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Identification of noise in room due to HVAC system

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ABSTRACT – This paper presents noise measurement and noise mapping for two lecture rooms. The results reveal that the background noise level of the empty lecture rooms has exceeded the recommended limit by ANSI 12.2-2008 [1], i.e. above 35 dB(A) due to excessive noise radiated from the structure-borne source coming from the VAV system above the ceiling. Two lecture rooms at the Kampus Teknologi in Universiti Teknikal Malaysia Melaka were used as the case study.

1. INTRODUCTION

Heating, ventilation, and air conditioning system (HVAC) are major sources of interior noise in a building. Vibration from the fan and motor may be transmitted into the structure of the building via transmission along the steel ducts and their hangers and support. The vibration transmitted may activate the building structure to generate noise which causes discomfort and also create secondary radiation of noise from vibrating panels, floors, and roof inside the building [2].

For any learning environment, control of acoustical quality in the room can be divided into three schemes: a) limit transmission of noise from outside the classroom, b) minimize the background noise from the building's HVAC systems, and c) reduce the reverberation time inside the classroom [3]. According to ANSI 12.2-2008, the background noise level of an unoccupied lecture halls and classrooms (volume < 2000 ft^3) should not exceed sound level of 35 dB(A). Excessive background noise level will decrease intelligibility of speech which can affect the understanding of students and uncomfortable for teaching and learning.

Two lecture rooms and one office room at the Technology Campus in Universiti Teknikal Malaysia Melaka were used as the case study. Measurements were carried out for comparison to show the difference of sound pressure levels (SPL) in both room.

2. NOISE MEASUREMENT

The measurement was carried out at two identical lecture rooms on the first floor at Technology Campus in Univerisiti Teknikal Malaysia Melaka. The rooms are located side-by-side separated by gypsum board partition. A variable air volume (VAV) box is located above the ceiling in Room-1 as shown in Figure 1. A VAV box is used to regulate the volume of the air by opening or closing the damper, controlling the air flow to a specific zone. A regular VAV box consists of a motor fan which is triggered to supply air into specific area.

Figure 1 Ventilation layout above the ceiling in Room-1.

The dimension of each room is 70 m^2 and was divided into 135 grids area for the measurement points The sound pressure measurement used RION NA-28 sound level meter calibrated with RION NC-74 sound calibrator. The noise measurement was taken when the lecture room was empty. The microphone is placed at listening position for a person sitting on a chair, roughly 1 m from the floor and not less than 0.03 m from the room walls. Measurement time for each measurement point was set to be 1 minute long. According to Guedes et al. [4], 30 seconds were sufficient to describe the noise events that required observation in their study.

3. RESULT AND DISCUSSION

The SPL in Room-1 taken from 135 measurement points are presented in 2-D contour maps as shown in Figure 3. Figure 3 shows the A-weighted SPL indicating that the background noise level in the lecture room has exceeded the ANSI 12.2-2008 limit of 35 dB(A). The most concentrated area is found to be below the location of the VAV box above the ceiling. It can be seen that this area has noise level at maximum of 60 dB(A). Meanwhile the remaining area can be observed to have an average noise level of 55 dB(A). Strong, rumble-like noise can be heard subjectively in the room, but it is rather difficult to locate the source due to the nature of the low frequency. The VAV box above the ceiling is suspected to transmit the structure-borne noise and also indirect air-borne noise to the classroom.

Measurements in Room-2 were also performed for comparison, and because the low frequency noise level was observed to be subjectively lower than that in Room-1. The A-weighted noise level shown in Figure 4 also shows that the noise level in the lecture room (Room-2) also exceeds the ANSI 12.2-2008 limit of 35 dB(A). This is due to airborne noise from the air flow at the ventilation which is dominated at higher frequencies [5].

