MEASUREMENT OF FIELD SOUND TRANSMINSSION LOSS OF BLOCKWALL PARTITION BETWEEN TWO ROOMS OF A TOWER IN JAKARTA

PENGUKURAN LAPANGAN RUGI-RUGI TRANSMISI SUARA UNTUK PARTISI BLOCKWALL ANTARRUANG PADA SEBUAH GEDUNG DI JAKARTA

Maharani Ratna Palupi and Denny Hermawanto
Research Center for Metrology, Indonesian Institute of Science (LIPI)
Complex of Puspiptek Building 420, Serpong, Tangerang Selatan 15314
maharani.rp@gmail.com

ABSTRACT

A field sound transmission loss measurement to obtain the field sound transmission class (FSTC) from partition between two rooms on the 27th floor of a tower in Jakarta was conducted in April 2017. Method that used in this measurement refered to ISO 140 Acoustics–Measurement of sound insulation in buildings and of building elements. The measurement graph showed that, although the trend indicates an increase, but the graph shape like saw tooth shape that indicates sound leakages. This measurement yielded 41 dB for the FSTC rating, which is considered far from the previous expectation, about 50 dB. After further analysis, it was found that the most dominant sound leakage was contributed by flanking noise via ducting works.

Keywords: field sound transmission loss measurement, field sound transmission class, FSTC, sound leakage.

ABSTRAK

Telah dilakukan pengukuran rugi-rugi transmisi suara di lapangan (Field Sound Transmission Loss) untuk mendapatkan nilai kelas transmisi suara di lapangan (Field Sound Transmission Class, FSTC*) pada partisi antarruang di lantai 27 pada sebuah gedung di Jakarta pada bulan April 2017. Metode pengukuran yang dilakukan merujuk pada ISO 140 Acoustics–Measurement of sound insulation in buildings and of building elements. Grafik hasil pengukuran memperlihatkan bahwa meskipun menunjukkan adanya kecenderungan naik, namun berbentuk seperti gigi gergaji yang mengindikasikan adanya kebocoran suara. Nilai* FSTC *sebesar 41 dB yang dihasilkan dari pengukuran ini dinilai jauh dari harapan sebelumnya, yaitu 50 dB. Setelah dilakukan analisis lebih lanjut, didapatkan bahwa kebocoran suara paling dominan disumbangkan oleh bising dari saluran perpipaan. .*

Kata kunci: *pengukuran rugi-rugi transmisi suara di lapangan, kelas transmisi suara di lapangan*, FSTC, *kebocoran suara*

A. INTRODUCTION

The field sound transmission loss measurement and determination of field sound transmission class (FSTC) were carried out at a tower by Metrology of Acoustic and Vibration Subdivision, Research Center for Metrology LIPI in April 2017. The measurement had been performed following the procedure I.MA.4.01 that refers to ISO 140: Acoustics–Measurement of sound insulation in buildings and of buildings elements, ISO 717: Acoustics–Rating of sound insulation in buildings and of building elements, ISO 354: Acoustics–Measurement of sound absorption in a reverberation room, ASTM E90: Laboratory measurement of airborne sound transmission of building partition and elements, and ASTM E413: Classification for rating sound insulation. This measurement was based on request of the owner of tower to obtain a measured FSTC value on the interconnecting wall of the rooms and then compared with the specification of the interconnecting wall that said its Sound Transmission Class (STC) value is 55 dB STC which theoretically is equivalent to 50 dB FSTC. The measurement result for FSTC value was obtained 41 dB. This value is considered too far from expectation value, i.e. 50 dB. Thus, further analysis is needed to find out anything that affected the measurement result in the field at measurement time.

B. BASIC THEORY

1. Evaluating the Sound Transmission Loss (STL) and Determining the Sound Transmission Class (STC)

The sound reduction index (or sound transmission loss) is evaluated from ISO 140: Acoustics–Measurement of sound insulation in buildings and of buildings elements (n.d.).

$$R = L_1 - L_2 + 10\log\frac{S}{A} \tag{1}$$

where:

L_1 : the average sound pressure level in source room (dB)

L_2 : the average sound pressure level in receiver room (dB)

S : the area of the test specimen (m^2)

A : the equivalent sound absorption area in the receiver room (m^2)

The equivalent sound absorption area is evaluated from the reverberation time measured according to ISO 354 and determined using Sabine's formula: (ISO 354: Acoustics–Measurement of sound absorption in a reverberation room, n.d.).

$$A = \frac{0{,}16V}{T} \tag{2}$$

where:

V : the receiver room volume (m^3)

T : the reverberation time di the receiver room (seconds)

Therefore, the equation (1) should be:

$$R = L_1 - L_2 + 10\log\frac{ST}{0{,}16V} \tag{3}$$

The results from equation (3) should be plotted in a curve called measurement curve. This measurement curve is then compared with the reference curve. Reference curve (Figure 1) is a curve plotted based on the reference values shown in Table 1.

Table 1. Reference Values for Airborne Sound

Frequency (Hz)	125	160	200	250	315	400	500	630
Reference Value (dB)	36	39	42	45	48	51	52	53
Frequency (Hz)	800	1000	1250	1600	2000	2500	3150	4000
Reference Value (dB)	54	55	56	56	56	56	56	56

