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FIELD MEASUREMENT OF SOUND INSULATION IN BUILDINGS AND BUILDING ELEMENTS

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Abstract: In recent years, in science and technology, the idea of controlling sound transmission in buildings has shifted from focusing on individual assemblies such as walls, floors and glass. We live in a noisy world where we are constantly exposed to different kinds of noise, ranging from low to high frequencies. Prolonged exposure to such noises harms the hearing capabilities as well as causing psychological harm to individuals. The International Standard Organization (ISO) has published a calculation procedure, ISO 717-1 and ISO 16283-1, which calculates the expected sound transmission and absorption areas between two adjacent rooms in buildings. This project follows this. The purpose of sound insulation is to reduce noise transmission between adjacent dwellings or rooms and units and between dwellings or units and other areas within the same building. Besides, the absorption coefficient was determined for several materials. The background noise in the receiving room was also measured. The average sound pressure level with the sound sources, generating the sound field in the rooms was measured by Bruel and Kjaer sound level meter accompanied by an omini-directional microphone. The reverberation time was also measured, and the time taken for the peak signal to drop to 30 dB value was regarded according to standard. Sound reduction or the transmission loss was expressed as the difference between average sound pressure levels in the source and receiving rooms plus a term depending on the equivalent absorption area (A). The absorption area was calculated to find the absorption coefficient. The model approach for the primary measurements of building acoustic materials confirmed the significance of such coefficients. According to the results obtained, the wall, wood, and concrete's calculated absorption coefficients were 0.084, 0.03, and 0.0504 within the acceptable limits of standard values (0.06, 0.04 and 0.02). However, the calculated absorption coefficients of tile and glass show a significant variation with the standard values. This new approach would help understand the factors that affect sound transmission within buildings and help reduce unwanted noise.

Keywords: acoustics, reverberation time, sound absorption, sound insulation, transmission lost

1 INTRODUCTION

Lack of sound transmission and insulation in buildings has been identified as an issue, therefore in past years, an increasing interest in building acoustics measurement for different frequencies has been observed. Hence the airborne sound insulation measurement is beneficial, particularly for the Sri Lankan constructional field. Noise sources, sound insulations, reverberation time and controlling the source, were considered according to the British Standard (BS) 8233:2014. It is considered as a part of a set for evaluating the sound-insulating properties of building elements. It is designed to measure sound transmission through a partition or the partition material in a building. The International Standard Organization (ISO) has published a calculation procedure, ISO 717-1 and ISO 16283-1, which calculates the expected sound transmission and absorption areas between two adjacent rooms in buildings. This research was mainly based on the calculation procedures mentioned by ISO standards. This test method still has not been used to evaluate the sound-insulating properties in Sri Lanka. This project covers the building measurement of airborne sound transmission loss of building partitions such as walls, windows, roofs, and sound absorption coefficients of wall, wood, glass, concrete and tile was calculated to compare with the standards. This project aims to calculate the absorption area and compare the sound absorption coefficients of materials used in the construction field in Sri Lanka.

2 PROCEDURE

2.1 ARRANGEMENT OF THE TESTING AREA

Two adjacent building rooms were arranged with an opening between them, in which the material was installed. The minimum volume (v) requirement of each room was 80*m3*. Care was taken that the only significant sound transmission path between rooms was by way of the material. An approximated 30 dB difference, which was later extrapolated to the 60dB sound field, was produced in one room, and it was considered the source room. There were sixteen rooms in two buildings within the Industrial Technology Institute (ITI) premises that were considered to take the measurements**.**

2.2 Data Colletction

The average sound pressure level with the sound sources, generating the sound field in two rooms was measured by Bruel and Kjaer sound level meter. This instrument is a precision sound level meter usually used in acoustics measurement. The maximum 'A' weighted sound pressure level was measured during the test. The background sound level of the receiving room was expected to be more than 10dB. The average sound, pressure levels in the two rooms, space and time, were determined. The sound pressure levels in the two rooms (source and receiving rooms) and the material area were used to calculate sound transmission loss.

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3 DISCUSSION

Sound reduction or the transmission loss was expressed as the difference between average sound pressure levels in the source and receiving rooms plus a term depending on equivalent absorption area (A). The absorption area was calculated in order to find the absorption coefficient as:

$$A = \frac{0.16\,V}{T} \qquad (1)$$

; where *T*- Reverberation time and *V*- Volume of source room

- Finding the absorption coefficients of materials

$$\mathbf{A} = \begin{pmatrix} a_{11} & a_{12} & a_{13} & \cdots & a_{1n} \\ a_{21} & a_{22} & a_{23} & \cdots & a_{2n} \\ a_{31} & a_{32} & a_{33} & \cdots & a_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & a_{m3} & \cdots & a_{mn} \end{pmatrix}$$

Let, x= Absorbance coefficient of the wall
y= Absorbance coefficient of wood
z=Absorbance coefficient of glass
p= Absorbance coefficient of concrete
q=Absorbance coefficient of tile

Then the equations were created as follows: $\boldsymbol{a_{11}x + a_{12}y + a_{13}z + a_{14}p + a_{15}q = b_j}$

Where $\boldsymbol{a_{ij}}$ = the area covered by the above materials separately

$\boldsymbol{i} = 1,2,\ldots,5$ and $\boldsymbol{j} = 1,2,\ldots,16$ and $\boldsymbol{b_j} =$ the total absorption area

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Since sixteen rooms considered as our sample, there were sixteen equations as above. Then the matrix A was created using as the elements. Since there are sixteen equations and only five variables, the solutions are inconsistent. To avoid this problem, we have to use the least square optimization to determine the variables` values. The sound absorption coefficients of materials can be calculated as follows:

$$\underline{X} = (A^T A)^{-1} A^T . b \qquad (2)$$

The obtained sound absorption coefficients were compared with the standard values.

Table 01. Comparison of absorption coefficients of the materials with the standards

Material	**Standard value**	**Calculated value**	**Absolute error**
Wall	0.06	0.084	0.024
Wood	0.04	0.03	0.01
Glass	0.03	-0.1419	0.1719
Concrete	0.02	0.0504	0.0304
Tile	0.07	0.1029	0.0329

- According to the results obtained, the calculated absorption coefficients of wall, wood, glass, and concrete and floor tile were 0.0660, 0.0768, 0.0205, 0.0338 and 0.0125 which show some deviation from the standard values.
- However, they are acceptable considering that the exact specific material's sound absorption values (e.g. Jack wood or brick wall with plaster) could be different to those cited in literature.
- Sound absorption coefficients were measured assuming that the sound absorption of small objects and human body were negligible.

4 Conclusion

According to the results obtained, the wall's calculated absorption coefficients, wood and concrete were 0.084, 0.03 and 0.0504, which show some deviation from the standard values. However, they are acceptable considering that the exact specific material's sound absorption values (e.g. Jack wood or brick wall with plaster). However, the calculated absorption coefficients of tile and glass show a significant variation with the standard values. Sound absorption coefficients were measured, assuming that small objects' sound absorption and the human body were negligible. The variations in calculating values with the standard values could have been caused due to such assumptions that have been made. This study would help understand the factors that affect sound transmission within buildings and thereby help reduce unwanted noise.

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