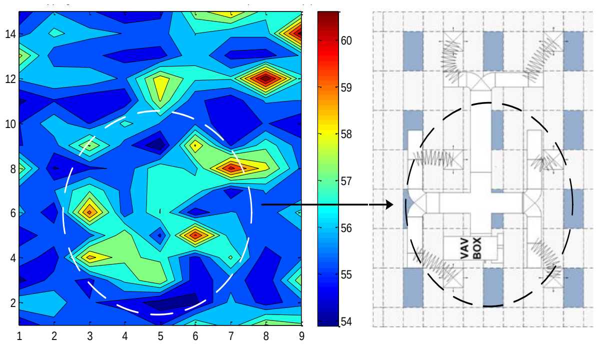

Figure 3 Mapping of SPL (dB(A)) in Room-1 corresponds to the HVAC-layout.

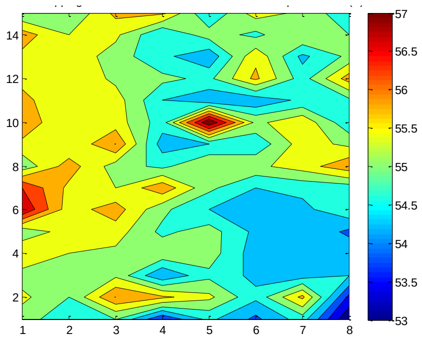

Figure 4 Mapping of SPL (dB(A)) in Room-2.

Figure 5 plots together the measured SPL in Room-1 and Room-2. It can be seen that Room-1 is dominated by low frequency noise below 500 Hz having 5 dB differences with SPL from Room-2. Above this frequency, Room-1 and Room-2 have almost the same SPL with 1-3 dB greater SPL for Room-2. Figure 6 again plots together the dB(A) noise distribution in Room-1 and Room-2 now with the same noise level indicator bar. It can be clearly seen that Room-1 has more concentrated noise areas compared to Room-2. The noise contour in Room-2 can be seen to have more uniform colour because the variability of the noise level in dB(A) is smaller than that in Room-1.

As already shown in Figure 6, background noise in Room-1 comes from the radiated noise from the vibrating VAV box. ‘Rumble’-like noise can be subjectively heard in this room which is a nature of a low frequency noise.

4. CONCLUSIONS

Noise measurements to identify the structure-borne noise level in lecture rooms have been conducted. The rooms have been found to have the noise level to exceed the recommended maximum background noise level of 35 dB(A) as in ANSI-12.2(2008). However, Room-1 has been identified to have dominant low-medium frequency content due to the structure-borne noise from the fault VAV unit above the ceiling. The noise is considered to be marginal (roar in nature), but is still acceptable for Room-2, where here the high frequency content is dominant mainly due to the noise from the air conditioning duct ventilation.

Assessment can be more accurate and of interest if vibration measurement can be made on the VAV unit and the ODS of the whole body of the unit, including the hanger rods can be obtained to observe the nature of the vibration mode transmitting the vibration wave to the above floor.

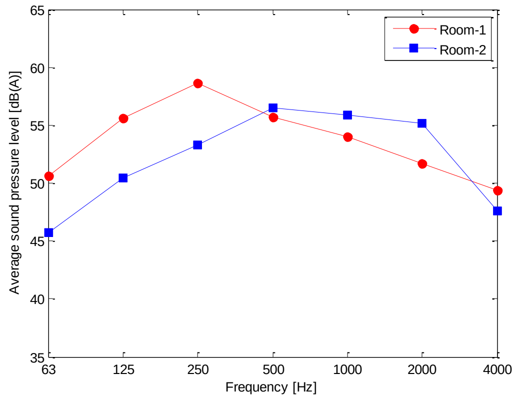

Figure 5 Average SPL in octave band frequencies.

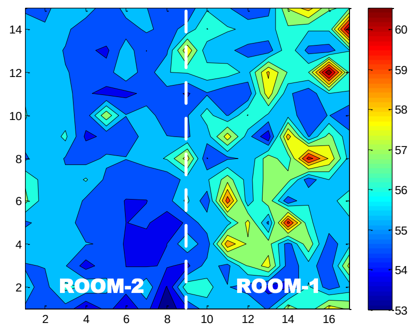

Figure 6 Mapping of SPL (dB(A)) in Room-1 and Room-2.

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