Source: ASTM E-413. Classification for Rating Sound Insulation

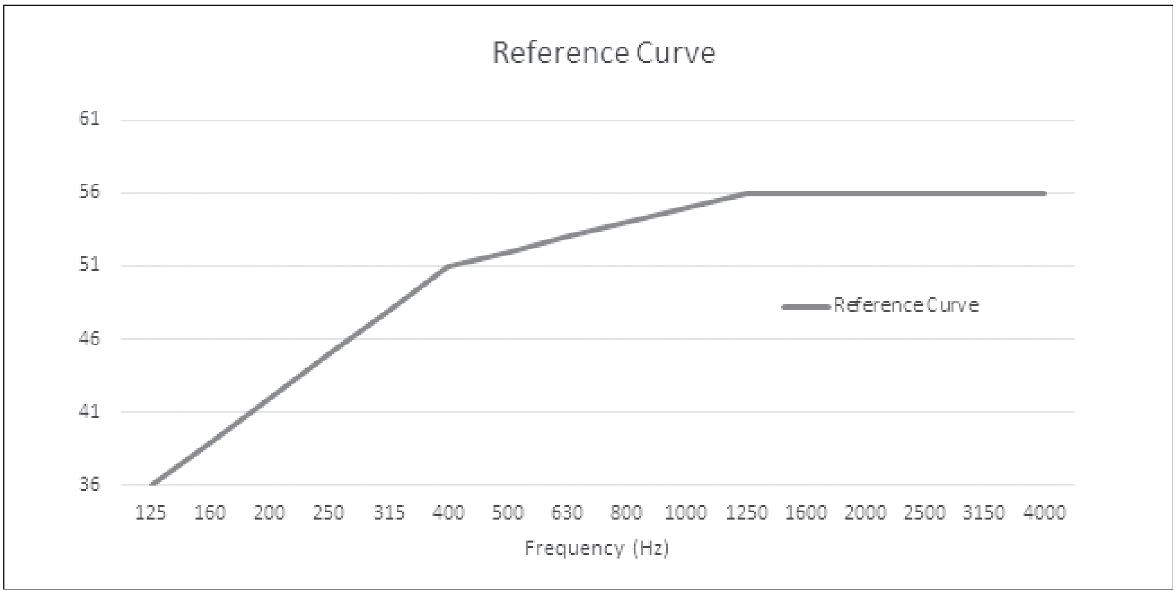


Figure 1. Reference Curve for Airborne Sound

The reference curve is shifted in steps of 1 dB towards the measurement curve until the mean unfavorable deviation, calculated by dividing the sum of unfavorable deviations by the total number of measurement frequencies, is as large as possible, but not more than 2.0 dB. After shifting the reference curve, the value at 500 Hz of reference curve is the value of STC rating (ISO 717: Acoustics–Rating of sound insulation in buildings and of building elements–Part 1: Airbone sound insulation, n.d.).

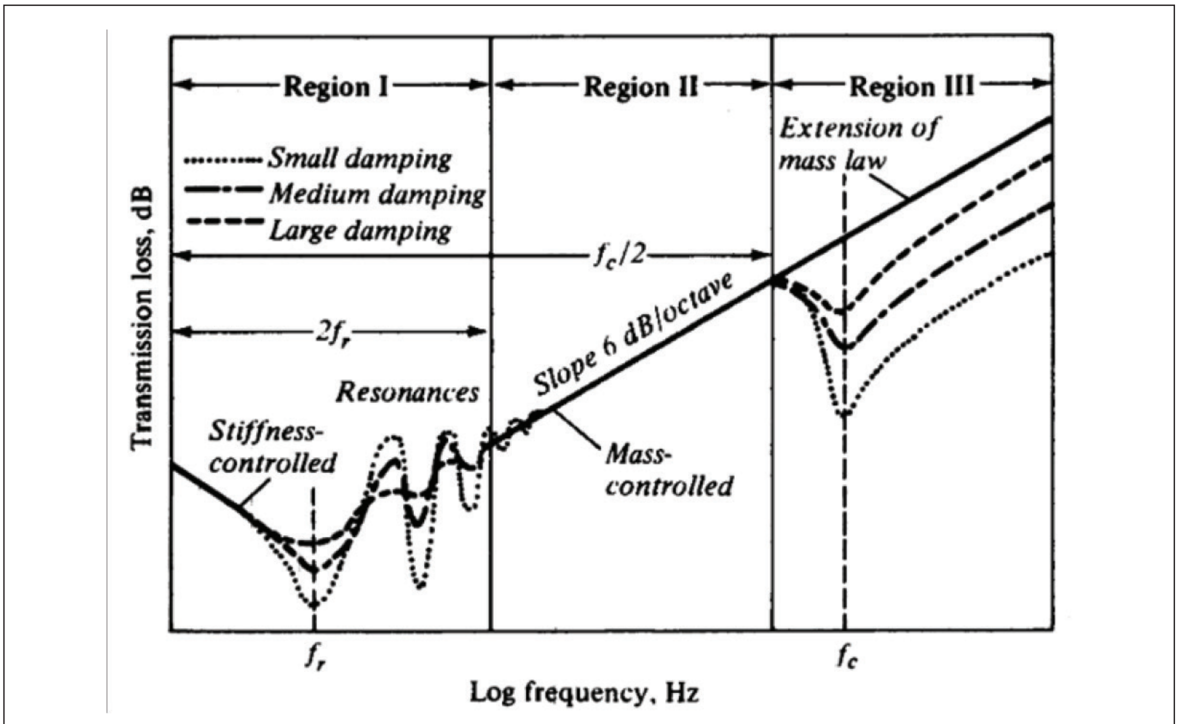
There are two measurement methods for determining the STC rating of a specimen, i.e. in laboratory measurement and on site measurement also called field measurement. Principally, data retrieval steps are the same, and the result of the field measurement is called field sound transmission loss and field sound transmission class (FSTC). Sound transmission class measured in the field is generally less than that obtained in the laboratory. A 5 dB difference in STC's can be expected between field and laboratory measurements (Kinsler, 1982).

2. Transmission Through Panel (Lamancusa, 2000)

STL are highly dependent on frequency. The STL behavior can be divided into three basic regions. In Region I, at the lowest frequencies, the response is determined by the panel's static stiffness. Depending on the internal damping in the panel, resonances can also occur which dramatically decrease the STL.

In Region II (mass-controlled region), the response is dictated by the mass of the panel and the curve follows a 6 dB/octave slope. Doubling the mass, or doubling the frequency, results in a 6 dB increase in transmission loss.

In Region III, there is a certain frequency at which the speed of sound in air equals to the speed of sound in the panel. Thus, a resonance occurs at this frequency. This phenomenon is called coincidence and at this frequency the STL is decrease.



Source: Lamancusa, 2000

Figure 2. Theoretical Transmission Loss for An Infinite Homogeneous Panel

3. Sound Transmission in Buildings

When sound travels through a partition between rooms this is known as direct transmission, however, the overall level of sound transmission is not governed simply by the insulation of the intervening partition. It is critical to consider the surrounding structure through which sound energy may travel—the leakage of sound through this path is known as flanking transmission. Areas that typically deliver the sound leakage in commercial buildings are: (Acoustics in Buildings, n.d.)

