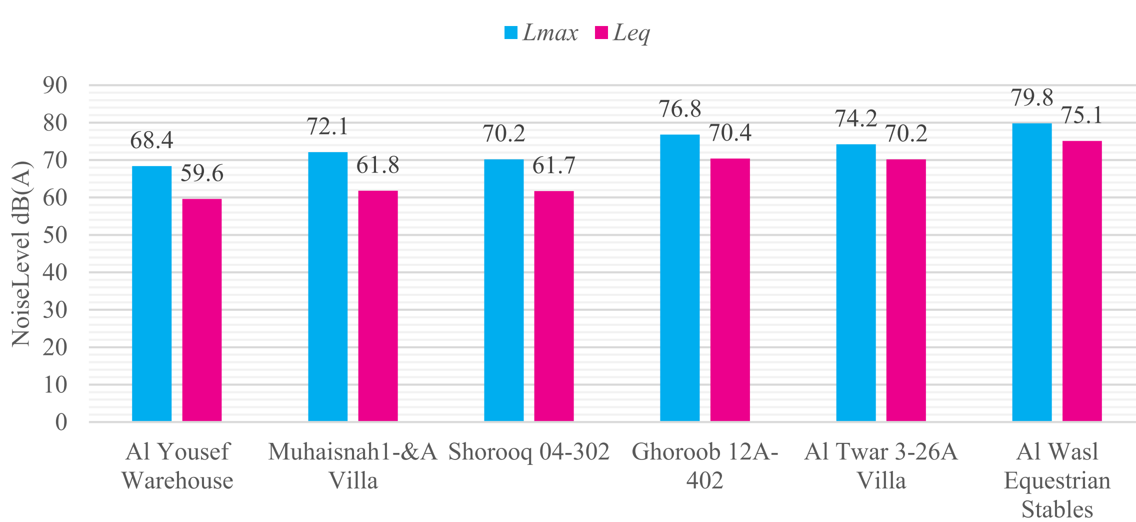

Fig. 3. Average Noise Levels in Each target Building.

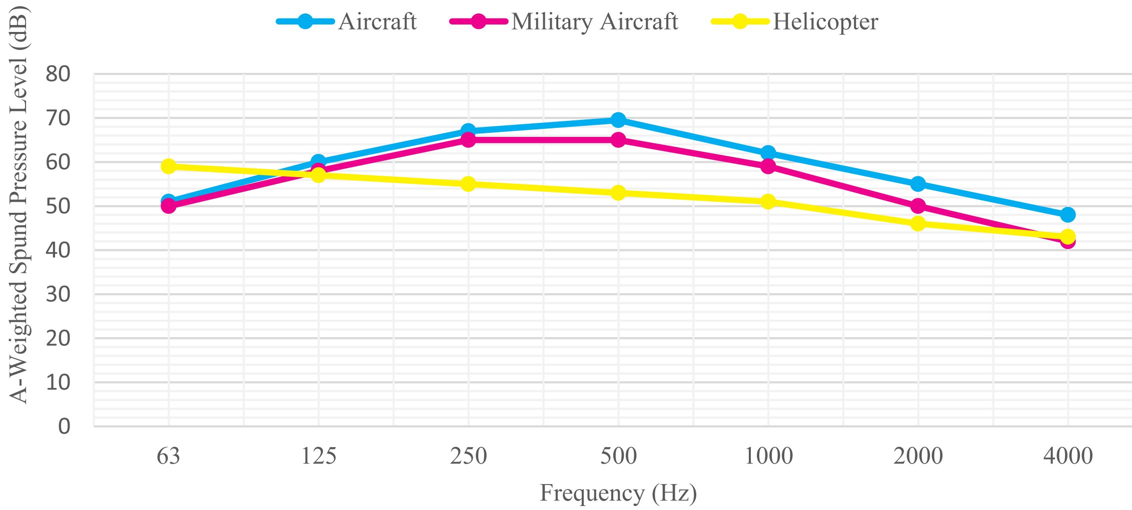

Fig. 4. Frequency Spectrum of Measured Aircraft Noise.

