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Assessment of acoustic comfort in a hostel building inside an educational campus.

Evaluación del confort acústico en un edificio de albergue dentro de un campus educativo.

Pavithra Raj J S[1], Amalan Sigmund Kaushik S[2]

[1] Department of Architecture, National Institute of Technology, Tiruchirappalli, India.

[2]Assistant Professor, Department of Architecture, National Institute of Technology, Tiruchirappalli, India.

Corresponding author's email: arpavithraraj@gmail.com (Pavithra Raj J S)

ABSTRACT

In the contemporary built environment, noise has emerged as one of the most pervasive and pressing issues across all building typologies. However, in recent times, an enhanced cognizance of the adverse impacts of noise pollution on human health has taken root. Specifically, within educational campuses, hostels, as the primary abode for most students, have been identified as sites where the assurance of indoor acoustic comfort is critical to bolster productive endeavors. However, the assessment of indoor acoustic comfort remains a less researched facet of indoor environmental quality. As a response to this knowledge lacuna, our research puts forth an innovative methodology that facilitates the assessment of the acoustic comfort of hostel buildings while meticulously analyzing the factors that impact the occupants' acoustic comfort. A case study hostel at the NIT Trichy campus has been selected, and two rooms from the same hostel block have been identified for further examination. The outdoor sound level is gauged at 2 meters from the facade, while the indoor sound level is assessed at the center of each room. Additionally, the reverberation time is measured in both rooms using the Bedrock SM 30 class -2 sound level meter. The collated data has been processed, and the results have been obtained. Furthermore, the methodology, as proposed by Project New TREND, has been employed to assign an acoustic class for each room. Room 1 has been categorized under class B, with a KPI of 4 points, while Room 2 has been allocated to class C, with a KPI of 3 points. This research posits a novel methodology that can enable designers to evaluate the acoustic class of hostels, which, in turn, can help them optimize facade elements to accentuate the indoor acoustic comfort.

Keywords: Acoustic comfort, Hostel acoustics, Acoustic classification, Building envelope.

RESUMEN

En el entorno construido contemporáneo, el ruido se ha convertido en uno de los problemas más generalizados y apremiantes en todas las tipologías de edificios. Sin embargo, en los últimos tiempos se ha arraigado un mayor conocimiento de los efectos adversos de la contaminación acústica en la salud humana.

Específicamente, dentro de los campus educativos, los albergues, como residencia principal de la mayoría de los estudiantes, han sido identificados como sitios donde garantizar el confort acústico interior es fundamental para impulsar los esfuerzos productivos. Sin embargo, la evaluación del confort acústico interior sigue siendo una faceta menos investigada de la calidad ambiental interior. Como respuesta a esta laguna de conocimiento, nuestra investigación propone una metodología innovadora que facilita la evaluación del confort acústico de los edificios de albergues mientras analiza meticulosamente los factores que impactan en el confort acústico de los ocupantes. Se seleccionó un albergue de estudio de caso en el campus del NIT Trichy y se identificaron dos habitaciones del mismo bloque de albergues para un examen más detenido. El nivel sonoro exterior se mide a 2 metros de la fachada, mientras que el nivel sonoro interior se evalúa en el centro de cada estancia. Además, se mide el tiempo de reverberación en ambas salas mediante el sonómetro Bedrock SM 30 clase -2. Se han procesado los datos recopilados y se han obtenido los resultados. Además, se ha empleado la metodología propuesta por Project New TREND para asignar una clase acústica a cada estancia. La sala 1 ha sido categorizada en la clase B, con un KPI de 4 puntos, mientras que la sala 2 ha sido asignada a la clase C, con un KPI de 3 puntos. Esta investigación propone una metodología novedosa que puede permitir a los diseñadores evaluar la clase acústica de los albergues, lo que, a su vez, puede ayudarles a optimizar los elementos de la fachada para acentuar el confort acústico interior.
Palabras clave: Confort acústico, Acústica de albergues, Clasificación acústica, Envolvente del edificio.

