Good acoustics with canopies – how to install them in the most effective way

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ABSTRACT

Concepts for architectural acoustics consider more and more modular sound absorbing elements like canopy islands. But without the knowledge about their operating principles it is a challenge to estimate the correct effect on the reverberation time. The aim of the research according to ISO 354 was to analyze the influence on the total absorption if we variegate different parameters like canopy dimensions, suspension height, distance between the elements and mounting angles. Beside that also the contributions of the different canopy surfaces (front face, reverse side and edge effects) are measured. A comprehensive understanding for these modular acoustic units will help us to use them in the right way.

Keywords: room acoustics, absorption, canopies

1. INTRODUCTION

In addition to classic laminar sound absorber like suspended ceilings or wall absorbers new architectural concepts consider more and more modular sound absorbing elements like canopy islands. In this context different material will be used but the most popular elements based on mineral wool or on acoustic foams (e.g. polyurethane foam).

Behind the use of this kind of elements there isn't only a design solution. In more and more situation it's necessary for the building concept with concrete core cooling systems because in that case a full suspended false ceiling isn't possible. To find out how to install such kind of elements on the best way we carried out a few measurement according to ISO 354.

1.1 Chamber room according to ISO 354

The measurements are carried out in the chamber room of the University of Applied Sciences at Stuttgart. The laboratory has an internal dimension (length x width x height) of 5.54 m (218 in) x 7.89 m (31 in) x 4.65 m (18.3 in) and from the concrete ceiling 6 diffusors (approx. 1.2 x 1.2 m) are suspended as shown in the picture. With a volume of 200 m³ (7063 ft³) we fulfil the requirements according to ISO 354 but we are on the lower limit because in this case we didn't need so many square meters of canopies to realize the measurements instead of using an chamber room with 400 m³ (14126 ft³) upper limit according to ISO 354).

1.2 Product information

For the measurement we are using our canopies OWAconsult® collection Selecta with the following dimension:

1.2 (47.2 in) x 1.2 m (94.5 in) and 2.4 x 1.2 m with a thickness of 40 mm (1.57 in).

The canopy based on mineral wool with a density of 110 kg/m³ (mass per unit area of 4.4 kg/m²) and is covered with a white painted fleece on all sides except the reverse side (without paint).

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1.3 Measurements

Based on the requirements according to ISO 354 canopies are single absorbers that means the sound absorption value α_s [-] can't be used. Therefore it`s necessary to use the equivalent sound absorption surface or total absorption value A_{object} [m²]. The problem of the A_{object} value is that we can't directly see how good the performance is related to the size of the element.

Based on that and for an easier handling, because the Alpha value is more common, all the results are presented as α_p (practical sound absorption) figures based on the front surface of the canopies. In this case we have to expect some α_p values will be greater than > 1 because the reverse side and the edges of the canopies will also absorbed energy and this absorption based on the dimension of the canopies, the suspension height and distance between the canopies.

2. Measurement results

2.1 Influence parameters of the sound absorption performance

The sound absorption performance of canopies depends on the following parameters

- Dimensions of the elements
- Suspension height (e.g. E40, E100, E200, E400)
- Distance between the canopies (50 mm / 2 in; 0.1 m / 4 in; 0.2 m / 8 in; 0.4 m / 16 in)
- Reverse side and edge absorption
- Additional acoustic layers on the reverse side (not test tested in this project)

2.2 Dimensions

To show the effect of the dimensions we build up following situations with a suspension height of 160 mm (E200) as shown in figure 1:

- **suspended ceiling build-up 3.6 x 2.4 m (142 x 94.5 in)**, that means the sides are covered with a MDF frame, so no sound energy can be absorbed by the reverse side
- **canopy size 3.6 x 2.4 m**
- **canopy size 1.2 x 1.2 m**
- **canopy size 2.4 m x 1.2 m**

