Influence of gaps under doors on the acoustic performance of wall and door assemblies separated by entrance halls

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ABSTRACT

This study investigated the influence of gaps under doors on the acoustic performance of wall and door assemblies separated by entrance halls. A case study was conducted, involving 32 in situ acoustic tests, following ISO 16283-1 and ISO 717-1 standards to evaluate the Weighted Standardized Level Difference (D_{nTw}) in relation to the average gap size (Mf). The hypothesis, which predicted a lower D_{nTw} with the presence of gaps, was confirmed. Results indicated that the presence of gaps significantly degraded acoustic performance, while the use of gap fillers effectively restored performance to the superior level required by NBR 15575, the Brazilian building performance standard. Notably, misaligned doors consistently showed higher D_{nTw} values than aligned doors, even with gaps, highlighting the combined importance of gap treatment and door positioning. These findings offer crucial evidence-based subsidies for architectural design and acoustic engineering, enabling professionals to prioritize interventions that improve acoustic comfort and user's quality of life in residential buildings.

1. INTRODUCTION

Acoustic control in residential buildings is a crucial factor for user comfort and is directly related to sound privacy between environments. The Brazilian performance standard, NBR 15575-4:2021 [1], establishes minimum criteria for the sound insulation of internal enclosures, including the assembly formed by walls and doors separated by a circulation hall. Despite this, specific constructive aspects, such as the presence of gaps under doors, are still underexplored in technical literature.

Previous studies indicate that bottom gaps in entrance doors can constitute preferential sound transmission paths for airborne sound, compromising the acoustic performance of the system, especially in multi-family building typologies. For example, it was observed that increasing gaps between the door leaf and the floor results in a loss of acoustic performance, highlighting the importance of adequate

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sealing of these openings [2]. Furthermore, the presence of poorly sealed gaps has been associated with a reduction in the efficiency of acoustic insulation in door and wall assemblies facing common circulation areas in residential buildings. Therefore, this study aimed to experimentally investigate the relationship between gaps under doors and the acoustic performance of wall/door assemblies separated by an entrance hall.

2. MATERIALS AND METHODS

This study was characterized as a case study, focusing on evaluating the influence of the average gap size under doors on the acoustic performance of wall and door assemblies separated by residential entrance halls. To this end, tests were conducted on 4 floors of a residential building located in Samambaia-DF. The selected building consists of housing units arranged on typical floors with similar constructive characteristics.
All tests were performed under controlled building and environmental conditions. However, aspects such as the floor, the position of the receiving room (and, consequently, the receiving door), the acoustic absorption of the hall, and, of course, the size of the exposed gaps were intentionally varied. The combination of these variations resulted in 32 acoustic tests. Figure 1 presents the typical floor plan of the building, highlighting the rooms selected for testing: source room (EM); receiving room with door aligned with the emission (R1); and receiving room with door misaligned with the emission (R2).

