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THE ANALYSIS OF SOUND TRANSMISSION LOSS ON LAMINATED GLASS

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ABSTRACT

Laminated glass is one type of glass that is commonly used for sound insulation (walls or doors). Tests related to the ability of insulating glass in Indonesia are still sporadic. One of the places to do this test is the SNSU BSN Lab. This Lab has a function to perform sound insulation level measurements commonly known as Sound Transmission Class (STC) and maintain to trace the ability of acoustic measurements. This paper describes the characteristics of Sound Transmission Loss (STL) of 12mm laminated tempered glass. The sample measurement method refers to ISO 10140-1 using two chambers (source and receiver room). Based on the study results, it was found that the laminated tempered glass sample was not good at reducing sound at low frequencies and tended to be good at high frequencies.

Keywords: sound insulation, STC, STL, tempered glass, ISO 10140-1

INTRODUCTION

Noise is an unwanted sound. Noise has a disturbing impact on human hearing. The noise sources are usually the traffic on the road, the sound of production machines, construction machines, and many more. There are many ways to reduce the noise level received, including using sound insulation materials to make walls or doors. Various types of materials are used in the manufacture of sound insulation, ranging from sandwich panels [1], glass [2], light brick, wood, and many more.

Various studies on the sound insulation ability of various materials and predictive methods to obtain sound insulation have been carried out. They were starting from J. A. Moore and R. H. Lyon who conducted research related to the characteristics of sound transmission loss (STL) in sandwich panels used for building walls [1], F. C. Sgard who conducted research related to STL on walls covered with an elastic porous layer [3], W. H. Tan who conducted research related to STL on laminated glass and perspex [2], and many more studies related to sound insulation.

One of the materials currently being used for sound insulation is laminated glass. Many types of research on the scale of mathematical modeling and implementation have been made. W. H. Tan has carried out research related to laminated glass in the realm of mathematical modeling. In his research, W. H. Tan carried out mathematical modeling to create and improve the STL characteristics of laminated glass using the response surface methodology (RSM) [4]. Research related to the implementation of laminated glass in buildings can be seen in the research conducted by W. H. Tan in the comparison paper of laminated glass and perlex and studies related to STL on building materials [2], [5]. M. S. Kanteyan carried out another research related to the implementation of laminated glass in his publication on improving sound insulation designs to reduce paper mill office noise [6]. The research studies above all use the impedance tube method in the measurement process.

This research focuses on calculating and analyzing the STL characteristics of a laminated tempered glass used as a wall. The aim is to obtain the STL and STC characteristics of the tempered glass. The measured sample has a thickness of 12 mm, while the measurement method used is the STL measurement based on ISO 10140-1 and uses two unique spaces for measurements. The frequency used is 125Hz to 4000Hz with a white noise source.

METHOD

The sample measurement process refers to ISO 10140-5 and ISO 10140-1. ISO 10140-5 contains specifications for laboratory facilities and equipment to measure the sound insulation of building elements, both in terms of components and constituent materials, types of building elements, technical types of elements (for small building elements), and how to improve sound insulation capabilities [7]. ISO 10140-1 contains defining test requirements for building elements and products, including detailed requirements for preparation, installation, operation, and test conditions, as well as applicable quantities and test information [8].

The test rooms are two reverberation or echo rooms (source room and receiving room). Between the source and receiving rooms, there is a partition. The tested sample is placed in the middle of the bulkhead between the source and receiver rooms. The shape of the test room, source, and receiver room is shown in FIGURE 1.