INTRODUCTION

In the modern world, where urbanization is happening swiftly, there is migration happening towards the urban areas for career purpose and educational purpose. Hostel buildings are becoming the dwelling place for a large group of people. While considering Indoor Environmental Quality, acoustics is the least explored part. It is significant to evaluate acoustic comfort while designing a space for dwelling. (Dahlan et al., 2009) states that both subjective and objective analysis is required to define the state of wellbeing of an occupant. Also, students who live in hostel rooms with projected balconies have more satisfactory acoustic comfort.(Orola & David, 2019) examined indoor acoustic conditions in student hostels where sound pressure level, wall area, window area, window-to-floor area ratios are considered. In addition, speech intelligibility index, speech privacy index and articulation index are also examined for a detailed study. (Orola & David, 2019) stated that noise annoyance is not related to gender but influences age. The sound pressure level increases with the floor level due to wind and air temperature influences. (Orola & David, 2019) examined the acoustic comfort in a private hostel and concluded that acoustic quality is affected by Reverberation time, absorption, sound insulation and physical room properties. According to (Ganesh et al., 2021), acoustic comfort is the subjective measure of how contented a person feels with the acoustic conditions. (Claudi et al., 2019) states that building envelope plays a major role in defining the acoustic comfort of a space. Project New TRENDS (Barbano et al., 2016) proposes a methodology to assess the acoustic performance of a building by assigning the spaces an acoustic class and calculating the Key performance Index to determine how comfortable the building is in terms of acoustic comfort. This is given by the formula,

$$L_{2,nT,w} = L_{p,A}\left(or\ L_{1,2m,w}\right) - D_{2m,nT,w}$$

Where, $L2$, nT, w= Is the average sound pressure level in the receiving room, standardized to 0,5 s reverberation time [dB(A)], Lp, A ($orL1$,$2m$, w) = Is the outdoor sound pressure level, 2 meters in front of the façade [dB(A)], $D2m$, nT, w= Is the standardized sound level difference [dB].

Table 1gives the range of acoustic classification and Table 2 gives the KPI point scale.

Table 1 Acoustic class determination

Acoustic classes	Acoustic comfort level
A	High level: fulfilment of acoustic design values with reserve greater than 5 dB(A)
B	Very good level: fulfilment of acoustic design values with reserve 2.6 to 5 dB(A)
C	Acceptable level: minimum fulfilment of acoustic designed values with reserve 0 to 2.5 dB(A)
D	Bad level: design values of acoustic comfort level are not fulfilled

Table 2 KPI Point assignment

Specification of space	Points
most (or all) spaces are in Class D	0
most spaces are in Class C, other spaces fall into Classes D	1
all spaces are in Class C	2
most spaces are in Class C, other spaces fall into Classes A/B	3
most spaces are in Class B, other spaces fall into Classes A/C	4
most (or all) spaces are in Class A	5

METHODOLOGY

The methodology implied for the research is given in Fig. 1

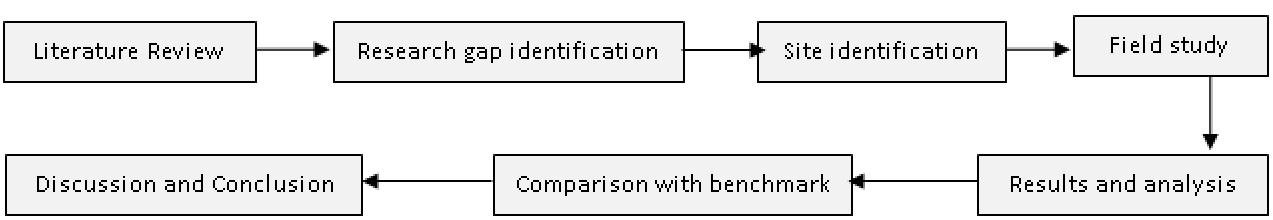

Fig. 1 Methodology

The literature review starts with the study of acoustic comfort (Ganesh et al., 2021), (Azar et al., 2020), (Antoniadou & Papadopoulos, 2017), acoustic parameters and the noise regulations. The site is identified at National Institute of Technology, Tiruchirappalli campus. Calculation of acoustic class is done by in accordance with the methodology given by Project New TRENDS document [9]. The calculated acoustic class is compared with the benchmarks.