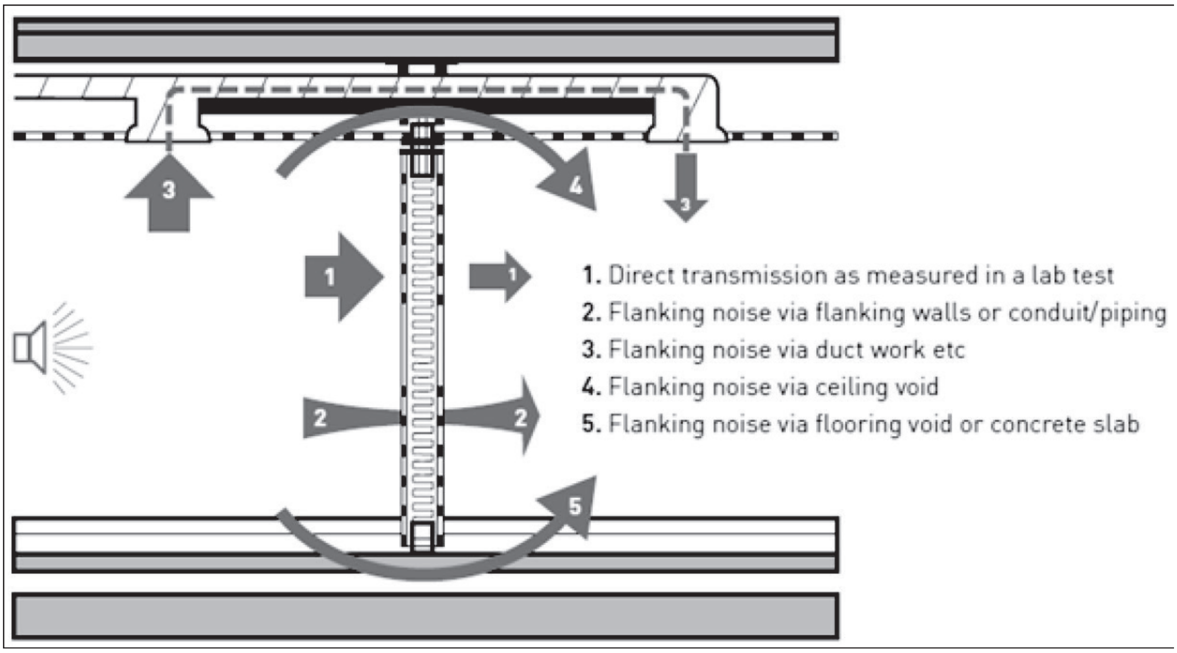
a) Abutting Walls, window mullions and columns.
b) Continuous suspended ceilings, access panels and common voids.
c) Continuous raised access floors and common voids.
d) Continuous perimeter piping or conduit systems.
e) Ventilation grills and connected ductwork and air diffusers
f) Doors common to corridors

The importance of restricting flanking transmission cannot be over stated. Areas of weakness can have a disproportionately negative effect on overall performance in walls where a high decibel rating is specified.

Wall design is principally concerned with ensuring high acoustic performance for minimal thickness, minimal weight and minimal cost. It is not easy to simultaneously meet all these conditions and therefore close attention to design is required. The acoustic performance of wall systems is generally improved by substituting either thicker/heavier wall systems or substituting systems with larger cavities and moderate cladding thicknesses. To minimalize weight, some heavy single-leaf wall systems can be replaced by lightweight constructions using thinner leaves of material and insulation filled cavities. To control noise transfer, it is good design practice to extend walls to full-height, from slab to soffit, or slab to roof. Wall partitions should be selected which allow for a margin of safety in the construction to reduce the risk of non-compliance (Australian Building Codes Board, 2016).

C. EQUIPMENT SETUP AND MEASUREMENT CONDITION

The required equipment for measuring the field sound transmission loss and the equipment setup is shown in Figure 4.



Source: Acoustics in Buildings, A Guide to The Specification of Movable Walls, n.d.

