

# THE INI-EVA RANKING: THE TRUTH ABOUT RESILIENT LAYERS

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#### Summary

Many types of resilient layers are available on the market. They are made of plastic foam; rubber; mineral wool; felt; metal; coconut; cork ... and they are all characterized by one single parameter. This parameter is determined in a certified laboratory. The time consuming and expensive tests according to the certified ISO 10140 standard make it difficult and almost impossible to organize meaningful round robin tests. The resilient layers can be combined with many other layers such as leveling layers, floor heating layers, different thicknesses of screeds and finishing top layers. This generates an enormous number of test results, confuses architects, contractors and the consumer. This paper describes a new method based on the ISO 16251 that allows a comparison in an objective, fast and reliable way different resilient layers under different circumstances. A very good agreement is found between the new and certified test. The development, method, setup, testing and accuracy analysis were performed over a period of three years. The robustness of the technique will be demonstrated in the paper. This led to a new classification system for the impact noise insulation of resilient layers when using the new measuring procedure. We call it for the moment, the EVA quality impact noise insulation ranking (INI-EVA ranking) and give the in our laboratory tested resilient layer products an INI performance EVA label. A dozen of manufactures have tested more than 50 different products of under screeds and underlays for laminate floors with the new method. They have also successfully used the technique for the development of new products.

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## 1. Introduction

It has been proven many times [1, 2] that the "Comet table" can be used to determine  $\Delta L$  values of locally reacting floor coverings according to ISO 16251 [3]. However, the method was found not to be suitable to measure  $\Delta L$  values of not locally reacting resilient layers with screeds. The low frequencies of the small concrete slab [1], the big fluctuations at the different measuring points and the change of the vibrational behaviour of the setup [2] are held responsible for this constraint. This paper proves the contrary and explains how one must proceed to get consistent results. Resilient layers measured the classical way in full sized laboratories according to ISO 10140-3 [4] were compared with the new "calibration" method.

#### 2. Definitions

The frequency range between 100 en 1000 Hz is considered relevant. Lower frequencies are in situ

unreliable and higher frequencies are not important [5]. Two situations are considered in this paper: resilient layers with or without a levelling layer. The thickness of a resilient layer should be less than 40 mm. Thicker layers are considered as a combination of a resilient and a levelling layer (sometimes also used as thermal insulation).

# 3. Characterizing resilient layers

The following parameters are important to characterise resilient layers: thickness; density; dynamic stiffness; open or closed structure (porosity); airflow resistivity; loss factor; resonance frequency of the system. The ISO 10140-3 [4] describes how to determine the single number  $\Delta L_w$  which is used in most of the countries in Europe. The Dutch system uses the  $\Delta L_{lin}$  and the  $\Delta I_{co,lab}$  parameter [6]. The USA uses a IIC (Impact Insulation Class [7], [8]) system which also results in a single number. They all refer to a well-defined reference curve. The old classification system in

Belgium [9] used 6 classes ( $I_a$ ,  $I^b$ ,  $II_a$ ,  $II^b$ ,  $III_a$ ,  $III^b$ ) based on octave bands. The difference between the "best" and the "worst" reference curves is 18 dB. The curves are horizontal for the 125 and 250 Hz octave bands. Then it goes down in steps of 3 dB. The ISO/DIS 19488:2017 [10] proposes 6 classes in steps of 4 dB. These different approaches were evaluated and resulted in an alternative classification proposal.

#### 4. Comet table

#### 4.1 Problem identification

The "Comet table" is used for locally reacting materials, but could not be used for globally reacting layers under a screed (floating slab). The base floor (concrete slab) has limited dimensions. Figure 1 shows some vibration modes. They cannot be compared with the vibration modes of a full sized laboratory. The position of the tapping machine cannot be localised on the 20 cm thick reinforced concrete for frequencies over 400 Hz. The first resonance frequency of the base floor is 455 Hz.

#### 4.2 Calibration of the measuring system

The vibrations induced by a tapping machine on a full sized laboratory 15 cm thick reinforce concrete slab (base floor) were measured in 16 points.

This gave the red zone on Figure 2 which shows the area between the minimum and maximum measured values. The same was done on the 20 cm thick reinforced concrete of the "Comet table" in 40 positions. The idea was to use one tapping machine position on the "Comet table" and to select for each one-third octave band one of the available 4 accelerometer positions in order to fit the "Calibration table" curve in Figure 3 as close as possible to the "Average laboratory" curve. In that way the resonance frequency was filtered out. The first tests with a 4,5 cm thick reinforce concrete "screed" and resilient layers also measured in full sized laboratories were disappointing. The "flat" reference curve subtracted from a "non" flat resilient test curve gave very irregular  $\Delta L$  curves.

We then tried metal plates as a replacement of the concrete reinforced screed. This was not successful. The air "film" between the "slightly bended" metal plates gave weird results.

Finally we applied the same procedure as the first time with a 7 mm thick resilient layer in rubber (Isolgomma Roll 7). This resulted in Figure 4. The fitted "Comet table" accelerometer positions to the full laboratory test gave the irregular reference curve "Calibration rubber" on the concrete in Figure 3. These 4 measurement positions marked with crosses on Figure 1 yielded very good results for all the other more than 50 types of resilient layers and laminate coverings that were tested.



Figure 1: vibration modes (acceleration in dB) of the 20 cm thick reinforced concrete slab (125 cm x 80 cm).

