An Apparatus for Measuring the Dynamic Stiffness of Acoustical Materials

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1. Introduction

A common practice to improve both the impact-noise isolation and the airborne sound transmission of a structural floor is to add a floating floor. It consists of a hard rigid floating slab supported on a resilient layer that dynamically decouples it from the structural slab. The impact-noise isolation of certain types of floating floors have been investigated by Cremer[1] and Ver[2]. One of the parameters that determines the performance of these floors is the dynamic stiffness of the resilient material used. A draft international standard, ISO/DIS 9052-1, exists that specifies a procedure for measuring the dynamic stiffness of the resilient material. This draft standard allows measurements to be made either with a shaker or an impact hammer.

In this report, a description of the test methods will be presented together with a comparison of the results obtained by both methods.

2. Test set-up and measurement procedure

The procedure specified in the draft standard applies to the determination of dynamic stiffness per unit area of resilient materials with smooth surfaces used in a continuous layer under floating floors. A specimen of dimensions 200 mm x 200 mm was placed between two horizontal surfaces, i.e. the baseplate and the load plate, as shown in Fig. 1. The load plate was square, with dimensions 200 mm x 200 mm, and was made of steel. The combined weight of the load plate, the accelerometer, and the force transducer was 8.1 kg. The baseplate was a 100 mm thick marble slab with dimensions 700 mm x 950 mm. It weighed about 150 kg. The baseplate rested on three resilient mounts. The system consisting only of the marble slab and the resilient mounts had a resonance frequency of about 7 Hz which would be below that of the system formed by the load plate and the test specimen.

Figure 1 also shows the other equipment used in the shaker test. The driving signal for the shaker was a 4095 point m-sequence generated by the computer at a clock frequency of 1250 Hz. The exciting force was measured by a force transducer and the response of the system was measured by an accelerometer. Both the force transducer and the accelerometer signals were low-pass filtered at 315 Hz with a dual channel anti-aliasing filters before they were digitized and processed. Since the driving signal is deterministic, synchronous averaging is possible. In this measurement, ten averages have been used. Individual signal was first cross-correlated with the m-sequence via the fast Hadamard transform[3] before they were converted into the frequency domain by FFT. The system frequency response was subsequently determined as the ratio of the cross-spectral density between the motion response and the excitation force divided by the auto-spectral density of the excitation force. Since the motion response was measured by an accelerometer instead of a displacement transducer,

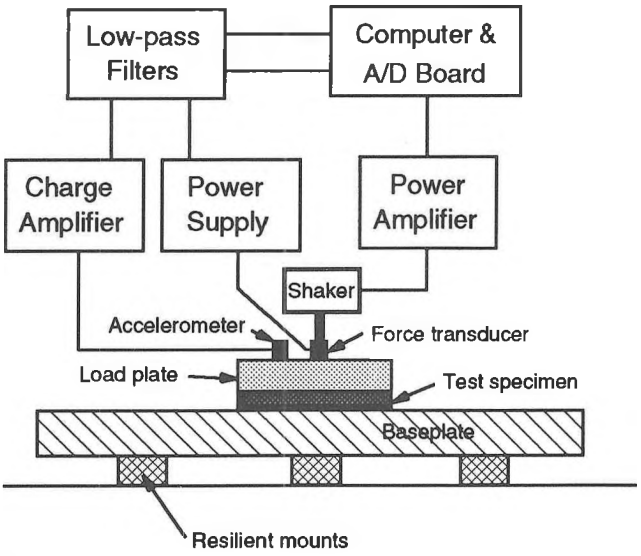


Fig. 1: Diagram of equipment used in the shaker test.