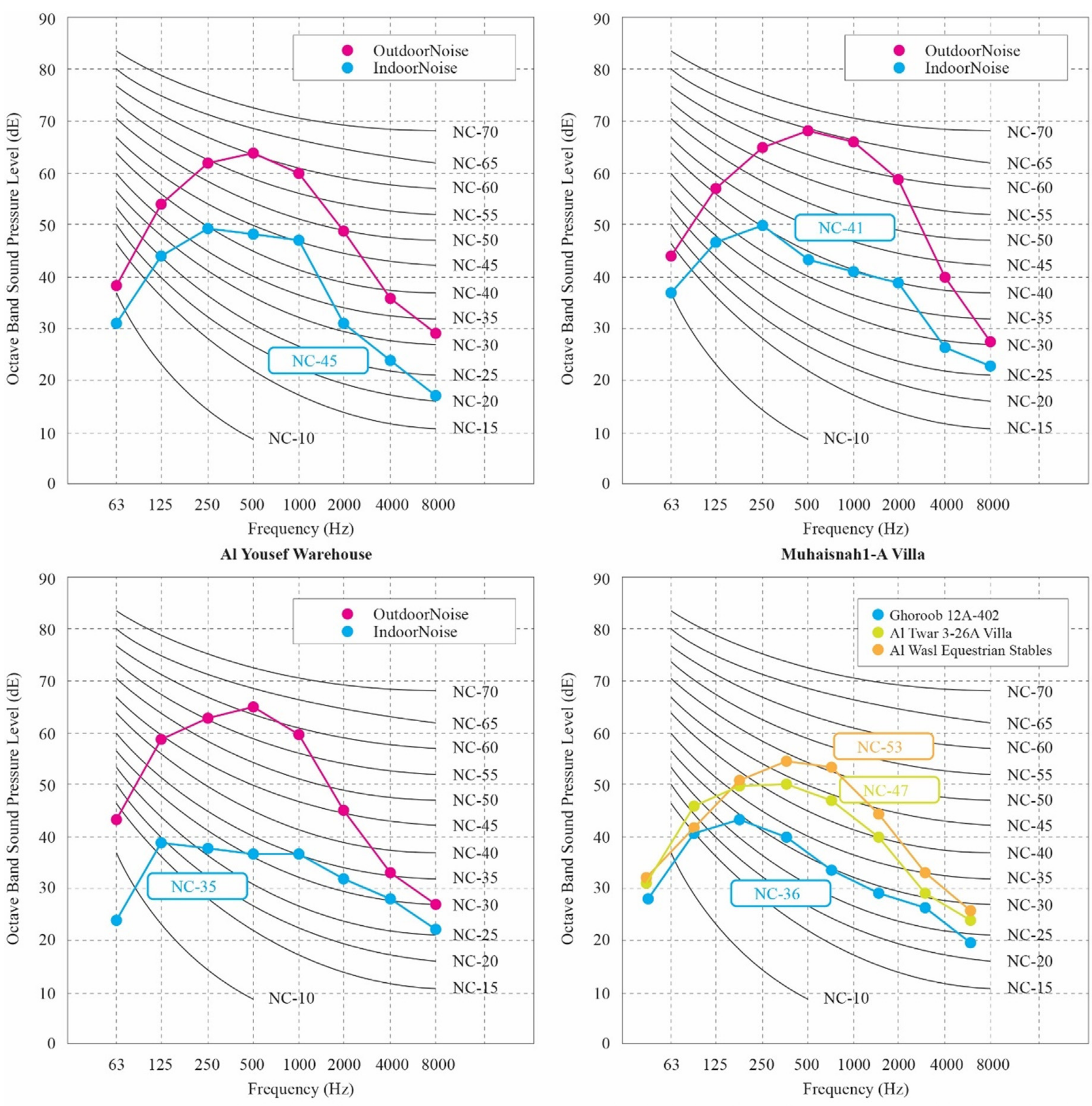

Fig. 5. Comparison of Indoor Noise Level with Acceptable NC with Closed Window.

was found to be exceeded in the 250–4 kHz band. Therefore, it is reasonable to establish countermeasures centering on these frequency bands when designing noise prevention (sound insulation design) for these buildings.