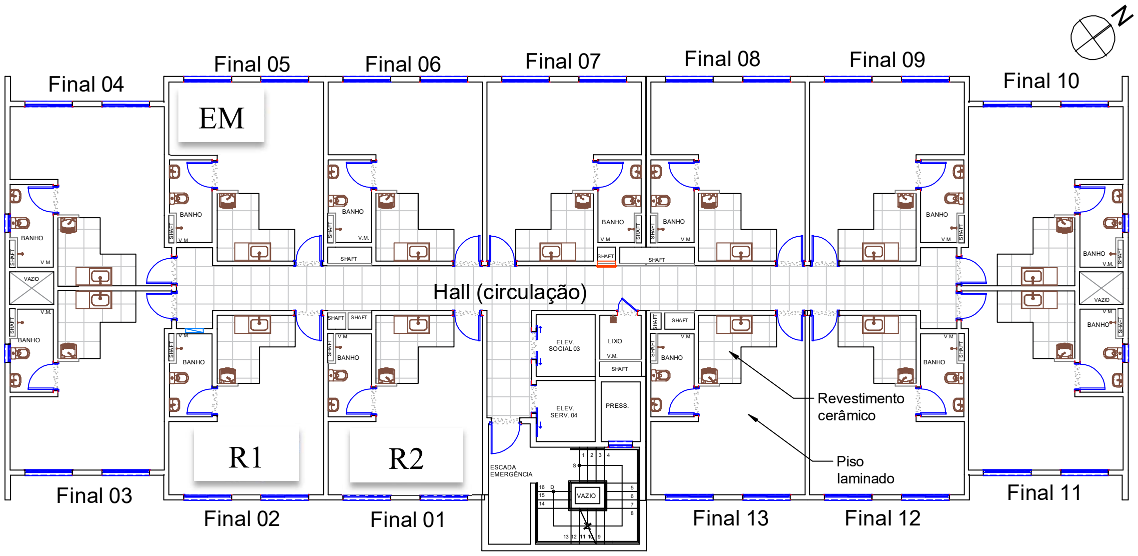

Figure 1: Typical floor plan of the building used in the case study.

Measurements followed the procedures established by ISO 16283-1:2014/Amd 1:2017 [3], which specified methods for in situ determination of airborne sound insulation between rooms. The acoustic performance evaluation parameter was the Weighted Standardized Level Difference (D_{nTw}), as defined in ISO 717-1:2020 [4]. Sound pressure level measurements were performed using an omnidirectional sound source, a sound amplifier, and a Class 1 sound level meter calibrated in an accredited laboratory. The test methodology included two main conditions regarding the presence of gaps under the doors:

- Condition with Exposed Gaps: In this condition, the gaps under the doors of both the source and receiving rooms were kept exposed. The size of the gaps was measured individually in the central region of the door leaf in both rooms, and from these measurements, the average gap size (Mf) was calculated for each test (Figure 2).

- without Gaps: For this reference condition, a gap filler material was inserted under each door (Figure 3), simulating a condition of zero gaps (Mf=0 mm).

For the analysis of the collected data, D_{nTw} and Mf values were plotted in scatter graphs, allowing visualization of the relationship between the variables and identification of trends.

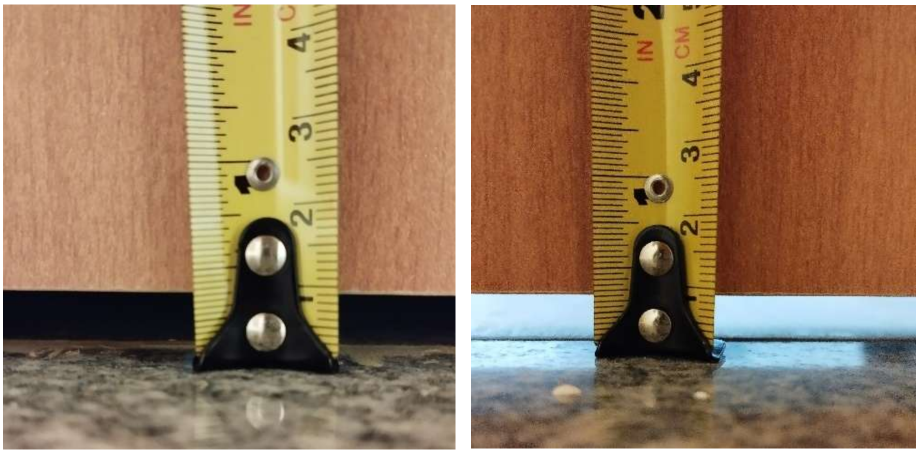

Figure 2: Example of gap measurement under doors with a tape measure.

Figure 3: Example of gap filler positioning under a door.