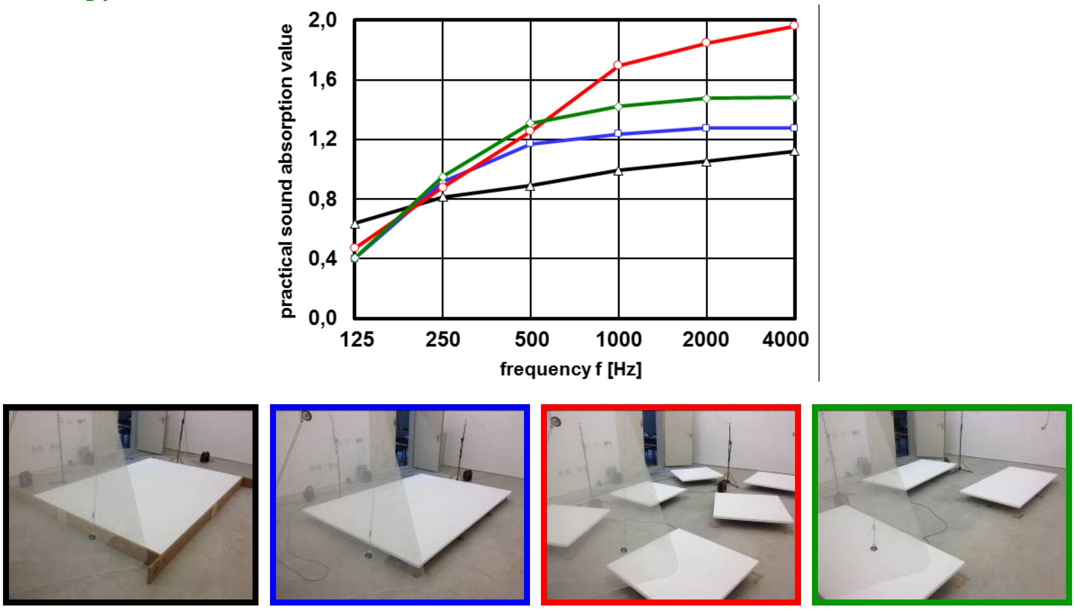

Figure 1 – practical sound absorption value for different dimensions for E200

Result: Small canopy dimensions offer higher absorption values because more energy can be absorbed by the reverse site. Therefore it's better to deal with α figures because by using the A value you will not detect that relationship.

2.3 Suspension height

The suspension height plays an important role for the reverse side absorption and therefore we realize a buildup for four situations:

- **E40 or 40 mm (1.6 in)**, similar to a direct fixing on a concrete ceiling (0 mm cavity)
- **E100 or 100 mm (4 in)**, that means 60 mm (2.4 in) cavity behind the canopy
- **E200 or 200 mm (8 in)**, that means 160 mm (6.3 in) cavity behind the canopy
- **E400 or 400 mm (16 in)**, that means 360 mm (14.2 in) cavity behind the canopy