Table 3 summarizes Fig. 4 and compares them with NC values. As shown in the figure and table, the noise level of the aircraft measured indoors was NC-45 in Al Yousef Warehouse, NC-41 in Muhaisnah1-A Villa, and NC-35 in Shorooq 04–302. In case of Ghoroob 12A-402, it was NC-36, in Al Twar 3-26A Villa, NC-47, and in Al Wasl Equestrian Stables without a window, when the door was closed, it was NC-53. The aircraft noise from the outside of the target buildings was L_{eq} 59.1–74.2 dB(A) (WECPNL 71 or higher), and the indoor noise of the target house was in the range of NC35-53. As a result of the analysis, all the target buildings exceeded the NC-30 standard for indoor noise when the windows were closed indoors.

The double-glazed Muhaisnah1-A Villa, Shorooq 04–302, and Ghoroob 12A-402 show a difference between NC-5 and 6. When the window is closed, the difference in indoor noise level between Ghoroob 12A-402 (double window) and Al Twar 3-26A Villa (single window with aluminum chassis) was NC-11. The difference in the indoor noise level of Ghoroob 12A-402 (double-glazed windows) and Al Wasl Equestrian Stables (when the door is closed) was NC-17. As a result of comparing only the cases where the window structure is almost identical (Shorooq 04–302 and Ghoroob 12A-402), the difference in indoor noise level appears to be due to the significant influence of the wall and roof structures of each building. In addition, in the case of Shorooq 04–302 and Ghoroob 12A-402, which show the highest sound insulation performance, the indoor noise level exceeds NC-30 even when the windows are closed. Aircraft noise measured from the outside is calculated as WECPNL 71–75, which satisfies WECPNL 75, the international regulatory standard of the Aviation Act [72]. The house's interior is affected by aircraft noise, indicating that noise reduction measures are necessary for the target buildings.

3.4. Indoor and outdoor noise level difference

Fig. 6 compares the acoustic performance (noise reduction effect) of each house as the difference between indoor and outdoor average noise levels when the window is closed. The noise reduction effect was particularly large for Muhaisnah1-&A Villa – made by cement block masonry - at 500 to 2 kHz. Shorooq 04–302 at 500 Hz. In case of Ghoroob 12A-402, noise reduction is about 14.0 dB or more in all frequency bands and the effect was large, especially in the range of 250 to 1 kHz due the reinforced concrete.

Table 3
Indoor Noise Level (NC Values) of Target Buildings.

Target Buildings	Structure	Wall Thickness	Window	Indoor Noise Level (Closed Window)
Al Yousef Warehouse	Light Weight Panel Structure	80 mm (Sandwich Panel)	FRP Sash & Single Glass (6 mm)	NC-45
Muhaisnah1-&A Villa	Cement Block Masonry	210 mm (1.0B Cement Block)	FRP Sash & Double Glass (6 mm + 6 mm)	NC-41
Shorooq 04–302	Reinforced Concrete & Block	350 mm (2.0B Brick)	FRP + Aluminum Sash & Double Glass (6 mm + 6 mm)	NC-35
Ghoroob 12A-402	Reinforced Concrete & Block	350 mm (2.0B Brick)	FRP + Aluminum Sash & Double Glass (18 mm Pair Glass + 12 mm Air + 3 mm Glass)	NC-36
Al Twar 3-26A Villa	Cement Block Masonry	200 mm (1.0B Cement Block)	Aluminum Sash & Single Glass (5 mm)	NC-47
Al Wasl Equestrian Stables	Wooden Structure	300 mm (Wood & Clay)	N/A	NC-53