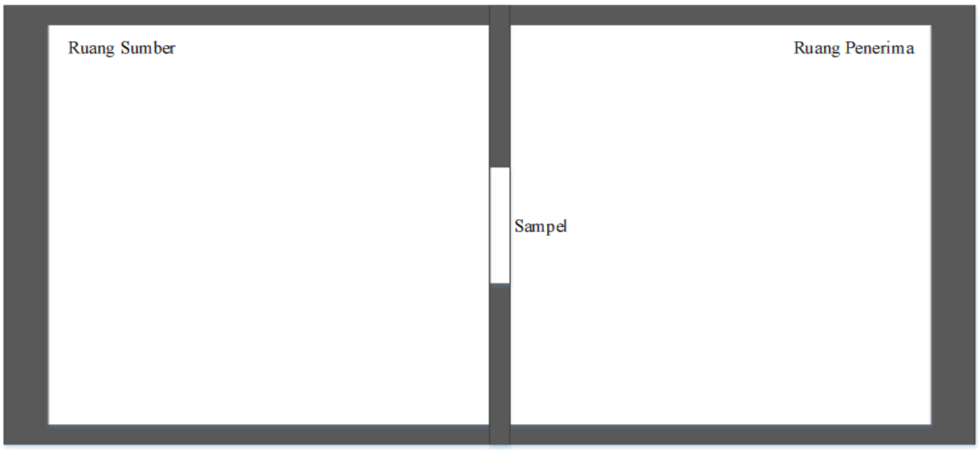
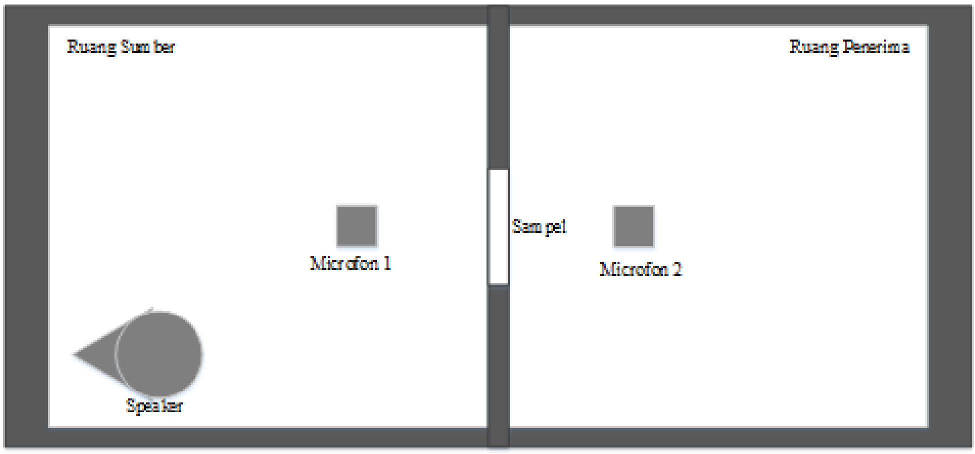
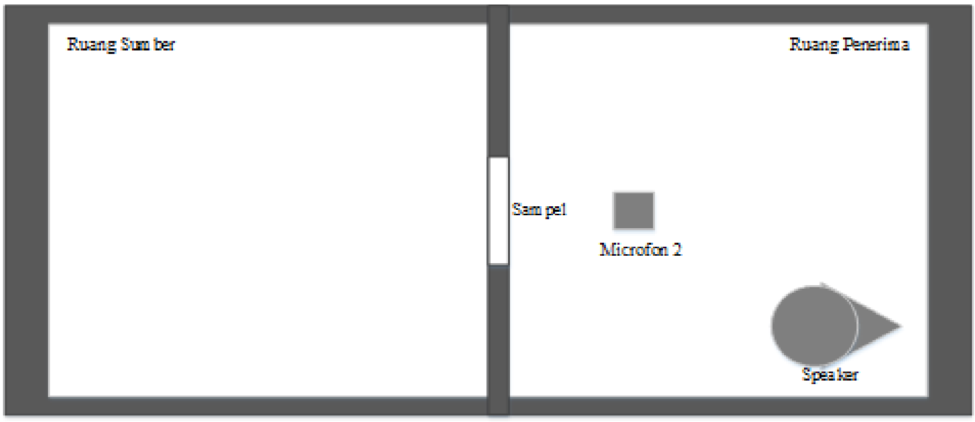


FIGURE 1. The Shape Of The Sound Insulation Test Room



(a)



(b)

FIGURE 2. (a) Schematic Of Sound Pressure Level Measurement (b) Reverberation Time Measurement Schematic

The data collection process for calculating Sound Transmission Loss is carried out by measuring the sound pressure level in the source and receiving rooms and then measuring the reception room's reverberation time. The schematic for measuring sound pressure levels for the source and receiver rooms is shown in FIGURE 2a, while the reverberation time measurement for the receiving room is shown in FIGURE 2b.

