Airborne sound insulation evaluation and flanking path prediction of coupled room

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Abstract. One of the parameters to review the acoustic comfort is based on the value of the insulation partition in the classroom. The insulation value can be expressed by the sound transmission loss which converted into a single value as weighted sound reduction index ($R_w, DnT_w$) and also have an additional sound correction factor in low frequency ($C, C_{tr}$). In this study, the measurements were performed in two positions at each point using BSWA microphone and dodecahedron speaker as the sound source. The results of field measurements indicate the acoustic insulation values ($DnT_w + C$) is 19.6 dB. It is noted that the partition wall not according to the standard which the $DnT_w + C > 51$ dB. Hence the partition wall need to be redesign to improve acoustic insulation in the classroom. The design used gypsum board, plasterboard, cement board, and PVC as the replacement material. Based on the results, all the material is simulated in accordance with established standards. Best insulation is cement board with the insulation value is 69 dB, the thickness of 12.5 mm on each side and the absorber material is 50 mm. Many factors lead to increase the value of acoustic insulation, such as the thickness of the panel, the addition of absorber material, density, and Poisson's ratio of a material. The prediction of flanking path can be estimated from noise reduction values at each measurement point in the class room. Based on data obtained, there is no significant change in noise reduction from each point so that the pathway of flanking is not affect the sound transmission in the classroom.

1. Introduction
Nowadays, the design of the building for the most part have already consider in some aspects. Acoustic comfort is one that should be considered because basically the building constructed on a specific function. There are some acoustic factors that can be considered in the design of a building, one of which is the transmission loss. Transmission loss declare that the amount of some energy is lost because the sound waves pass through a barrier[1]. The value of transmission loss measured in a certain frequency range and this value can be obtained from the following equation[2]. According to the regulations European standard, ie EN ISO 717-1[3] the value of transmission loss can be calculated per frequency in a certain range and will be transformed into a single value that is weighted sound reduction index ($R_w, DnT_w$) and also have an additional sound correction factor in low frequency ($C, C_{tr}$). The higher $DnT_w + C$'s value, made the higher ability of a partition to muffle the sound. $DnT_w$ value obtained using the following equation[4]. Frequency range used in this measurement is in the range of 100-3150 Hz (1/3 octave frequency band)[5]. The way to measure isolation between the couple room has been standardized in ISO 140-4[6]. The objective of this paper is to measure sound insulation between two class rooms of UPT Bahasa building in Sepuluh Nopember.
Nopember Institute of Technology. In this paper will provide an evaluation of the type of material used in the partition wall by performing simulations and design calculations based on the single value of sound insulation (DnT+C) and also predict the flanking path in the classroom based on the noise reduction at each point of observation. The simulated material serves as an insulator and must follow the requirements in terms of weight, density, elasticity, and the principle of isolation [7]

2. Numerical Methods
The study starts with determining the existing condition of the partition wall in the classroom which consisting of plywood 12mm on each side and the width of cavity is 66 mm with the size of classrooms 5.97 x 3.97 x 3 meters. Measurements were performed at 4 symmetrical points and 5 points randomly in classrooms.

![Figure 1](image)

**Figure 1.** The sketch of classrooms in two position measurement where the requirements are in the ISO 140-4 standard (at least 0.7 m between the microphone, 0.5 m between the boundary of the room and at least 1 m between the source) (a) The Symmetrical position (b) A random position

Sound source (dodecahedron) raised the high volume and placed in the middle of the room in order to get the diffuse sound area. Sound Pressure Level in the source room is measured with a BSWA microphone connected to the soundcard BSWA where the height of the microphone 1.2 m from the floor as high as the sound source. Measurements performed twice for each predetermined point. Then the parameters will be calculated in a single value (DnT+C). The calculation is performed on a 1/3 octave band frequency between 100 Hz and 3150 Hz. To obtain a single value DnT+C, the value of DnT in the field compared to the reference curve. DnT value at a frequency of 500 Hz is used as a reference in the shifting of the value in reference curve. The results were compared with the terms specified in the European standard that is equal DnT+C > 51 dB. If the insulation value of the existing wall does not qualify the standard, it will be simulated in the selection of materials that include the standards. From the results of the design, the insulation value of the simulation will be compared again with the specified standard. As for predicting the path flanking the classroom, predicted from the amount of noise reduction at observation points in both classroom.
3. Results and Discussion

Based on the graph, it can be seen that the performance of a partition wall which represented by the value of DnT is still far below the reference curve so that the reference curve should be shifted down by 31 dB. The final result of both calculation is $D_{nT} + C = 19.6$ dB. This means that the partition wall of classrooms still does not meet the standards because the result is less than 51 dB. Hence, it takes the partition walls with a good sound insulation accordance with the minimum requirements specified standard. Before selecting material, existing partition is simulated according to the actual design of the classroom. This following is the simulation of existing partitions using AFMG SoundFlow software:

![Simulation of existing partitions using AFMG SoundFlow software](image1)

**Figure 3.** Comparison between DnT curve and reference curve of plywood material based on simulation with material specification; thickness 12 mm; density 800 Kg/m$^3$; young’s modulus 12 GPa; poisson ration 0.06; bending loss factor 0.02

Figure 3 show that the insulation value on the simulation (DnT) is approximately 21 dB, while the on-site measurements the insulation value (DnTw + C) is 19.6 dB. The value obtained is still within range
of the measurement boundary between measurements in the field (on-site) and measurements in the laboratory. The results of direct measurements is permitted to be worth 5 dB lower than the value of Rw. The design of simulation using gypsum board, plasterboard, cement, and PVC as the material of change for the partition walls. From the result, gypsum board material obtain the insulation value is worth 59 dB. Second, using plasterboard with insulation value is worth 65 dB. Then on the third design by using material cement board the insulation value is worth 69 dB. Lastly, the design obtained by using PVC the insulation value is worth 60 dB. Based on those values, every designs of the materials has already include the standard. The best insulation material owned by cement board. The following is a comparison of DNT curve and reference curve of cement board material:

![Figure 4. comparison between DnT curve and reference curve of cement board material](image)

**Figure 4.** comparison between DnT curve and reference curve of cement board material based on simulation with material specification; thickness 12.5 mm; density 2000 Kg/m$^3$; young’s modulus 20 Gpa; poisson ratio 0.23; bending loss factor 0.01

Considering that the incoming transmission apart from transmission through the partition wall (flanking) can be seen from the value of noise reduction from some of observation points in both classrooms. The following is the graph of noise reduction in the class room of UPT Bahasa:

![Figure 5.](image)

**Figure 5.** show the graph of noise reduction at two points in symmetrical position, parallel between the source and receiving room.

The comparison of noise reduction at point one and two in both room each worth 23.27 dB and 23.19 dB. While the value of noise reduction at point three and four each worth 24.66 dB and 23.51 dB. Based on the noise reduction of each point, the incoming transmission apart from transmission through
the partition wall (flanking) is not significant that the prediction flanking paths do not occur on the side wall in the classroom.

4. Conclusion
The insulation value (DnTw + C) of the partition walls in the classrooms worth 19.6 dB and does not meet the existing standards, so it necessary to redesign in order to improve the performance of acoustic insulation in the classroom. The best insulation value from the design is the third design using cement board material. The insulation value of this material is worth 69 dB. Based on the noise reduction of each point in measurement, the prediction of flanking paths in UPT Language neither too significant nor give an impact in the classroom.

5. References
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