FIELD MEASUREMENT

The site is in the NIT Tiruchirappalli campus at the OPAL girls' hostel complex. Two rooms were identified in OPAL block. One in the North wing and the other in the South wing. The rooms are 3m wide, 2.5m long and 3m high. It has two windows on the outer side and a door on the corridor side. The part plan of each wing is given in Fig. 2 and Fig. 3

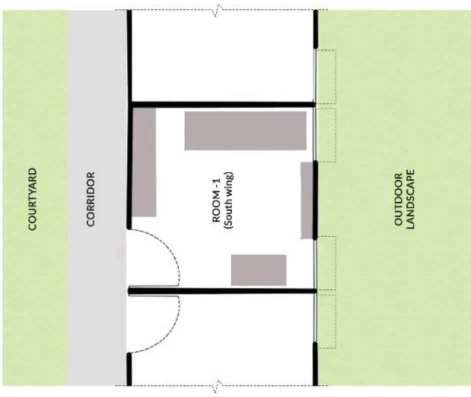

Fig. 2 South wing part plan

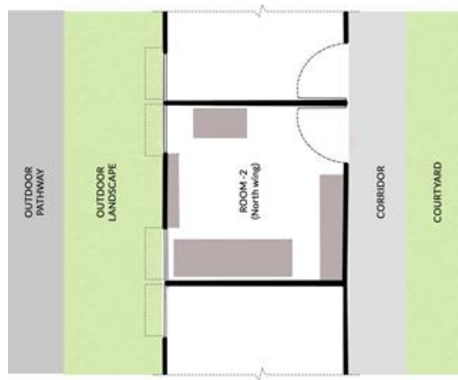

Fig. 3 North wing part plan

There is about 10m from the South façade to the outer pathway. Whereas there is distance of 4.5m from the North façade to the outer pathway. This Northern pathway (Fig. 4) is used by the students predominantly to access the dining hallFig. 5and Fig. 6show the façade of room 1 and 2 from the pathways respectively.

Fig. 4 Northern Pathway

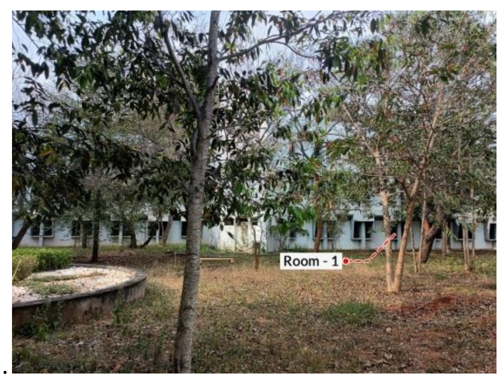

Fig. 5 View of Room 1 from the Southern pathway

Fig. 6 View of Room 2 from the Northern pathway

The building data considered for the calculation of sound reduction of the façade is given in the Table 3

Table 3 Building data

Length	3000 mm
Width	2500 mm
Height	3000 mm
Area	7.5 Sq.m
Volume	22.5 Cu.m
Door type	Single flush
Area of Door	1.89 Sq.m
Material of door	Timber
Window type	Casement (2 Nos.)
Area of Window	1.62 Sq.m
Material of Window	Glass
Wall surface area	18.99 Sq.m
Total surface area	20.61 Sq.m
Wall material	Brick Wall

Two instruments of the same specification (Bedrock SM 30 Class 2 Sound level meter) are used for the measurement of indoor and outdoor sound pressure levels. Continuous sound level measurement was done for duration of 10 minutes per hour in each room. It was carried out for a period of 24 hours (3 pm to 3 pm). 1/1 Octave band width is considered for the measurement. The sound level meter on the outdoor is measured at 2m from the façade as shown in Fig. 6. The instrument is placed at the center of the room to measure the indoor sound pressure level. The sound level meters were fixed at 1.5m from the floor level. This is in accordance with the ISO 16283 – Part 3 universal procedure. The sound levels of indoors and outdoors throughout the day is plot in graphs for the two rooms. The sound levels were analyzed at four-time intervals of the day. Morning (5 am to 10 am), Afternoon (11 pm to 4 pm), Evening (5 pm to 10 pm), and Night (11 pm to 4 am). The reverberation time for each room was measured at the center of each room using the impulsive response method. An impulse is created at the center of the room, and the decay time is recorded in the T20 and T30 measurements which are then converted into T60. The points at which the instruments are placed is shown in Fig. 6