Figure 3. Sound Transmission in Buildings

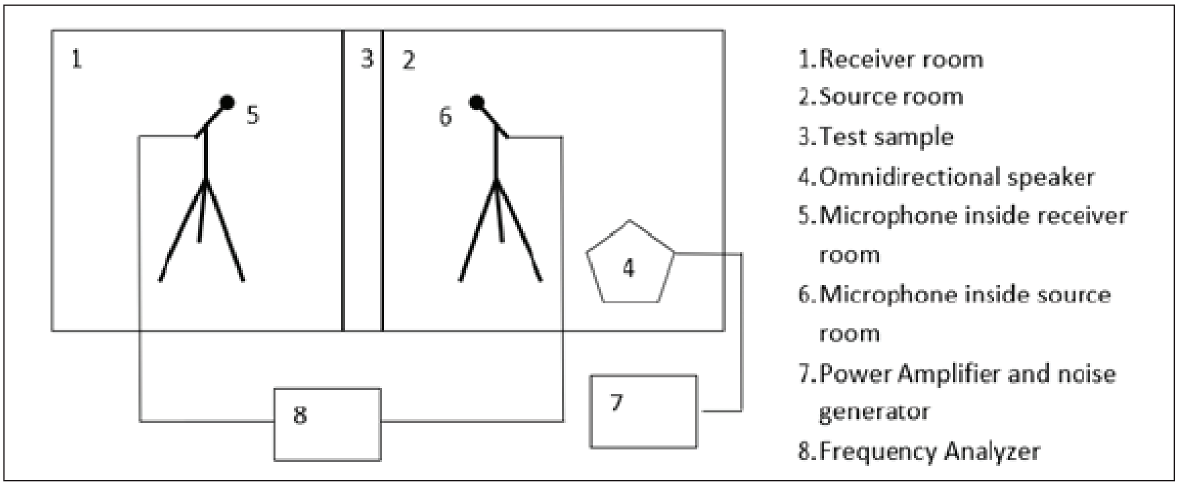


Figure 4. Equipment Setup

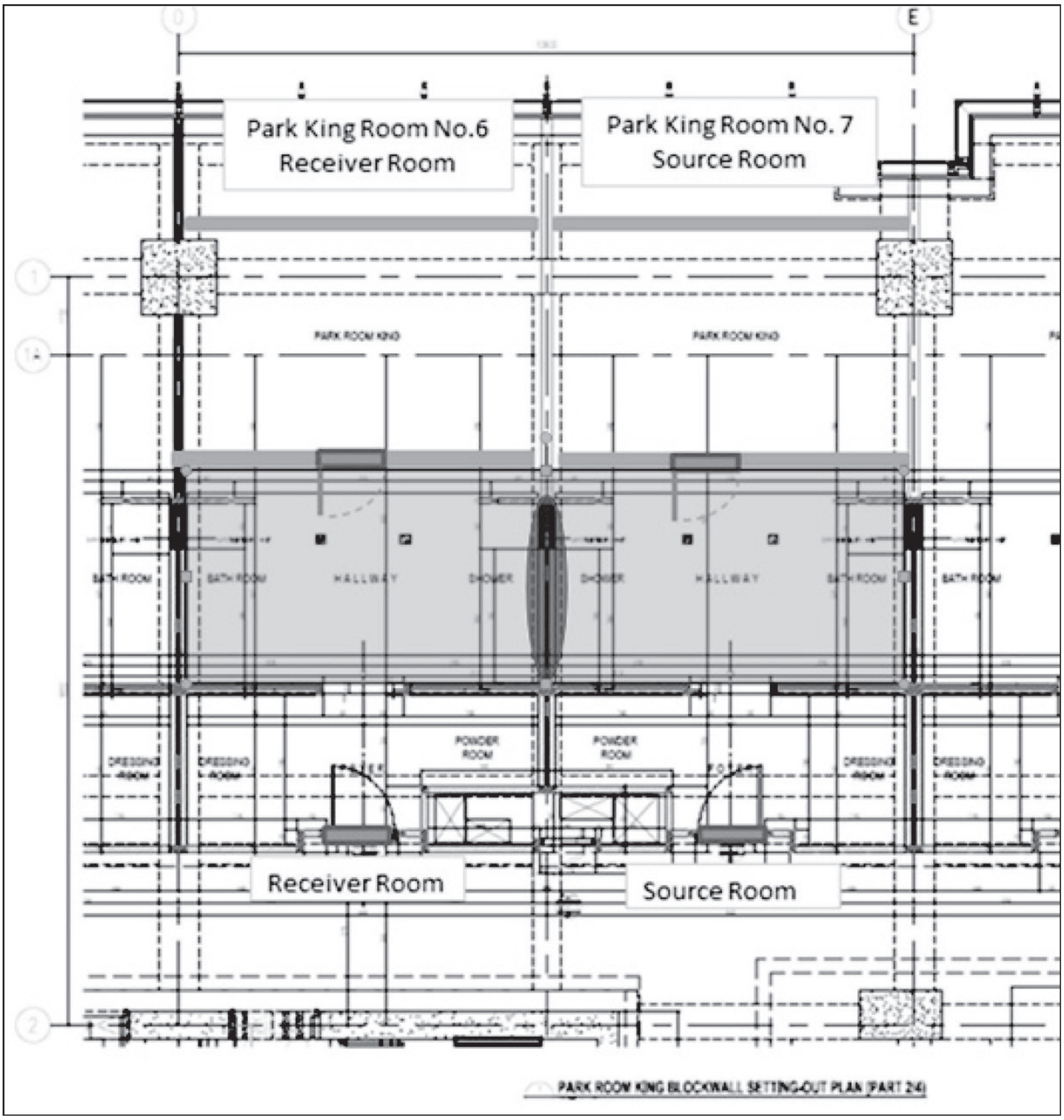


Figure 5. Measurement Location. The blue area is the measurement taken place and the red area is the sample (Blockwall).

Measurement was conducted at Park King Room 6 and Room 7 on the 27th floor at a tower in Jakarta. The test sample was a wall called Blockwall separator between two shower-rooms. It consisted of two layer of 100 mm autoclaved aerated concrete that separated by 50 mm of 60 kg/m^3 rockwool and plaster finishing at both outer surfaces. Measurement location and the position of sample are shown in Figure 5, and the configuration of Blockwall is shown in Figure 6.

D. MEASUREMENT DATA AND CALCULATION RESULT

The data of this measurement is shown in Table 2, information of room and sample dimension is shown in Table 3, calculation result is shown in Table 4, and the graph of measurement result and the FSTC value is shown in Figure 7.