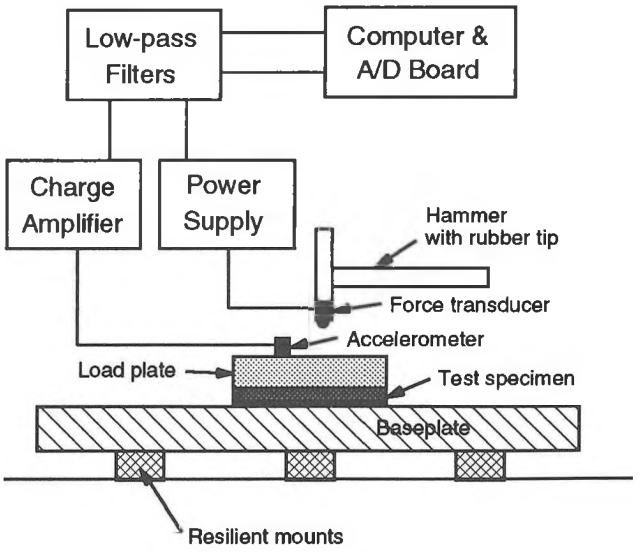
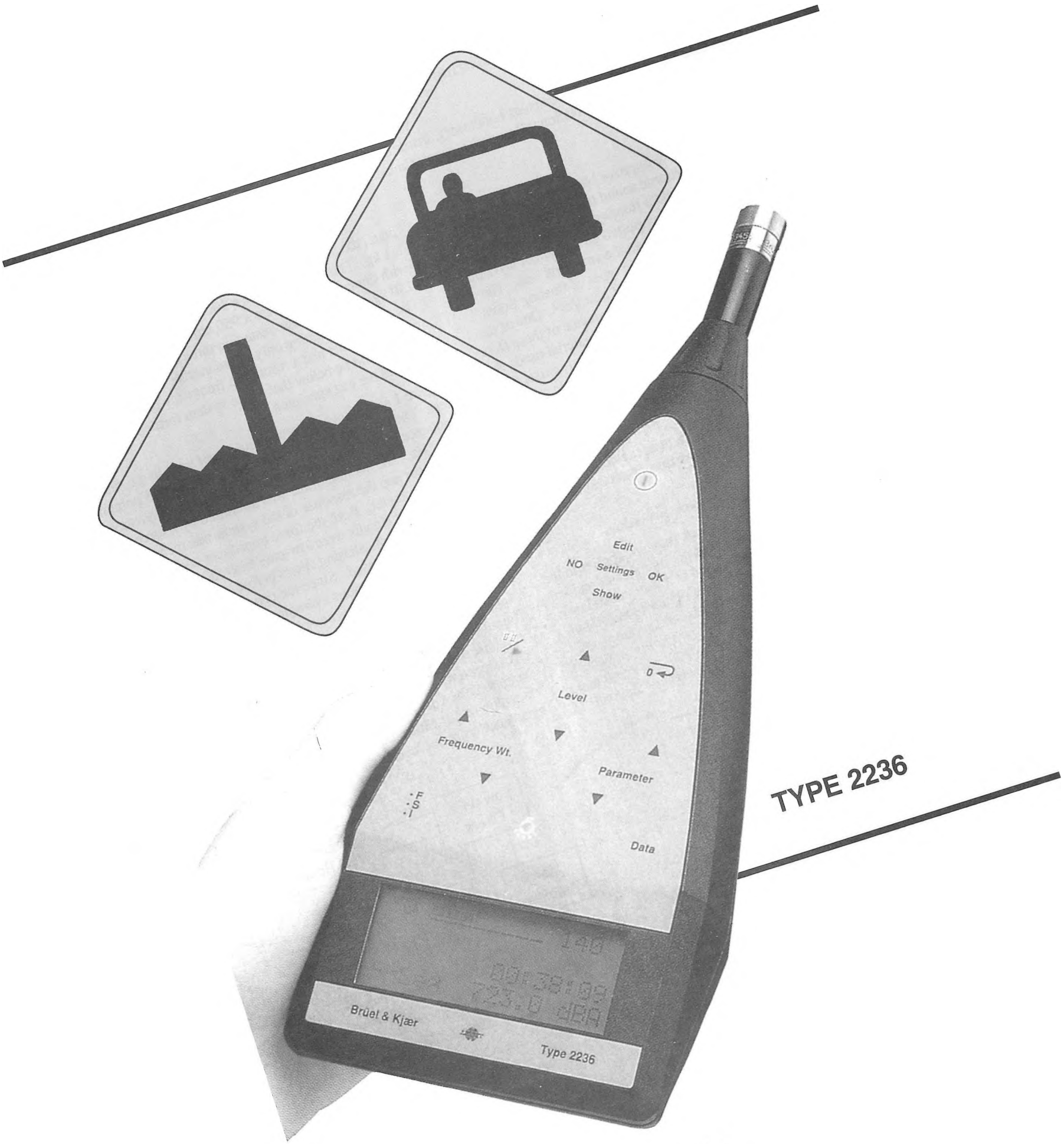