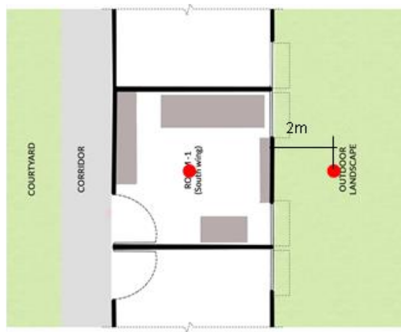

Fig. 7 Points of measurement

RESULT AND ANALYSIS

The outdoor sound level and the corresponding indoor sound level in each space are tabulated in Table 4

Table 4 SPL (dB) outdoor and indoor

Room 1	Morning	Afternoon	Evening	Night
R1_Out	52.2	49.8	52.3	50.0
R1_In	43.8	43.2	47.1	42.0
Room 2	Morning	Afternoon	Evening	Night
R2_Out	62.6	54.9	60.2	52.0
R2_In	57.2	48.4	52.2	47.3

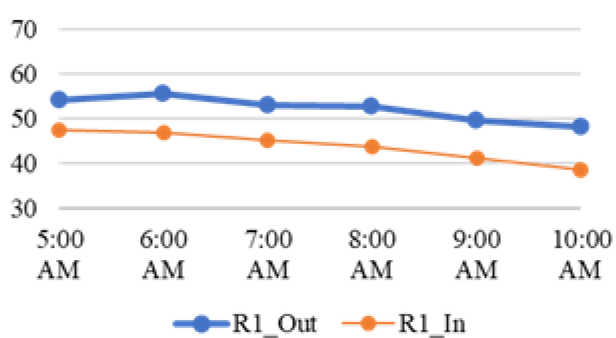

Fig. 8 Room 1_Morning SPL

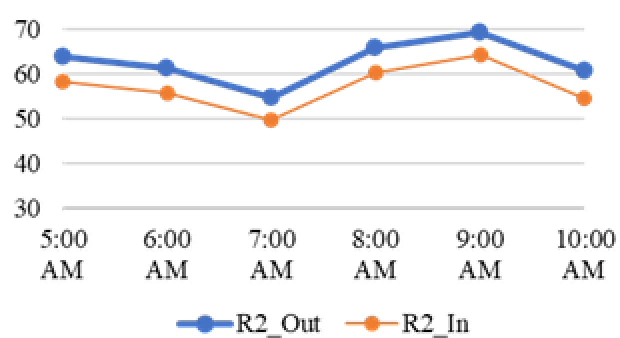

Fig. 9 Room 2_Morning SPL

Fig. 8 shows the morning outdoor SPL and corresponding indoor SPL in room 1. Room 1 is comfortable during the morning period as the students use the southern pathway only for riding vehicles and it is around 10m away from the façade. The sound pressure level gradually decreases as the students go to the college for class. Fig shows the morning outdoor SPL and corresponding indoor SPL in room 2. Room 2 is less comfortable compared to room 1 during the morning period. Since this is the pathway predominantly used by the students to access the mess, the communication noise and continuous cycling increases the SPL. The mess closes at 9.30 am. Hence, the SPL reduces gradually.