The data read by microphones 1 and 2 are processed using a sound analyzer B & K 2260 so that the sound pressure level in the L1 source room, the sound pressure level in the L2 receiving room, and the reverberation time from the T2 receiver room are obtained.

The value of Sound Transmission Loss (STL) for each frequency is calculated by calculating the values obtained from the measurements as shown in FIGURES 2a and 2b. The equation used to calculate the STL value is EQUATION 1 [9]:

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

S is the sample surface area (m^2), and A is the equivalent sound absorption area (m^2). The value of A is obtained from calculating the value of T2 into the following EQUATION 2.

$$A = \frac{0,163 \cdot V}{T} \tag{2}$$

where V is the volume of the room in m3. So that the sound reduction index (R) or sound transmission loss (STL) can be written with the following equation:

$$R = L_1 - L_2 + 10 \log \frac{S \cdot T}{0,163 \cdot V} \tag{3}$$

RESULT AND DISCUSSION

In this study, the glass sample used was laminated tempered glass. The model of the sample used is shown in FIGURE 3. The glass sample measured is 2x1 m^2 and uses an aluminum frame for installation. The gap between the tempered glass and the frame is then sealed to prevent leakage. The frequency measured in this study is the frequency of 125 Hz to 4000 Hz with 1/3 octave increments.

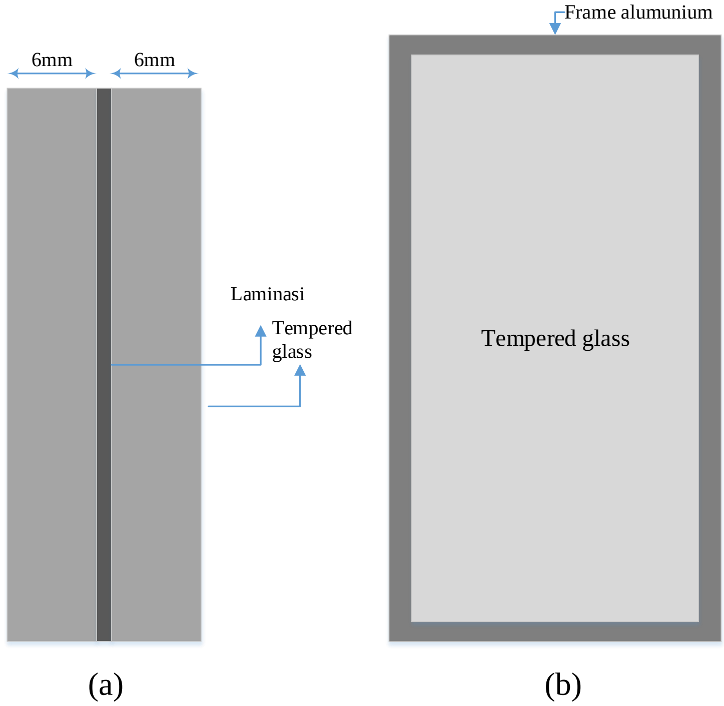


FIGURE 3. (a) Tempered Glass Laminated Side View (b) Tampered Glass Installation

Based on the measurements according to the scheme shown in FIGURE 2a and 2b, the values of L1, L2 and T2 are obtained. The average values of L1, L2, and L3 are shown in TABLE 1. This sample measurement was carried out under uncontrolled temperature and humidity conditions, namely at a temperature of 27°C and humidity of 48%.

TABLE 1. Table of L1, L2 and T2 values.