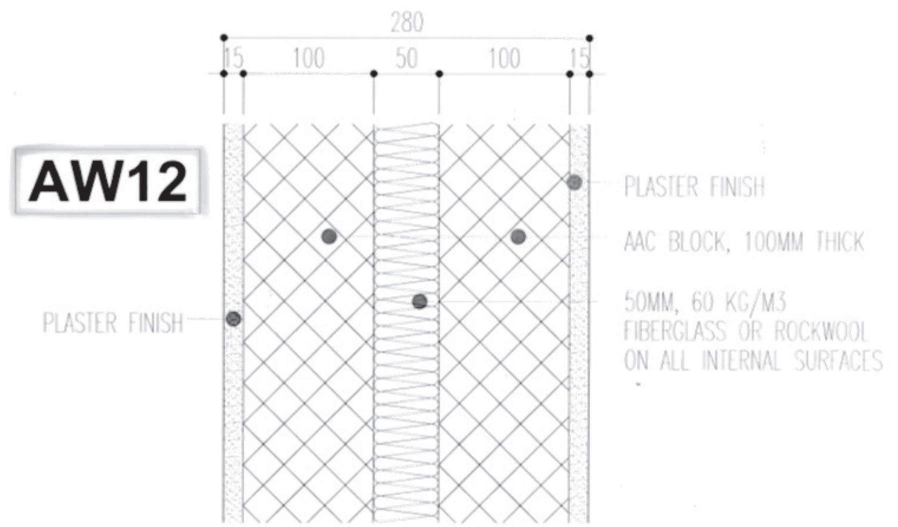


Figure 6. The Configuration of Blockwall

Table 2. Measurement Data

Frequency	Average SPL (dB)		Background Noise	Average Reverberation
(Hz)	Source	Receiver	At Receiver (dB)	Time at Receiver (sec)
125	85.42	57.50	39.10	1.87
160	89.34	61.29	42.60	2.47
200	88.59	61.06	48.90	2.00
250	87.58	59.66	41.80	2.20
315	86.66	56.24	41.20	2.05
400	88.09	54.25	40.30	1.92
500	83.52	50.65	40.40	1.90
630	83.08	47.68	40.20	1.76
800	82.23	43.69	35.10	1.60
1000	80.03	42.52	33.20	1.58
1250	83.42	41.75	29.20	1.58
1600	83.47	42.39	23.90	1.62
2000	84.28	40.84	18.60	1.52
2500	83.44	38.46	15.20	1.51
3150	85.42	38.08	13.00	1.46
4000	84.40	33.97	11.30	1.36

Table 3. Dimension Information

Parameter	Source Room	Receiver Room	Partition
Length (m)	5.14	5.14	NA
Width (m)	3.01	3.01	2.73
Height (m)	3.5	3.5	2.83
Volume (m^3)	54.1499	54.1499	NA
Area (m^2)	NA	NA	7.7259

Table 4. Calculation Result of Field Sound Transmission Loss

Frequency (Hz)	125	160	200	250	315	400	500	630
STL (dB)	30.1	31.5	30.0	30.9	33.0	36.2	35.2	37.4
Frequency (Hz)	800	1000	1250	1600	2000	2500	3150	4000
STL (dB)	40.1	39.0	43.2	42.7	44.8	46.3	48.5	51.3