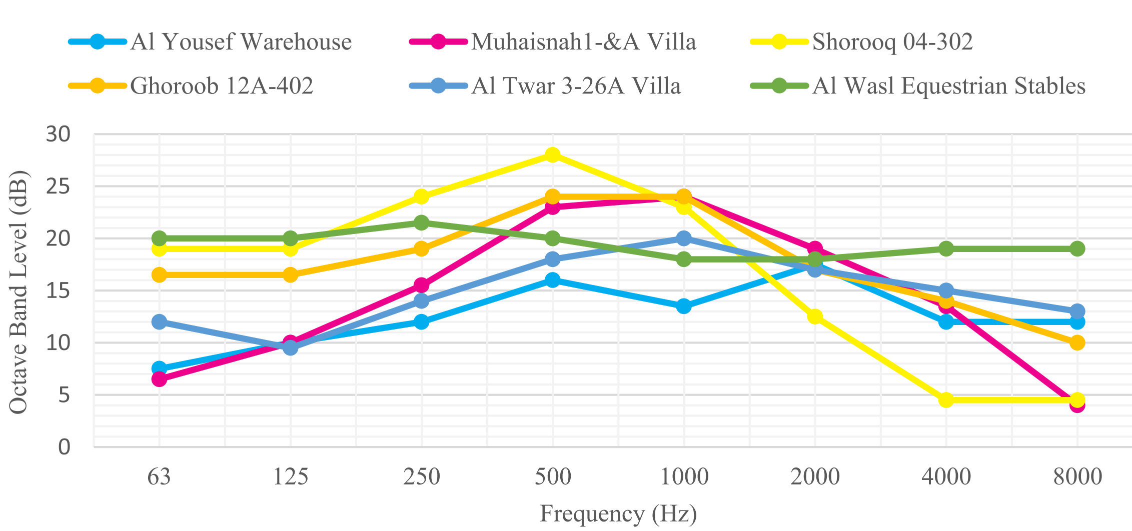

Fig. 6. Indoor and Outdoor Noise Level Difference of Target Buildings with Closed Window.

Table 4
General Information of Respondents.

Categories		Percentage (%)
Gender	Male	72.6
	Female	27.4
Age	Over 60	55.1
	40–59	34.9
	20–39	9.5
	Under 20	0.6
Structure of the Building	Masonry	23.6
	Reinforced Concrete	49.2
	Wood Structure	3.6
	Light Metal Panel	3.7
	Etc	30.7
Window Types	Double Window	49.1
	Single Window	42.9
	Etc	8.0
Construction	10 Years	60.8
	6 – 10 Years	13.3
	3 – 6 Years	13.1
	0 – 3 Years	3.0
	Etc	9.8

In case of Al Twar 3-26A Villa, the noise reduction effect was large in the frequency band of 250 Hz or higher. In case of Al Wasl Equestrian Stables, it was found that there was a uniform noise reduction effect in all frequency bands when the door was closed.

The noise reduction was the higher at 23.8 dB(A) for Shorooq 04–302 and 30.5 dB(A) for Ghoroob 12A-402, both are made with reinforced concrete & block. The noise reduction was 16.8 dB(A) for Al Twar 3-26A Villa, and 18.8 dB(A) for Muhaisnah1-&A Villa, both made from cement block masonry. The noise reduction effect was 19.9 dB(A) for Al Wasl Equestrian Stables when the door was closed as it is a wooden structure. The noise reduction effect was more advantageous for the double-glazed house than for the single-windowed house. Finally, Al Yousef Warehouse was found to have a noise reduction effect of about 10 dB or more in all frequency bands and the effect becomes large in the range of 500 to 2 kHz due to the light weight panel structure of the building.