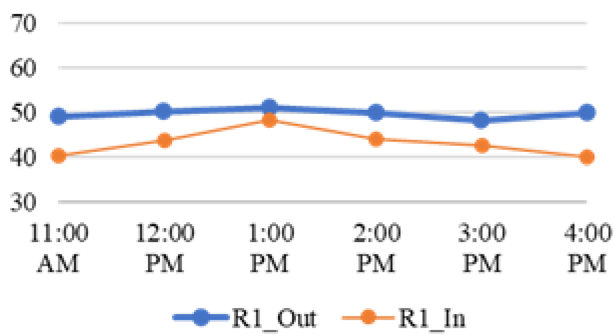

Fig. 10 Room 1_Afternoon SPL

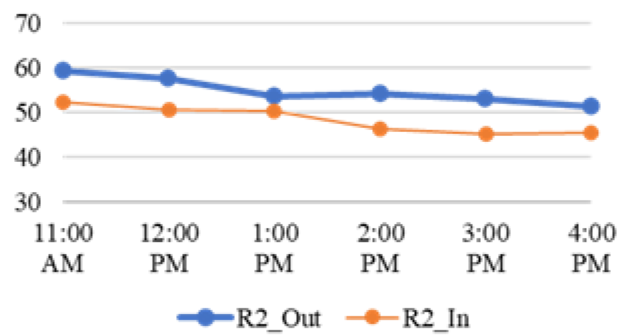

Fig. 11 Room 2_Afternoon SPL

Fig. 10 show the afternoon outdoor SPL and corresponding indoor SPL in room 1. Room 1 is less comfortable during the afternoons. It is affected by the workers at the corridors who make noise by communication and cleaning. Low frequency noise caused by birds chipping also affects the sound pressure level. Fig. 11show the afternoon outdoor SPL and corresponding indoor SPL in room 2. Room 2 is less comfortable when compared to room 1 because of few factors. The pedestrian communication noise, cycle noise, workers in the corridor and the vehicles which come in the hostel campus for groceries delivery, gas delivery & garbage collection.

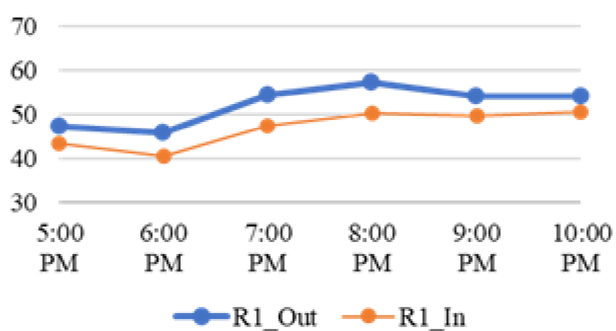

Fig. 12 Room 1_Evening SPL

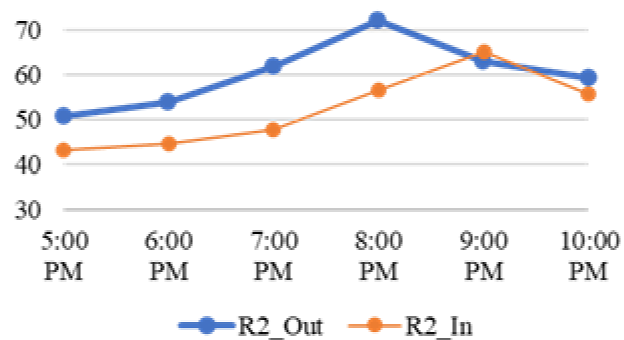

Fig. 13 Room 2_Evening SPL

Fig. 11 Room 2_Afternoon SPL Fig. 12 Room 1_Evening SPL shows the evening outdoor SPL and corresponding indoor SPL in room 1. Room 1 is very comfortable from 5pm to 6pm after which the SPL increases gradually and reaches its peak during 8 pm as most of the students walk around the campus, play and have a chat after the dinner. The SPL stays almost constant as the students use the southern pathway to spend their leisure time. Fig. 13 shows the evening outdoor SPL and corresponding inddor SPL in room 1. Room 1 is very comfortable from 5pm to 6pm after which the SPL increases gradually and reaches its peak during 8 pm as most of the students walk around the campus, play and have a chat after the dinner. The SPL stays almost constant as the students use the southern pathway to spend their leisure time.