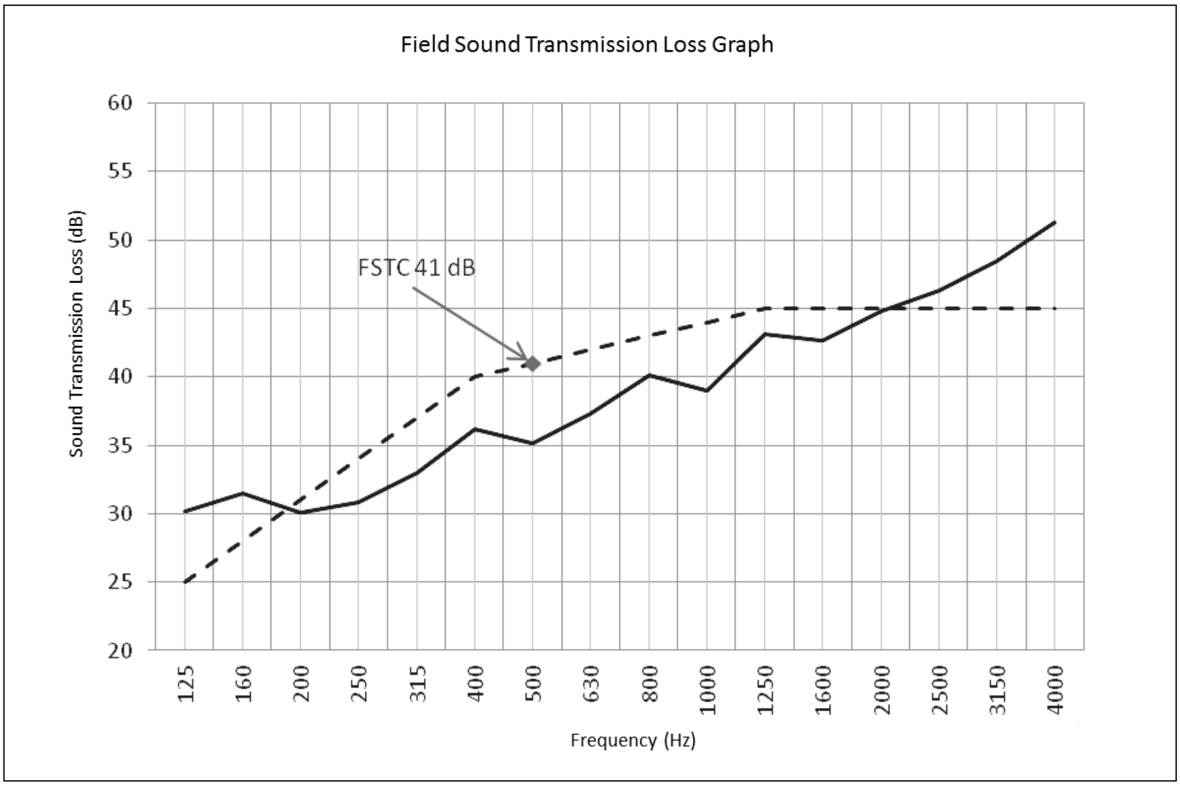


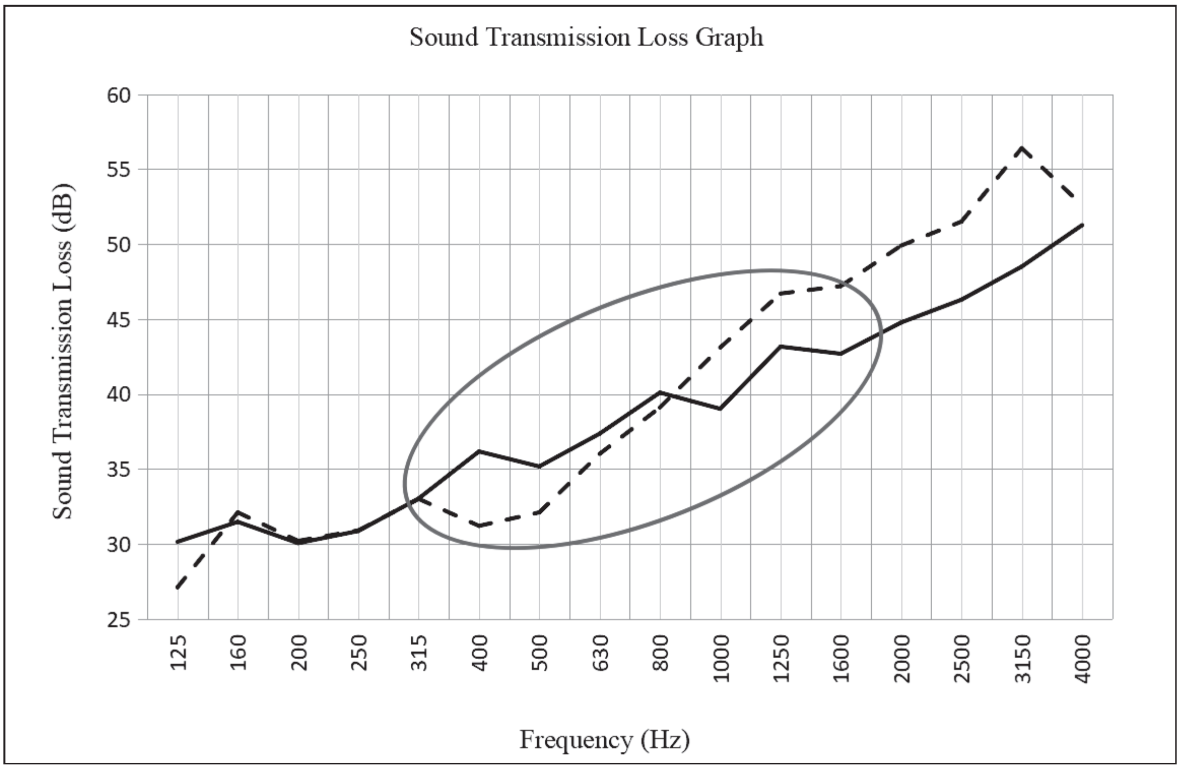
Figure 7. Measurement result graph (solid line) and the reference curve (dash line) that already shifted toward the measurement graph. At 500 Hz, the reference curve value is 41 dB. This value is the FSTC of the sample.

E. ANALYSIS

1. Measurement Result Analysis

In 2011, a test of sound transmission loss for an unfinished single layer of 100 mm autoclaved aerated concrete (AAC) wall had been undertaken. The sound transmission loss result compared with the Blockwall's measurement result can be shown in Figure 8 (Puslit KIM LIPI, 2011). STC rating of an unfinished single layer of 100 mm AAC wall is 40 dB.

Solid line in Figure 8 is the field sound transmission loss graph of Blockwall and dash line is the sound transmission loss graph of an unfinished single layer of 100 mm AAC.



Source: Puslit KIM LIPI, 2011

Figure 8. Sound Transmission Loss Graph of Block Wall (Solid Line) and of An Unfinished Single Layer of 100 mm AAC Wall (Dash Line)

Focusing to the area within the red boundary, this area should be in the region II which is the mass-controlled region. The graph shape of an unfinished single layer of 100 mm AAC followed the theory, but not the graph shape of Blockwall. Normally, the graph will be similar in trend because the material of Blockwall consists two layer 100 mm AAC. Moreover, with inserting of 60 kg/m^3 rockwool among them, theoretically the higher measurement result will be obtained (Lamancusa, 2000).

Ideally, the curve followed the mass law. The tooth shape curve indicating that there is sound leakage happened. There was no gap on the Blockwall, so, the leakage causing the gap at Blockwall is small in possibility. Thus, it needs other analysis such as measurement location analysis to find out the cause of the leakage.

2. Measurement Location Analysis

Considering the sound leakage can also be caused by other things than the sample installation. It is necessary to analyze the things that may caused sound leakage, such as wall height and the possibility of flanking. As seen in Figure 5, the shape of source and receiver room are the same, but mirroring. Thus, the conditions inside both rooms are identical. Figure 9 shows the measurement testing area, focuses on an area inside the red boundary zoomed in Figure 10.

Source room was the shower room and bathroom connected directly to the powder room and dressing room (called WC$_1$) beside source room. They were separated with a 2.66 m height wall. Meanwhile, the height of source room is 3.5 m. So, there is an aperture between separation wall and ceiling about 0.84 m. Furthermore, there is an opening in the separation wall about 1.2 m. Thus, the source room is not in a fine isolation for sound transmission loss measurement.

The same condition also occurred in the receiver room. The receiver room was a shower room and a bathroom connected directly to powder room and dressing room beside it (called WC$_2$). There is a separation wall too with the same condition as the separation wall in the