3.5. Subjective reaction survey

Table 4 summarizes the results obtained from the survey respondents' general information analysis. The respondents' resi-

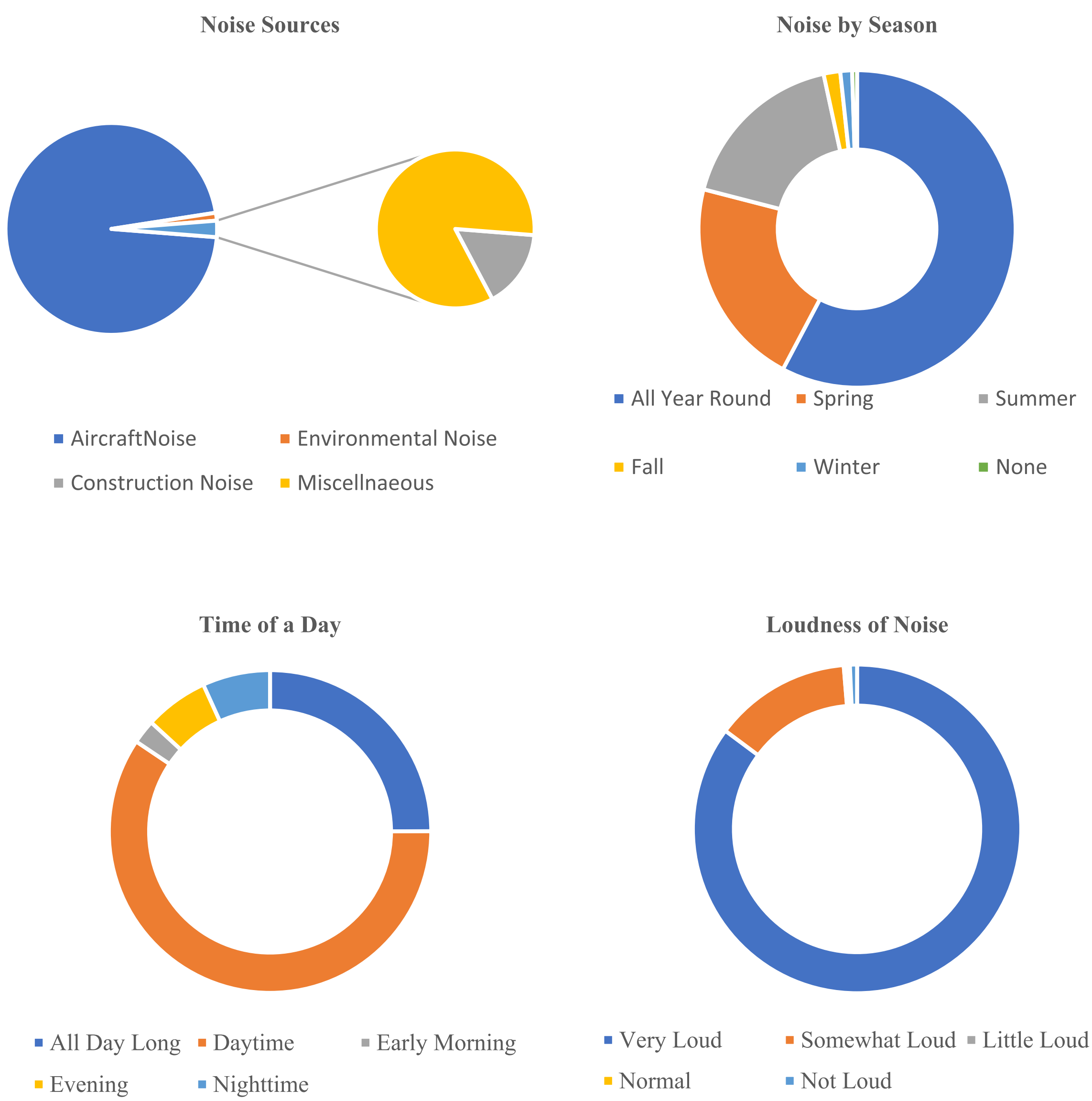

Fig. 7. Noise Sources and their Characteristics.