Frequency (Hz)	L1 Average (dB)	L2 Average (dB)	T2 Average (dB)
125	80.2	47.5	2.0
160	80.2	46.0	2.4
200	80.4	47.7	2.5
250	81.6	51.3	3.0
315	80.1	48.1	2.9
400	80.9	46.4	3.6
500	80.7	44.2	3.2
630	79.0	41.0	3.9
800	78.8	40.5	3.9
1000	78.5	37.7	3.3
1250	80.3	37.8	3.2
1600	81.4	38.0	2.9
2000	81.8	40.2	2.5
2500	82.3	48.6	2.2
3150	84.1	49.0	2.0
4000	83.1	45.0	1.7

The values in TABLE 1 are then calculated using EQUATION 3 to get the STL value for each frequency. The STL value data from each frequency is then graphed to see the characteristic graph of the sample being measured. The graph of the STL value from the calculation results is shown in FIGURE 4.

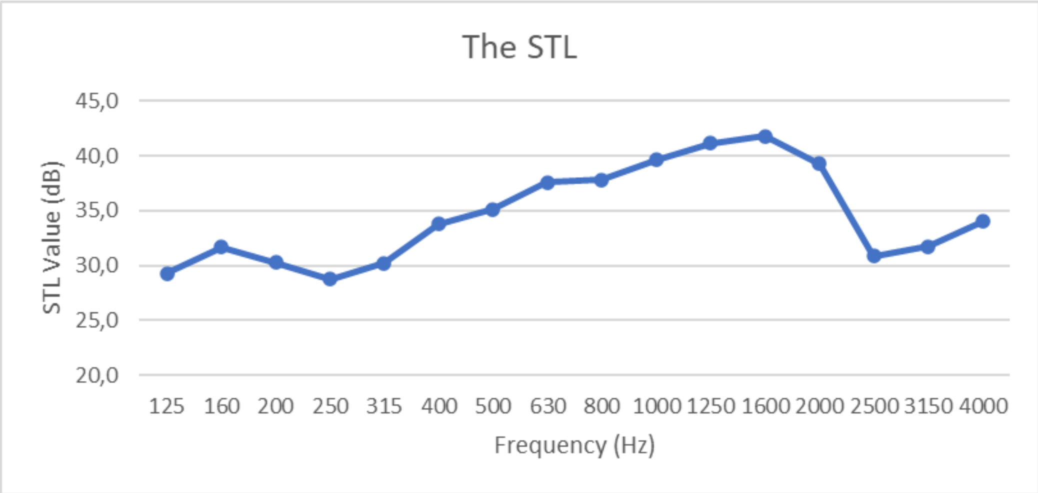


FIGURE 4. The SLT chart of 12mm tempered glass sample with lamination.

Based on the graph in FIGURE 4, the lowest STL value is at a frequency of 250 Hz, which is 28.7dB, while the highest STL value is at a frequency of 1600 Hz, which is 41.8dB. This tempered glass's STC value from 250Hz to 1600Hz is improving, as evidenced by the increasing graph. However, after the frequency of 1600 Hz to 2500 Hz, the graph decreased in value, then the STL value increased again. The increase and decrease in the STL value of each frequency is usually due to the characteristics of the tempered glass. This condition can also be caused by the condition of the frame and sealant used in the installation of tempered glass to the test site. This also happened to other laminated tempered glass samples measured in the Lab. Although the decreasing frequency found was different, at high frequencies (more than 1000Hz-2500 Hz), a value decreased with a similar pattern. That is, a decrease in STL value will then increase again. STL graphs from other samples are shown in FIGURES 5 and 6.