3. RESULTS AND DISCUSSION

The gap heights under doors are presented in Table 1, where Mf1 and Mf2 refer, respectively, to the average gaps between EM/R1 and EM/R2 rooms. The 32 acoustic tests performed consistently revealed the significant influence of the presence of gaps under doors on the D_{nTw} of wall and door assemblies separated by entrance halls. As the average gap size showed little variation, it was not possible to observe a clear trend of this variable on D_{nTw} and, consequently, on the acoustic performance of the assembly.

Table 1: Dimensions of gaps under doors measured on the building floors.

Floor	EM (mm)	R1 (mm)	R2 (mm)	Mf1	Mf2
P2	8.0	14.5	9.5	11.25	8.75
P3	9.0	10.0	10.5	9.5	10.0
P4	9.5	9.5	10.5	9.5	9.5
P5	12.5	12.0	11.5	12.25	12.0

Initially, a general analysis of the data (Figure 4) showed that, in situations where Mf=0, the D_{nTw} value tends to be higher compared to that obtained with exposed gaps. Deepening the analysis, the separation of results by door alignment conditions (Figure 5) provided more detailed insights into the impact of both gaps and the geometry of door positioning. It is evident that better results are obtained when, in addition to sealing the gaps, the room doors are misaligned. It can also be stated that, even with the presence of gaps, door misalignment alone provides an acoustic performance gain.

When comparing the obtained D_{nTw} values with the requirements of NBR 15575:2021 [4] for airborne sound insulation between dwelling units, it is observed that:

- Measurements performed in the no-gap condition (Mf=0 mm) mostly achieved the superior performance level, with $D_{nTw} \geq 55$ dB.
- In conditions with exposed gaps, especially in "aligned doors," many D_{nTw} values fell to intermediate or even minimum levels ($D_{nTw} < 50$ dB in some cases), demonstrating the significant degradation caused by the presence of gaps and the difficulty in meeting higher performance requirements without proper sealing. Tests with "misaligned doors" with gaps, on the other hand, tended to maintain performance at intermediate to superior levels, reinforcing the importance of alignment.

The initial hypothesis of the study, that the average gap size under the doors interferes with the evaluated D_{nTw}, is clearly confirmed by the results. The zero-gap condition (Mf=0 mm), obtained with the use of gap filler, resulted in the highest D_{nTw} values (ranging from 55.5 dB to 61.7 dB), demonstrating the effectiveness of gap treatment in improving acoustic performance. This finding corroborates existing literature that points to the sealing of openings, such as gaps in doors and windows, as a fundamental strategy for sound insulation in environments.

The results of this study offer important insights for improving acoustic performance in buildings. Identifying scenarios that effectively enhance acoustic performance allows civil construction and acoustic engineering professionals to prioritize evidence-based interventions. For example, scenarios that include adjustments to hall doors, specifically their relative positioning and the gaps under their leaves, can be implemented in architectural designs, with a direct impact on user's quality of life.

The combination of gap treatment with door misalignment proves to be the most promising strategy for achieving better acoustic performance results. Planning for displacement between residential unit doors in the design phase can be an efficient initial way to achieve acoustic gains. Furthermore, the use of gap filler under doors stands out as a low-cost, easy-to-apply, and good-performance solution, which can be complemented or replaced by more complex and potentially more effective treatments.