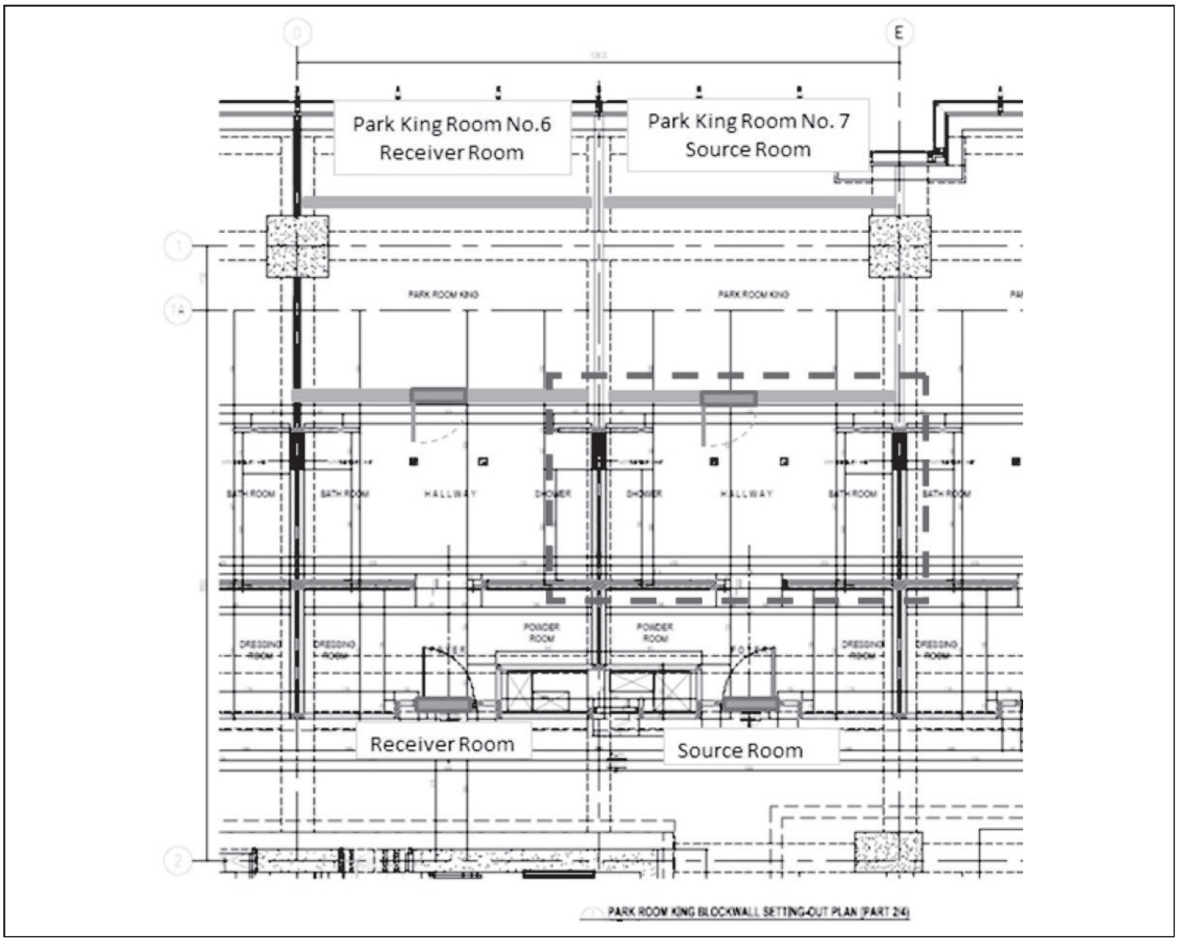


Figure 9. Location of Source Room

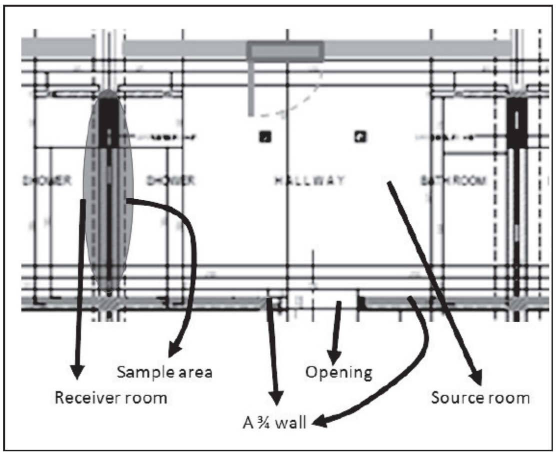


Figure 10. Source Room

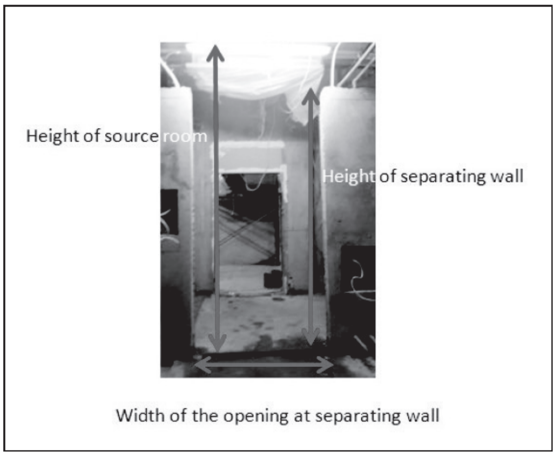


Figure 11. The Separating Wall and the Opening Between Source Room and WC_1

source room. So, the receiver room is not in a good isolation too for sound transmission loss measurement.

With this condition, the sound that emitted by sound source did not only dispersed in source room, but it spread freely into WC_1 through the aperture and opening of the separation wall. Then the sound transmitted into receiver room not only through the testing sample area, but also through the wall between WC_1 and WC_2. Consequently, the sound captured by microphone in the receiver room is capturing the noise from WC_2 too.

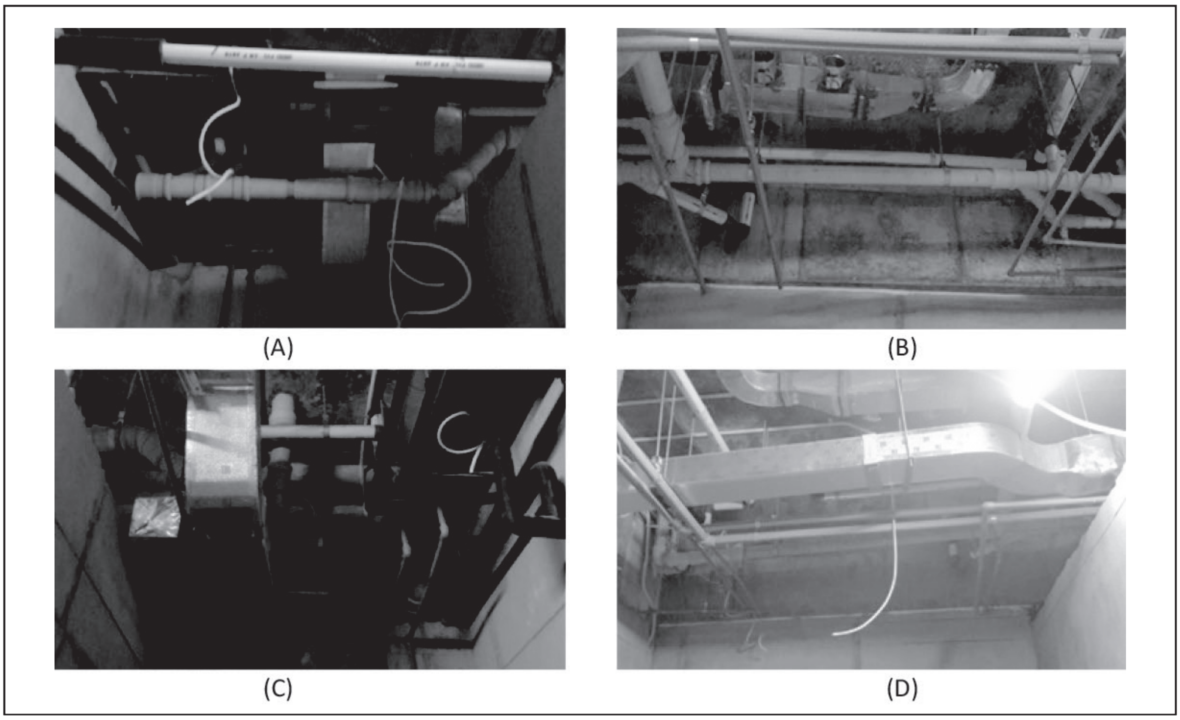


Figure 12. Pipes and Ductings in (A) WC_1, (B) Source Room, (C) WC_2, and (D) Receiver Room