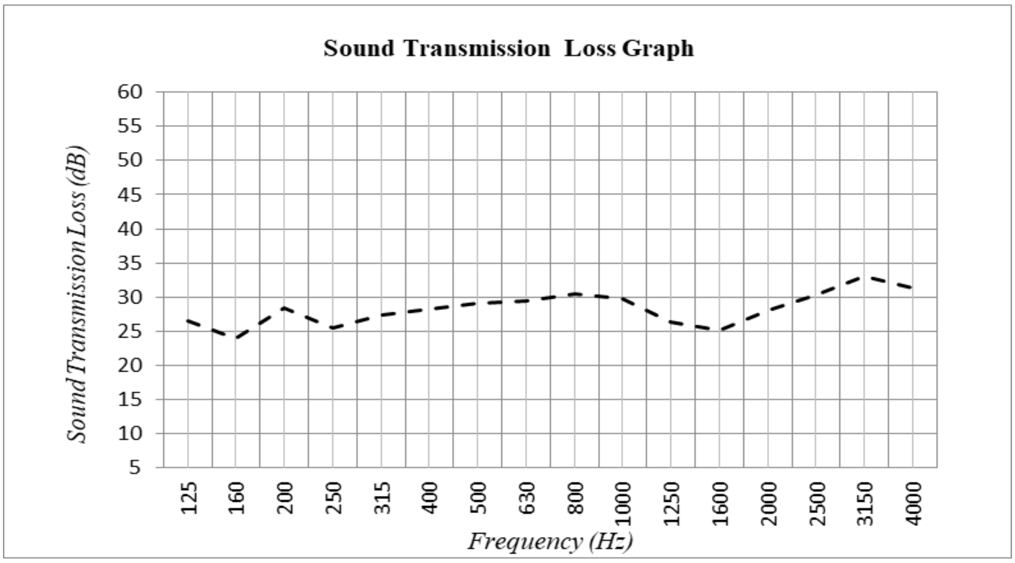


FIGURE 5. The STC on tempered glass at 10mm thickness.

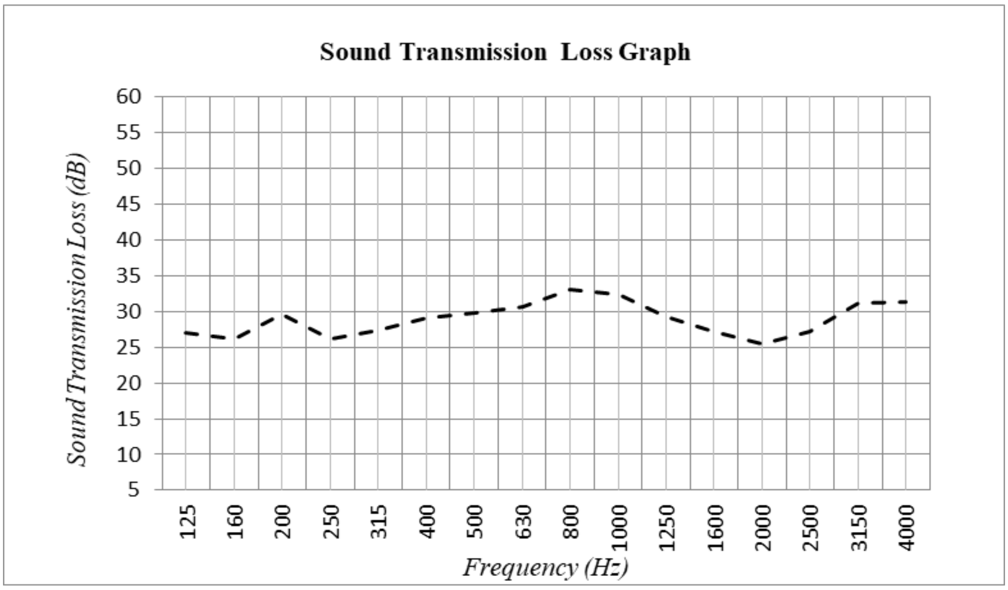


FIGURE 6. The STC on tempered glass at 10 mm thickness with lamination.

Based on research conducted in the literature [10], the effect of frames and sealants in the installation of tempered glass significantly affects the STL value of a material. Thus, to increase the STL value, the installation method needs to be considered. In theory, increasing the density of the measured material will increase the STL value—one way to increase the density of the material. One of them is by increasing the thickness. So that the addition of the thickness of the tempered glass can also increase the STL value of a material

CONCLUSION

The laminated tempered glass sample with a thickness of 12mm is not good at reducing sound from a frequency of 125Hz to a frequency of less than 500Hz and a frequency of 2500Hz-4000Hz, while this sample is good enough to muffle the sound with a frequency of 500Hz-

2000Hz. In order to increase the sound attenuation capability, the installation process and the addition of the thickness of the tempered glass can be carried out.

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