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Technical Note

Variations in measured sound transmission loss due to sample size and construction parameters

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ABSTRACT

The influence of the sample size on the measured transmission loss of several different sample constructions is assessed. The sound transmission loss of two different sized samples was evaluated for a wide range of different materials and constructions. The two sample sizes were; a 2400 mm × 4800 mm sample that is compliant with ISO15186-1 and a smaller non-compliant 1550 mm × 950 mm sample. The samples tested were single and double leaf wall systems, with and without studs, made from a gypsum plasterboard, plywood, and vinyl mass-loaded barriers. The results presented compare two sample sizes for all the samples tested. Further testing is performed to quantify the effect of the room arrangement on the sound transmission loss. Finally a qualitative analysis is performed to assess the influence of various factors on the sound transmission loss.

1. Introduction

Research has shown that altering the size of a sound transmission loss sample can have a significant effect on the transmission loss below the critical frequency. In this paper the influence of the sample size on the sound transmission loss on a range of different sample constructions are presented. It was found that the sample size has a significant effect on the measured sound transmission loss above and below the critical frequency. The construction of the sample was found to influence the variance caused by the changes in sample size. This interaction between the construction and the observed size effects makes the development of any correction factors to allow for small sample results difficult.

There are two sample sizes specified by ISO10140-4 [1] for use in sound transmission loss testing. The larger size specified for testing wall systems is given as approximately 10 m^2, and must be between 10 m^2 and 20 m^2. The smaller size is reserved for testing of small building elements such as windows and is 1250 mm × 1500 mm (1.875 m^2). Preparation and testing of a full size (10 m^2) transmission loss sample involves significant time and cost. Consequentially full sized wall testing is often prohibitively expensive for product development applications where a large number of samples are to be tested. This work focused on the evaluation of a small, 950 mm × 1550 mm (1.4725 m^2), sound transmission loss test rig. This test rig is specifically designed for measuring the sound transmission loss a large number of samples quickly and efficiently in order to obtain comparative data.

Some prior research has been undertaken which investigates the effects of various laboratory parameters on the measured sound transmission loss. A more detailed examination of some of the articles presented in this section will be presented in the discussion section of this article. Important aspects of a sound transmission loss facility were found to be; the presence and depth of a sample niche [2–6], the sample size [7,8], the size of receiving and source room [9,10], the sample mounting conditions [2,11–14], source and receiving room conditions [11,15], and the construction of the sample [10,16].

It is clear from the work presented by Kihlman and Nilsson [2], and Guy et al. [12] that the measured sound transmission loss is dependent on a number of interrelated parameters which interact to a large extent. Kihlman and Nilsson found that the high frequency (above coincidence) behaviour was independent of laboratory design and mounting conditions, whereas below the critical frequency the sound transmission loss depended on a range of different parameters. Guy et al. showed that the largest effects were due to the sample size and mounting conditions. It was also noted that changes to the sample size and mounting conditions could result in changes to the measured critical frequency.

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The measurement procedure can also have an effect on the measured sound transmission loss. The sound transmission loss values presented here were measured using the pressure-intensity method as described in ISO 15186-1:2000 [17]. ISO 15186-1:2000 allows these measurements to be compared to measurements made using the pressure–pressure method (which is described in ISO 10140-2 [18] and ISO 10140-4 [1]). The sound transmission loss measured using the pressure–pressure and intensity methods have been compared experimentally [19]. It has been found that there are some variations between the measured results [20], especially at low frequencies [21,22]. The major variations between the two methods are due to the fact that the pressure–pressure method measures the transmission loss of the entire wall system, including any baffles and mountings. In comparison the intensity method only measures the transmission loss of the sample scanned by the intensity probe. Despite the different method used, results found in this study should be comparative to the results presented by other authors who utilised the pressure–pressure method.

Theories for the prediction of sound transmission loss use different methods to account for the finite size of a real transmission loss sample. The original theories of sound transmission loss were based on an infinite panel system [23]. An infinite panel is inherently easier to predict the transmission loss of as the interaction at the edges and baffles adds complexity to any model of the system. These infinite panel models are adjusted and modified to accommodate finite sized panels [24–26]. It is accepted that altering the size of the sample will alter the natural frequencies of the sample and modify the effective panel impedance and the transmission loss of a sample is increased below the critical frequency as the sample size is decreased [12].

The results of testing the same sample in a small test rig (1.5 m^2) and a large test rig (11.6 m^2) are presented and discussed. The reasons for variations seen between the two were investigated using further testing and comparison of current theories. The purpose of the small transmission loss facility is comparative testing for which it is helpful if the general trends in the results of the small sample match those of the large sample.