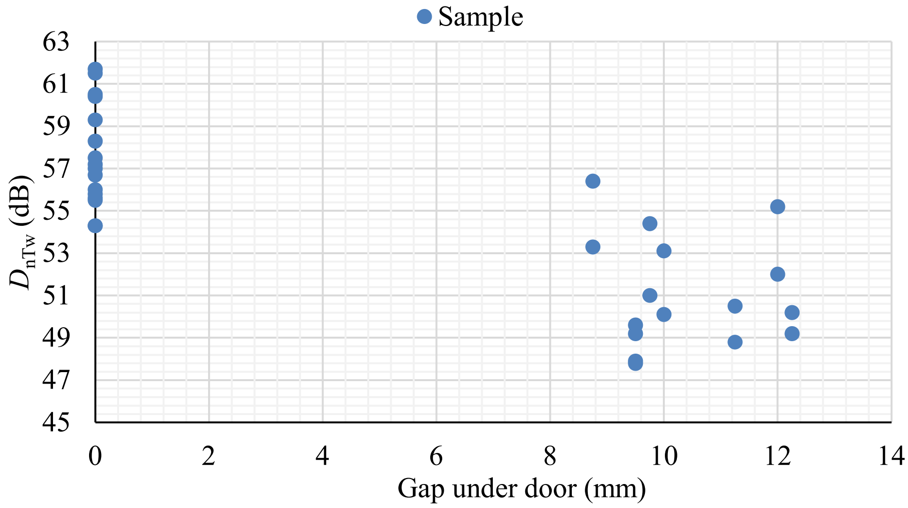

Figure 4: Scatter plot of test results.

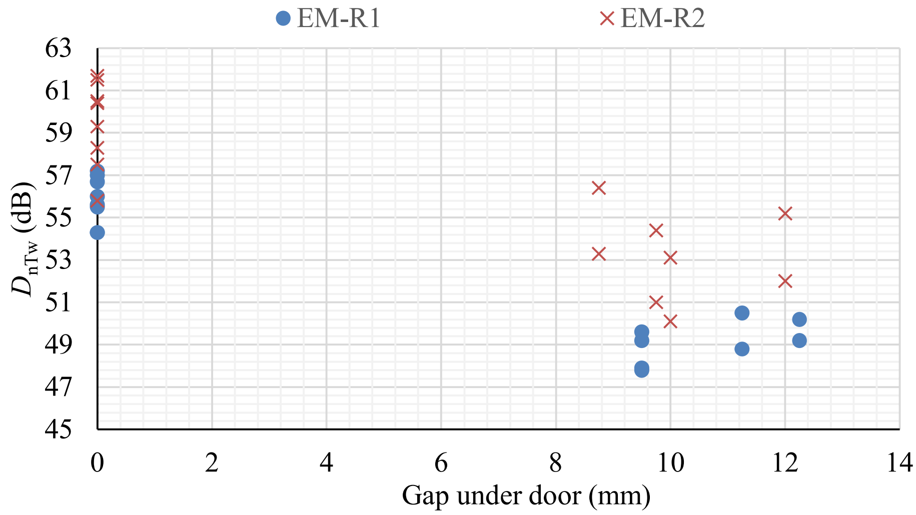

Figure 5: Scatter plot of test results, categorized.

4. CONCLUSIONS

This study investigated the influence of gaps under doors on the acoustic performance of wall and door assemblies separated by entrance halls, confirming the hypothesis that there is a clear relationship between the presence of gaps and the decrease in the D_{nTw} result of the assembly.

The most relevant findings include:

- The effectiveness of gap treatment with gap filler, which elevated acoustic performance to the Superior (S) level of NBR 15575 [1], indicating that low-cost solutions can generate significant gains in acoustic comfort.
- The marked influence of door alignment, where the "misaligned doors" condition consistently showed higher D_{nTw} values than "aligned doors" for the same gap dimensions. This suggests that hall geometry and the relative positioning of doors are crucial factors that can complement gap treatment.

In terms of practical application, the results offer valuable insights for civil construction professionals and acoustic engineers. The research demonstrates that simple interventions, such as the use of gap fillers, and design considerations, such as the misalignment of doors between residential units, can be implemented to enhance the acoustic performance of buildings. These strategies, being low-cost and easy to apply, directly contribute to improving user's quality of life, meeting performance requirements, and promoting more comfortable environments.

For future studies, it is suggested to conduct tests in different hall typologies and buildings to validate and generalize the results obtained in this case study. Computational modeling could also be employed to explore a greater number of scenarios and optimize door and hall configurations for acoustic insulation.

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