Fig. 2: Diagram of equipment used in the hammer test.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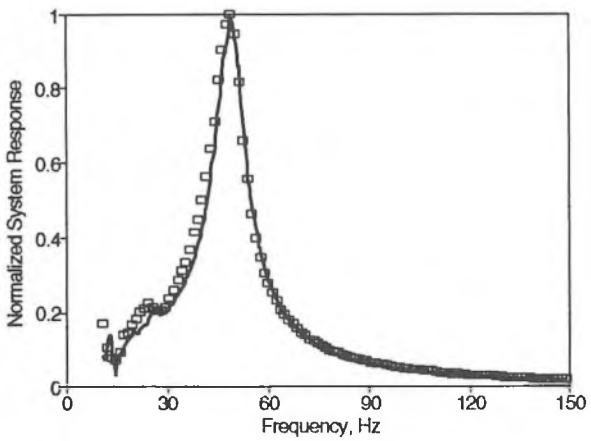

Fig. 3: Comparison of the system frequency responses measured by the two methods: line - shaker method; open square - hammer method.

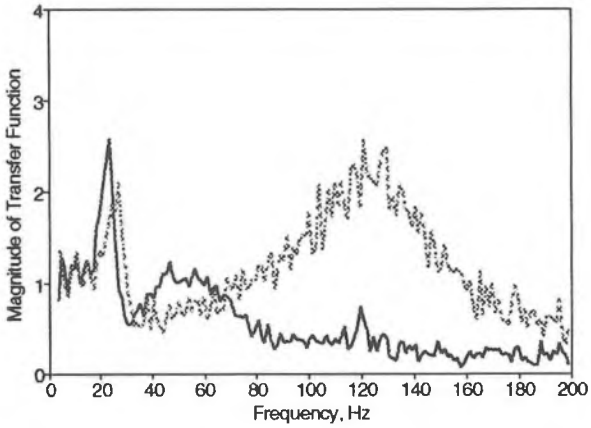

Fig 4: Comparison of the magnitudes of the transfer functions between the vertical acceleration of the baseplate and that of the load plate coupled by resilient channels from two different suppliers.

an additional division by the square of frequency was applied. The dynamic stiffness of the material is given by the resonance frequency of the fundamental vertical vibration of the spring and mass system.

Figure 2 shows a similar set-up when measurements were made using an instrumented impact hammer. The sampling frequency used was 1250 Hz. A direct 1024 point FFT was applied to both the force transducer and the accelerometer signals. Similar data analysis was used to obtain the system frequency response.

3. Results and Discussion

The sample tested consisted of two layers of 10 mm thick rubber pads. Figure 3 compares the system frequency responses measured by the shaker method and the hammer method without showing the resonance frequency of the baseplate assembly. The response curves have been normalized by the magnitude at resonance. Although the hammer test consisted of a single run, the results show good agreement with those obtained by the other method. Because of its simplicity and ease of operation, the impact method seems to be a better procedure to use.

4. Other Applications

Recent studies of the sound transmission loss of party walls of identical configuration using resilient channels supplied by different manufacturers show significant differences in results. An attempt has been made to see if the methods presented here can be applied to study the transmissibility of the resilient channels used in the wall assemblies. As a preliminary investigation, the test specimen shown in Fig. 2 was replaced by two pieces of resilient channels screwed to the bottom of the load plate near two opposite edges. The assembly was attached to the baseplate using double sided adhesive tape. Another accelerometer was used to measure the acceleration of the baseplate. The hammer was used to impact the baseplate and the accelerations of the baseplate and the load plate were measured simultaneously. A transfer function between the acceleration of the load plate and that of the baseplate was calculated. Figure 4 shows significant differences in the magnitudes of the transfer functions obtained for the resilient channels supplied by two different manufacturers. Although no quantitative results can be derived from these preliminary data, the results shown in Fig. 4 seemed to correlate well qualitatively with the performance of the party wall employing the two different types of resilient channels. The one characterized by the solid curve of Fig. 4 gave the party wall a better transmission loss performance. A more detailed study of this application is currently in progress.

5. Reference

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