Applied Acoustics 97 (2015) 115–120

Contents lists available at ScienceDirect

Applied Acoustics

journal homepage: www.elsevier.com/locate/apacoust

Technical Note

The "dust spring effect" on the impact sound reduction measurement accuracy of floor coverings in laboratory

Alessandro Schiavi [a,*], Andrea Prato [b,*], Andrea Pavoni Belli [b]

[a] Mechanical Division, National Institute of Metrological Research – INRIM, 10135 Torino, Italy
[b] Thermodynamical Division, National Institute of Metrological Research – INRIM, 10135 Torino, Italy

ARTICLE INFO

Article history:
Received 5 November 2014
Received in revised form 24 March 2015
Accepted 13 April 2015
Available online 27 April 2015

Keywords:
Floor covering
Impact sound insulation
Standard measurements
Dust

ABSTRACT

Standard measurement methods of impact sound insulation of floor coverings (resilient surface layers) in laboratory are stated on Standard ISO 10140 series. Laboratory test allows evaluating the acoustical performance of resilient surface layers in terms of reduction of impact sound pressure level ΔL. Resilient surface layers applied on the top of the structural reference floor effectively reduce the impact noise produced in the receiving room by a tapping machine excitation. In any case, an accurate characterization of the acoustical performances of the resilient surface layers depends on several boundary conditions. In this paper, it is shown a very relevant effect on the measurement accuracy, due to the cleaning condition of the structural reference floor. In particular it has been observed that the presence of sand and/or dust (in a very small quantity, i.e. of about 5 g/m^2) scattered on the bare slab greatly influences the experimental results. Researchers and technicians involved in building acoustic measurements in standard laboratories are well aware about the issues of proper cleaning, in particular if the resilient surface layers must be fixed on the surface by gluing. Nevertheless, the ISO 10140 standard (as well as previous ISO 140 standard series) does not state, as requirement, to glue the layers on the surface of the reference floor. As a consequence any accidental impurity on the bare floor surface can be a relevant source of inaccuracy.

1. Introduction

In building applications the presence of floor covering materials (or resilient surface layers) applied on the bare surface of the structural slab, reduces the impact noise level. The impulse force, acting on the elastic surface, is damped and the mechanical power put in the structural slab is partially absorbed by the resilient surface layer [1,2]. The acoustical performance characterization of resilient surface layers is a common measurement in building acoustic standard laboratories. In general terms, used materials for resilient surface layers are rigid rubber, vinyl tiles, linoleum tiles, moquettes, but also wood and ceramic-like tiles (united with porous and/or elastic underlayers) [3,4].

The ISO standard measurement procedure [5–7] states to apply at least 3 tiles, large enough to support the whole tapping machine, on the bare standard slab (without any requirement about the fixing method: they can be installed loosely or by adhesion to the floor surface) and to measure the sound pressure level produced in the receiving room by the excitation of the tapping machine. Measurements are performed with the tapping machine acting both on the surface of the bare reference floor and on the resilient surface layer under test, in order to evaluate the sound pressure level of both conditions. The structural reference floor is made in concrete (density 2500 kg/m^3, thickness 140 mm). The acoustical performance of the material is determined in terms of reduction of impact sound pressure level ΔL, on the basis of the difference between the normalized impact sound pressure level measured on the bare floor (L_{n0}) and on the resilient surface layer under investigation (L_n).

On the basis of an occasional bilateral commercial comparison between two laboratories a relevant dispersion of reduction in impact sound results, in terms of reproducibility, has been observed. The dispersion ranged from about 5 dB up to 10 dB, depending on the typology of the material.

In order to investigate the possible sources of a so relevant dispersion, an accurate analysis of measurement procedures and boundary conditions has been performed.

At first, instruments calibration and devices properties, measurement methods and suitability of the standard laboratories, in order to fulfil any basic metrological requirements, useful to lead a correct reproducibility test, have been investigated. Besides, a

* Corresponding authors. Tel.: +39 011 3919627; fax: +39 011 3919621 (A. Prato).
E-mail address: a.prato@inrim.it (A. Prato).

http://dx.doi.org/10.1016/j.apacoust.2015.04.011
0003-682X/

series of repeatability tests has been performed. Since discrepancies have not been highlighted, the attention has been focused on the materials properties and on measurement boundary conditions.

Material properties have been defined on the basis of stiffness and damping, in terms of dynamic Young's modulus and loss factor measurement. As boundary condition, once verified the laboratories features, the bare structural slab surface have been investigated. It has been observed that, although the surface roughness fulfils the standard requirements (the surface of the reference floor shall be flat to ±1 mm in a horizontal distance of 200 mm), only few sand/dust was scattered on the surface. It is well known that in building acoustic standard laboratories, because of several heavy structures built and demolished per year (e.g. floating floors), dusts and other very small rubble particles can deposit on the surface.

As a matter of fact, as recognized by Cremer et al. [8], "one must also take into account that the (not readily quantifiable) spring effect of even a layer of dust may lead to errors in the measurements at very high frequency", in floor coverings characterization.

As it will be shown in this technical paper, the surface cleaning condition of the reference floor is of paramount importance to avoid errors in measurement and a systematic evaluation and quantification of the dust spring effect on the accuracy of impact sound laboratory measurement is performed.