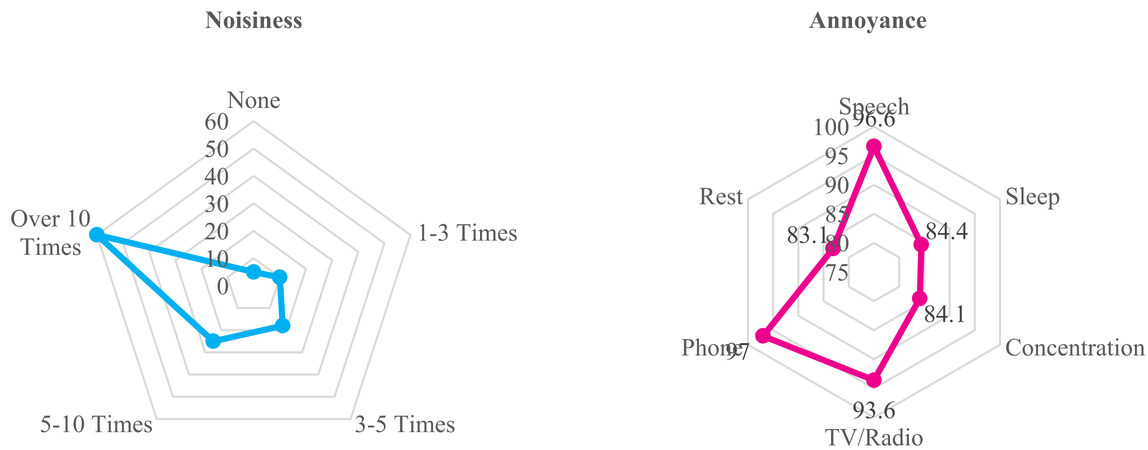

Fig. 8. Influence of Aircraft Noise.

dence was in the Dubai International Airport vicinity, and the gender of the respondents was more male than female, and most of the respondents were in their 40 s or older, showing the characteristics of the Dubai suburban area [73–75]. Most buildings inhabited are masonry and concrete using bricks and blocks; most buildings are over ten years old. In general, double-glazed windows and single-pane windows have a similar distribution in windows and doors that determine the sound insulation performance of a building, and it appears that double-glazed windows were installed for noise reduction and cooling efficiency.

Fig. 7 shows the target area's noise source and generation period. As a noise source, aircraft noise was overwhelmingly answered, and most respondents answered that such aircraft noise occurred throughout the year regardless of the season. It is most often said to occur during and throughout the daytime (24 h). The target area is affected by aircraft noise, and the time-of-day occurrence of the noise source and aircraft noise is also consistent with the observation results at the time of measurement. People tend to be attentive to the noise level much of the day when they are awake and aware of their surroundings, especially when doing their daily activities, although the noise exists all day and all season.

3.6. Loudness/ Noisiness, and annoyance

Fig. 8 (Influence of Aircraft Noise) and Fig. 7 are the results of responses to noise and annoyance expressed in terms of noise loudness and the number of times the noise is perceived as the effect of aircraft noise. As shown in Fig. 7 (Loudness of Noise), the response rate for the top two levels of "very loud" and "somewhat loud" was over 98 %, which was overwhelmingly large. As for the number of times of feeling noisy about the aircraft noise shown in Fig. 8 (Noisiness), the response rate of 10 or more times was 57.8 %, and about 5 to 10 times showed a response rate of 21.3 %. Fig. 8 (Annoyance) is the result of responding to the degree of disturbance in daily life that feels unpleasant as annoyance to aircraft noise. Regarding the degree of disturbance in daily life, the results of responses to "very severe" and "severe", which are the top two levels among the five-step scale of "very severe", "severe", "normal", "slight", and "never". As a result of the response, they are greatly disturbed in the order of phone calls, conversations, TV and radio listening, sleep disturbances, concentration disturbances, and rest disturbances. It is judged that the target area is greatly affected by aircraft noise in the real life of the residents.

4. Discussion and conclusions

Aircraft noise was measured inside and outside of 6 buildings in order to present the basic data necessary to secure the acoustic performance of buildings against aircraft noise. In addition, a survey was conducted on the effect of aircraft noise on the residents of the target area. The main conclusions obtained through this study are as follows.

First, the average equivalent noise level (L_{eq}) outside of the buildings to be measured was in the range of 59.1–74.2 dB(A), and the overall average was 66.4 dB(A). The average maximum noise level was 67.3–79.4 dB(A), and the overall average maximum noise level (L_{max}) was 73.3 dB(A).