As we wanted to simulate different loads on the natural blue stone instead of the 4,5 cm reinforced concrete "screed". Suddenly the setup did not work anymore as can be seen on the green curve in Figure 5. The same problems appeared with 6 and 10 cm levelling screeds. It was not possible to find new measurement positions that give results comparable to full scale laboratory tests. Then we used the 4,5 cm reinforced concrete "screed" again and added weight on the plate. Figure 5 shows the result. It worked again, the blue curve is for us acceptable. So, the mass is not the reason why it did not work. Vibration modes and not the mass of the floating screed seems to be the dominating factor.

# 4.3 Scrutiny of the results delivered by the method

Ten measurements were done over a period of 5 months on a same product to check the repeatability of the measurement procedure using the 4,5 cm reinforced concrete screed. This was done for 6 types of resilient layers. Figure 6 shows that the differences can go up to 10 dB at 3150 Hz over that period. The overall standard deviation on the  $\Delta L_w$  was 0,5 dB. The standard deviation between 100 and 3150 Hz of all the tests is given in Figure 7. It stays below the allowed interlaboratory curve according to ISO 12999-1 [11].



Figure 2: vibration measurements on a full sized laboratory slab (maximum – minimum = red zone).



Figure 3: vibration measurements on the "Comet table" (maximum - minimum = red zone).



Figure 4: best fit of the 4 table measurement positions compared to ISO 10140-3 results.



Figure 5: influence of the load on the resilient layer.



Figure 6: example of the repeatability over 5 months and 10 measurements (waffled rubber).



Figure 7: example of the repeatability over 5 months and 10 measurements (all 6 types of resilient layers).

## 5. INI-EVA ranking

The new "calibration" method makes it possible to compare dozens of materials under the same conditions in one day. The poor, average and excellent materials can easily be distinguished. None of the existing quantification methods (single values; classes; categories) were found adequate. Especially the single value system invites manufactures of resilient layers to force the highest possible  $\Delta L_w$  values into the contracts.

They want to exclude the competitors even for less demanding situations. Architects that do not know what they are talking about, simply focus themselves on a product with the highest possible  $\Delta L_w$ . They also often confuse the laboratory results with the in situ requirements.

Therefore, a new impact noise insulation label inspired by the sound absorption class of ceilings (ISO 11654) [12] was introduced. Figure 8 shows the INI-EVA label. It has 2 letters (A, B, C, D or E). The first letter indicates the result of the resilient layer without a levelling layer, the second letter indicates the result of the resilient layer with a levelling layer. The proposed classification is based on the one third octave bands of 100 Hz and 125 Hz. We found the octave bands of 125 and 250 Hz too "raw" to base a new classification system on. The following identification letters are used when the average ( $\Delta L_{100Hz} + \Delta L_{125Hz}$ )/2:

- is between > 10 dB and  $\leq$  15 dB B.
- is between > 5 dB and  $\leq 10$  dB C.
- $\leq 5 \, dB$  D.
- is not tested with a levelling layer or has no classification E.

We chose the increment in steps of 5 dB because of the accuracy issues at low frequencies.



Figure 8: example of an INI-EVA ranking label

#### 6. Future research

The top priority for future research is to understand why till now, only the 4,5 cm thick reinforced concrete that is used as a screed, works. A next item for future research is to examine the influence of the load (pressure) and time on resilient layers. Furthermore we will investigate if a shaker can be used instead of a tapping machine. Finally it is also interesting to know if the measurement procedure is applicable in full size laboratories.

#### 7. Conclusions

The "Comet table" can be used to measure  $\Delta L$  spectra of resilient and levelling layers (not locally reacting) starting from 100 Hz and higher, but not by applying the ISO 16251 procedures. Very specific measurement points must be chosen for each one third octave band and for one tapping machine position together with a specific screed. A very specific calibration procedure that must be followed was described in this paper. It opens new opportunities for manufactures of resilient and levelling layers to develop and compare new products in a quick and cheap way.

#### References

- [1] Foret R., Chéné J-B., Guigou-Carter C., A comparison of the reduction of transmitted impact noise by floor coverings measured using ISO 140-8 and IS/CD 16251-1, Forum Acusticum Aalborg, (2011).
- [2] Schmidt J-H., Wittstock V., Langer S., Uncertainties and validation procedures for the Compact Measurement Setup, Inter-Noise Melbourne, (2014).
- [3] EN ISO 16251, Acoustics Laboratory measurement of the reduction of transmitted impact noise by floor coverings on a small floor mock-up, (2014).
- [4] EN ISO 10140-3, Acoustics Laboratory measurement of sound insulation of building elements *Part 3: Measurement of impact sound insulation*, (2013).
- [5] Verbandt F., Vandendriessche J., Van de Velde B., *Impact noise annoyances*, Inter-Noise San Francisco, (2015).
- [6] NEN 5079, Geluidwering in woongebouwen Het weergeven in één getal van de geluidisolatie van bouwelementen, gemeten in het laboratorium, (1990).
- [7] ASTM E492-9, Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine, (2016).
- [8] ASTM E989, Standard Classification for Determination of Impact Insulation Class (IIC), (2012).
- [9] NBN S 01-400, Akoestiek Kriteria van de akoestische isolatie, (1977).
- [10] EN ISO/DIS 19488, Acoustics Acoustic classification of dwellings, (2017).
- [11] EN ISO 12999-1, Acoustics Determination and application of measurement uncertainties in building acoustics - *Part 1: Sound insulation*, (2014).
- [12] EN ISO 11654, Acoustics Sound absorbers for use in buildings - Rating of sound absorption, (1997).