2. Experimental evidences

2.1. Material properties

Three different commercial resilient surface layers (RLS) of 610 mm width and 610 mm length, with different technical features and properties, have been used in the following experimental tests (Fig. 1).

Resilient surface layer 1 (RSL-1): single layer in rubber (SBR type) 31–35%, filler 50–55%, other vulcanized compounds 10–19%.

Resilient surface layer 2 (RSL-2): 2 layers, a hard rubber cover united with a polyurethane foam with rubber shavings.

Resilient surface layer 3 (RSL-3): 3 layers, a hard rubber cover, polyurethane foam and a rubber underlayer.

The case history, although limited to 3 samples, can be considered enough for a relative comparison in which only the variability due to a single boundary condition is investigated.

In Table 1 measured technical properties are shown. The average dynamic Young's modulus E_{dyn} has been determined from the dynamic stiffness values s', measured accordingly to ISO 9052 Standard [9], on the basis of the simplified relation $E_{dyn} = s' \cdot t'$, in which t' is the compressed thickness value of the layers (i.e. the layer thickness measured under a static load of 200 kgm^{-2}).

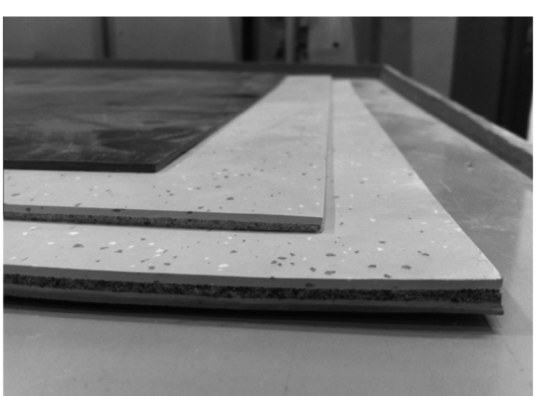

Fig. 1. The 3 commercial resilient surface layers under test.

Damping, in terms of loss factor η, has been evaluated on the basis of half-power point method, from the width of resonant peak of mass-spring (i.e. mass-resilient surface layer) system, at −3 dB from the maximum peak amplitude. Actually, dynamic stiffness measurement has been performed with the aim to evaluate qualitatively the relative magnitude of elastic and damping properties of each layer and the average dynamic Young's modulus has to be considered as a representative elastic response of the system as a whole. The actual evaluation of the elastic properties of RSLs is outside the aim of this technical paper.

2.2. Standard reduction of impact sound pressure level measurement

A series of standard reduction of impact sound pressure level measurements has been carried out on 3 different samples of surface resilient layers. Measurements have been performed in accordance to ISO 10140 standard series.

The surface of the reference floor surface has been accurately cleaned, to avoid the presence of dust and any other small rubble particles. A series of repeatability tests has been firstly performed in order to define the range of uncertainties (~2.8σ) due to the measurement position on the reference floor for each resilient surface layer (uncertainty averages in the order of ±1 dB for RSL-1, ±2.4 dB for RSL-2, ±2.4 dB for RSL-3, for sound pressure level measurements L_n and reduction of impact sound pressure level measurements ΔL and uncertainties of ±0.8 dB for RSL-1, ±2.3 dB for RSL-2, ±2.4 dB for RSL-3 for weighted reduction of impact sound pressure level measurements ΔL_w). Once repeatability has been evaluated, a series of measurements of impact sound pressure level has been performed by scattering defined quantities of fine sand on the reference floor surface. It has been used a commercially available siliceous river sand (washed and selected with a granulometry between 0 mm and 1 mm), in accordance to EN 13139 standard [10].

The quantity of sand scattered on the reference floor surface varies between 0.3 g/m^2 and 13.4 g/m^2.

In the graphs of Fig. 2 the sound pressure level L_n, measured as a function of increasing quantity of scattered sand are depicted.

In the graphs of Fig. 3 the reduction of impact sound pressure level ΔL are depicted.

3. Results and discussion

Experimental results clearly show the systematic effects due to the presence of scattered sand on the reference bare floor surface. The sound pressure level L_n, systematically decreases as a function of increasing quantity of sand, while, as a consequence, the reduction of impact sound pressure level ΔL increases. The effect due to the presence of sand on the bare surface is relevant in particular at high frequencies, in which the values of sound pressure level show large variations, depending on resilient surface layer properties. Actually, the influence of sand on the bare surface is more evident in RSLs with low acoustical performances (RSL-1 and RSL-2). Measurements of impact sound have also been performed on the bare reference floor surface (L_{n0}) with and without sand and no differences have been observed.

In the graph of Fig. 4 the variation of weighted reduction of impact sound pressure level (*single number*) ΔL_w is depicted (uncertainty averages in the order of ±0.8 dB for RSL-1, ±0.8 dB for RSL-2, ±0.3 dB for RSL-3). It is of interest to highlight that the dust spring effect influences the experimental results also for very small quantities of scattered sand, in particular in the range from 0.3 g/m^2 to about 5 g/m^2. Above 5 g/m^2 a steady (but not actually accurate) acoustical behaviour is reached, for all tested samples.