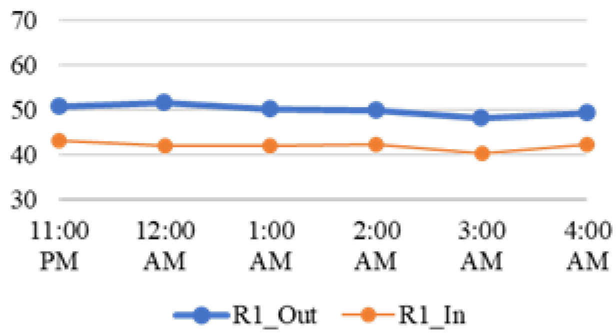

Fig. 14 Room 1_Night SPL

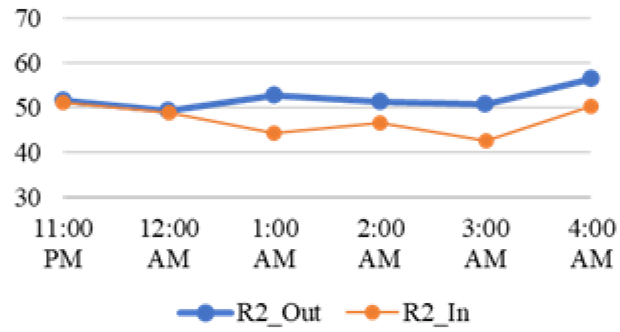

Fig. 15 Room 2_Night SPL

Fig. 14 show the night outdoor SPL and corresponding indoor SPL in room 1. Room 1 at night is very comfortable except for the small disturbances caused by unpredictable noise sources. Fig. 15 shows the night outdoor SPL and corresponding indoor SPL in room 2. Room 2 at night is less comfortable when compared to room 1. There is a heavy disturbance caused by the community noise.

Table 5 Acoustic class determination

Room	Room 1	Room 2
Reverberation time	0.58 s	0.61 s
Acoustic class	B	C

Other parameter considered for the determination of acoustic class is the sound reduction index of the wall, door, and the window. After analyzing the acoustic conditions of Room 1 and Room 2 at different times of the day, it is inferred that Room 1 provides better acoustic comfort during the morning and night periods, while Room 2 is less comfortable during those periods due to various noise sources such as pedestrian communication, cycle noise, and community noise. However, during the afternoon, Room 1 becomes less comfortable due to noise from workers in the corridors and low frequency noise from birds. Additionally, the acoustic class of the rooms is determined based on not only the sound pressure levels but also the sound reduction index of the wall, door, and window. The study highlights the impact of various factors on the acoustic comfort of rooms and provides valuable insights for designers to optimize acoustic comfort by modifying the design elements such as the façade, doors, and windows.

The result of the experiment is tabulated in Table 5.The acoustic class for room 1 is calculated to be B and for room 2 it is calculated as C. This shows that room 1 has a good acoustic comfort and room 2 has a poor acoustic comfort according to Project New TREND acoustic classification. Room 1 acquires a KPI of 4 points and room 2 acquires a KPI of 3 points out of 5.

CONCLUSION

The present investigation has sought to comprehensively evaluate the effectiveness of the building envelope in mitigating noise transmission from the exterior environment to the indoor space by considering both outdoor and indoor sound pressure levels. By subjecting two rooms in a hostel block located at the NIT Trichy campus to rigorous acoustic testing, the acoustic class for Room 1 and Room 2 were determined to be B and C, respectively, according to the Project New TREND acoustic classification system. This outcome conclusively establishes that Room 1 affords a high degree of acoustic comfort, while Room 2 is characterized by poor acoustic comfort. In essence, the proposed research offers a rigorous and sound methodology that architects and designers can utilize to assess the acoustic comfort of various spaces within a building, by assigning a Key Performance Index (KPI) value to each space based on its acoustic class. Nonetheless, it is important to note that the occupants' perception of acoustic comfort also plays a critical role in the evaluation of a building's acoustic quality, and therefore, the subjectivity of human experience must be accounted for in any comprehensive assessment of indoor acoustic quality. Therefore, this study offers a valuable tool for designers to evaluate the acoustic class of a hostel and proposes simple façade modifications to enhance the indoor acoustic comfort for occupants.

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