Second, the indoor noise of the house to be measured by aircraft noise was found to be in the range of NC-35 to NC-53, exceeding NC-30, the permissible noise standard. Measurement points at Al Yousef Warehouse, Muhaisnah1-&A Villa, and Shorooq 04–302 are calculated as WECPNL 71–75, which satisfies WECPNL 75, the international standard of the Aviation Act. However, it appears to be affected by aircraft noise indoors, so noise reduction measures are needed for the target buildings.

Third, the average noise level difference between indoor and outdoor of the buildings to be measured was in the range of 13.6–30.5 dB(A). It is considered that a comprehensive review is necessary in terms of construction technology, such as reinforcement of windows (improving airtightness) and application of double walls.

Fourth, as a result of the survey, aircraft noise is pointed out as an address sound source. The highest response rate was that it occurred all day throughout the year regardless of the season. The response rate for loudness and noise caused by aircraft noise was found to be very high. Regarding the degree of disturbance in daily life due to annoyance, it is judged that noise in real life is greatly affected in the order of telephone calls, conversations, listening to TV and radio, sleep disturbance, concentration disturbance, and rest disturbance.

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Institutional Review Board Statement.

The study was conducted according to the guidelines of Ajman University Research Ethics Committee.

Informed Consent Statement.

Informed consent was obtained from all subjects involved in the study.

CRediT authorship contribution statement

Naglaa Sami Abdelaziz Mahmoud: Writing – review & editing, Investigation, Project administration, Resources. **Chuloh Jung:** Writing – original draft, Conceptualization, Methodology, Data curation. **Nahla Al Qassimi:** Writing – review & editing, Software, Formal analysis, Validation, Supervision.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Dr. Naglaa Sami Abdelaziz Mahmoud obtained Philosophy of Doctorate of Fine Arts – Interior Architecture in Lighting and Acoustics in 2002 from the Faculty of Fine Arts - Cairo / Helwan University, Egypt and Ecole d'Architecture d' Interieure Camondo (scientific channel), France. Since 1991, she taught at F.A. – Helwan University, Arab Academy for Science and Technology and Maritime Transport, Egypt, and currently at Ajman University, UAE. Her research focuses on interior spaces to maximize well-being and human behavior, lighting and acoustics in interior. She is serving as a reviewer of the Journal of Interior Design. Dr. Naglaa has several acoustic interior designs and consultancy in Egypt and UAE. She created a professional "Lighting and Acoustics Lab at Ajman University." She was selected to be APID's Ambassador - May 2018 -(Association of Professional Interior Designers, the only professional association in the MENA region) to prepare the biannual IFI Congress Dubai 2020 hosted by APID.

Dr. Chuloh Jung is an innovative, inclusive and positive faculty member with extensive experience in government-funded R/D since 2000 in the Department of Architecture, College of Architecture, Art, and Design at Ajman University. He received B. Arch. and Ph.D. from Yonsei University in Seoul, Korea. He also holds two master's degrees, namely M. Arch. and M. Des. S. from Graduate School of Design at Harvard University. He joined Ajman University in 2013. As his Ph.D. degree was about applying ubiquitous computing on residential environments, he became one of the national board members of U-City (Smart City) in Korea and head of several government-funded interdisciplinary R/D teams such as Smart Home Industrialization Center in KMU in Seoul, Korea. Now he is the director of Ajman University Innovation Center and incubates many innovative startups and keep on writing success stories within the SME ecosystem of United Arab Emirates.

Dr. Nahla Al Qassimi has doctorate in Architectural Engineering with specialization in the urban built environment with 15+ years of rich diverse leadership experience in the Middle East. Expertise in risk management, governance & fraud prevention domains across business units of a large conglomerate. Adept in formulating, implementing and updating systems, processes, policies and procedures contributing to organizational objectives of sustainable profitable growth. Extensive experience in large projects in the real estate, government & private sectors . Skilled in building, reinforcing and sustaining productive relations with all internal and external stake holders. More than 12 years' experience in Academic teaching and student development .