2. Sound transmission loss tests

A range of samples were tested in both transmission loss facilities; the samples tested included single leaf plywood panels, single leaf gypsum plasterboard panels, twin leaf gypsum plasterboard walls and twin leaf plywood walls. In total nine small samples and nine large samples were tested. The samples tested varied significantly in material properties and overall construction. The construction was found to have a large effect on the variation in the measured transmission losses for the different sample sizes. All the samples tested are outlined in Table 1.

The large samples were mounted between a 220 m^3 reverberation room and a 200 m^3 semi-anechoic space. The small sample was mounted between the same reverberation room and a 9 m^3 semi-anechoic space. The surface area of the large receiving room is 236 m^2, and the surface area of the small receiving room is 27 m^2. The layout of the test rooms is presented in Fig. 1.

The large samples were constructed on a standard timber frame, which was mounted in 2400 mm × 4800 mm test aperture between the source room and the receiving room. The timber frame stud spacing was 600 mm and the stud depth was 75 mm. The layout of the timber frame within the test wall is shown in Fig. 2. The single leaf panels were attached to the receiving room side of this wall. The double leaf systems were also constructed on this frame and cavity absorption was added. In all cases the single leaf samples were on the receiving room side of the test wall. The typical layout of the large wall system is shown in Fig. 3.

The small sample was clamped into a 1550 mm × 950 mm aperture, as shown in Fig. 4. The clamping force was supplied by a series of M12 bolts around the perimeter of the frame, which clamp onto a section of RHS steel (shown in Fig. 5). The single leaf samples were clamped into the frame with no modifications. The double leaf systems were constructed as complete systems with the same dimensions as the frame and similar sized stud spacing as the large system. These systems were then clamped into place using the same arrangement shown in Fig. 5.

The niches on either side of the sample are dependent on the thickness of the tested sample. The small samples have a constant niche depth on the source room side which is not affected by the thickness or construction of the sample. The receiving room niche is equivalent to 200 mm minus the thickness of the sample being tested. In the large transmission loss sample both the receiving and source room niches vary with the sample thickness. The receiving room niche depth is 210 mm minus the thickness of the panel attached to the receiving side of the frame. The source room niche is constantly 160 mm for single leaf panels, and is 70 mm minus the thickness of the panel attached to the source room side. The niche conditions of both the sample sizes are summarised in Table 2.

In all cases the edges of the large samples were sealed using silicone sealant. The joints between the individual panels occurred over studs and these joints were then taped over to reduce leakage. The edge sealant and taped joints are shown in Fig. 6. If any large gaps between the panels occurred these were sealed using the same silicone sealant; and then taped over. The small sample was sealed by the presence of a thin layer of rubber around the frame clamping surface. There were no joints within the smaller samples and as such they did not require taping.

The large unsupported panel was built to allow the influence of the studs on the measured sound transmission loss to be evaluated. The internal stud frame was removed leaving just the timber beams around the perimeter. The edges of the panels were attached to the outer timber frame via screws at 150 mm centres. The edges were also sealed with silicone sealant, and in the joints were glued and taped. This combination was intended to prevent any leakage that may occur due to the removal of the studs at the joints. The arrangement used is presented in Fig. 7.

The large samples were tested following the procedures described by ISO 15186-1. The intensity probe was held at a distance of approximately 150 mm from the wall and a scan spacing of approximately 200 mm was used. Five microphones were used to measure the sound pressure level within the reverberation room. The intensity and sound pressure level values allow the sound transmission loss to be calculated. The measurements were sufficiently repeatable within the 100 Hz–5000 Hz frequency range.

The small samples were measured in a similar manner, but the scan spacing was reduced to approximately 100 mm. This reduced the overall scan time length, thus the averaging time was reduced accordingly. This method was sufficiently repeatable within the same 100 Hz–5000 Hz frequency range presented. The repeatability of the small transmission loss tests was somewhat worse than that of the large transmission loss tests, but it was still within acceptable tolerances.

The sound transmission loss was measured for four thicknesses of plywood (7 mm, 9 mm, 12 mm, and 21 mm); in different partition arrangements. Fig. 8 shows the transmission loss of single leaves of 7 mm and 9 mm plywood measured in both the small and large transmission loss rigs. These two plywood samples have very similar transmission loss behaviours in both sample sizes.

The large sample displays some unusual behaviour below 400 Hz. The 7 mm plywood has a higher sound transmission loss than the 9 mm plywood despite the 9 mm plywood panel being