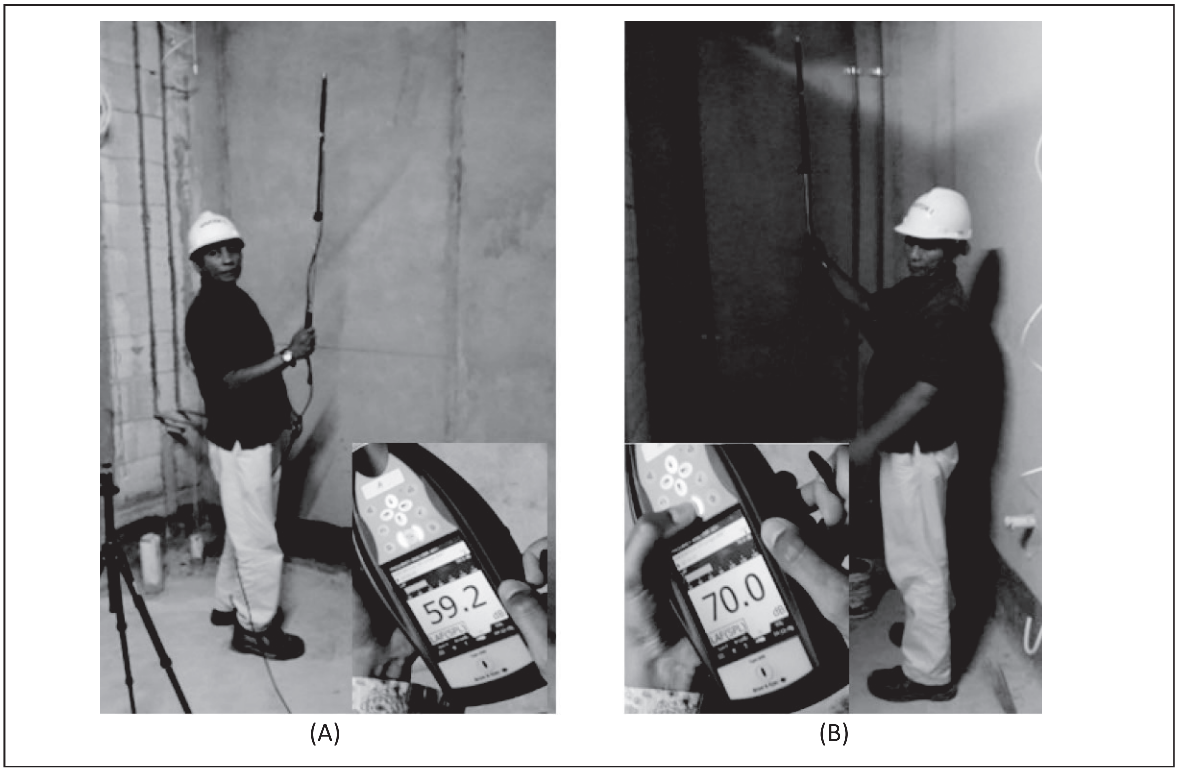


Figure 13. Measuring Noise Near (A) Blockwall in Receiver Room and (B) Ducting in WC_2

The subsequent thing is the ductings placed under ceiling. The ductings were connecting the source room and receiver room indirectly through the ductings in WC_1 directly connected to WC_2. These ductings produced noise in high sound pressure level, until 70.0 dB when measured in WC_2 (Figure 13).

When the measurement was performed, base ducting on WC_1 already closed with cement. Thus, the sound was expected not to enter the ducting. Sound is a mechanical wave, which also propagates through the structure. The sound penetrated the ducting and vibrating ducting's wall that caused the emergence of a new sound source that is the vibration of the ducting's wall itself. Inside ducting, the sound resonated and freely run towards WC_2, as there was no barrier between WC_1 and WC_2 in ducting. As a result, the sound level around ducting in $WC_2$was very high. This also leads to a decrease in Blockwall performance during testing.

F. CONCLUSION AND RECOMMENDATION

1. Conclusions

The field sound transmission loss graph of Blockwall at region II indicates that there were sound leakages during measuring process. Sound leakages could be coming from sample installment and room conditions.The aperture and opening of the separation wall affected the sound in source room and receiver room. The sound emitted by sound source did not only dispersed in source room, but it spread freely into WC_1 through the aperture and opening of the separation wall. Then the sound transmitted into receiver room, it was not only pass through the testing sample area, but also through the wall between WC_1 and WC_2.The sound going through WC_1 penetrated the ducting and vibrated ducting's wall causing the emergence of a new sound source. This new sound source was the vibration of the ducting wall itself. The sound inside ducting resonated and freely run toward WC_2, thus increasing the sound level around ducting in WC_2 and also decreasing the Blockwall performance during testing.

2. Recommendation

The recommendations to optimal block wall FSTC rating are a) to know that the installation of the sample wall in the field is fine, it is advisable to do Blockwall sound mapping in the receiver room wall side; b) between shower room and bathroom should be well insulated, in addition to the bedroom, also to the powder room, so the sound emitted by the sound source is completely distributed optimally in the source room and the sound transmitted by the Blockwall to the receiver room is not affected by sounds that are not from the source room; (c) to find out the laboratory performance of Blockwall, it is recommended to test the sample in the laboratory, so the results can be compared between field test and laboratory test.

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