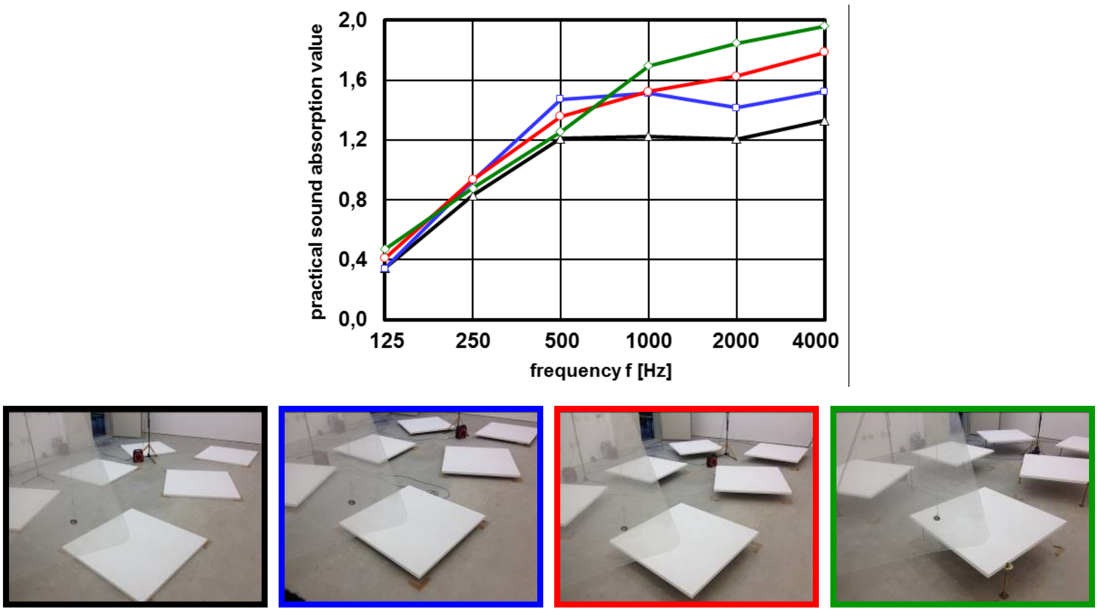

Figure 2 – practical sound absorption value for different suspension heights (canopy 1.2 x 1.2 m)

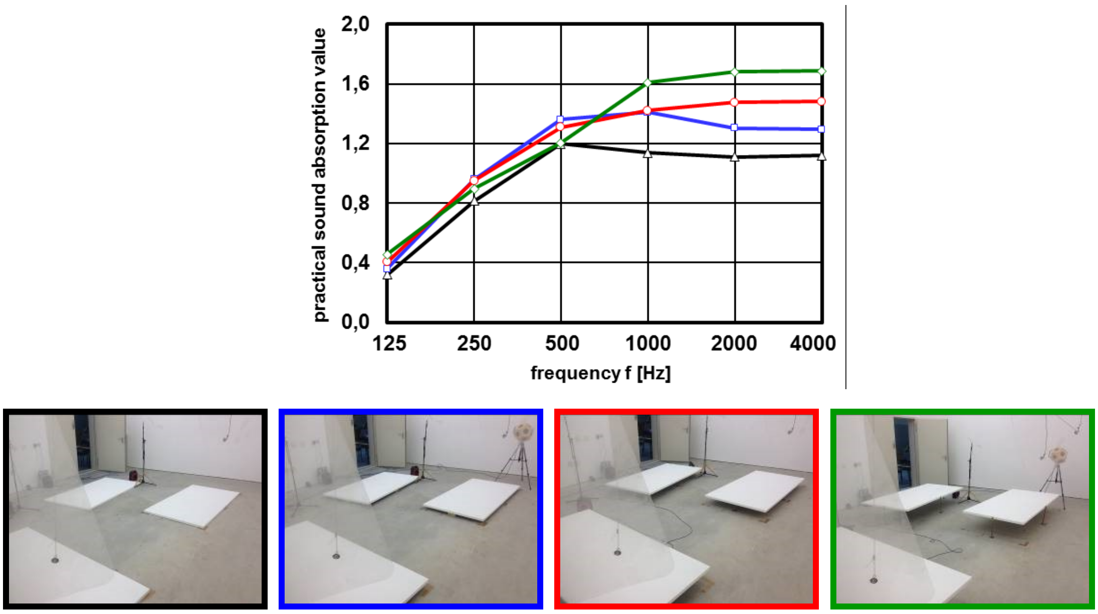

Figure 3 – practical sound absorption value for different suspension heights (canopy 2.4 x 1.2 m)

Result: Higher suspensions offer better absorption at the high frequencies but if you will generate an optimal absorption also in the mid frequency range it's necessary to install the elements with a distance of 0.1 - 0.2 m. In most real situation extreme high absorption at the high frequencies isn't requested so from our option the better effect at 500 Hz will helps more to improve the room acoustic comfort (reverberation time). For the low frequencies the suspension has an insignificant effect.

2.4 Distance between the canopies

In addition to the suspension height also the distance between the acoustic objects has a huge effect for the sound energy which can be absorbed by the back side. For that reason we set up the following 4 distances between a 1.2 x 1.2 m and 2.4 x 1.2 m canopy:

- **50 mm (2 in)** distance
- **100 mm (4 in)** distance
- **200 mm (8 in)** distance
- **400 mm (16 in)** distance

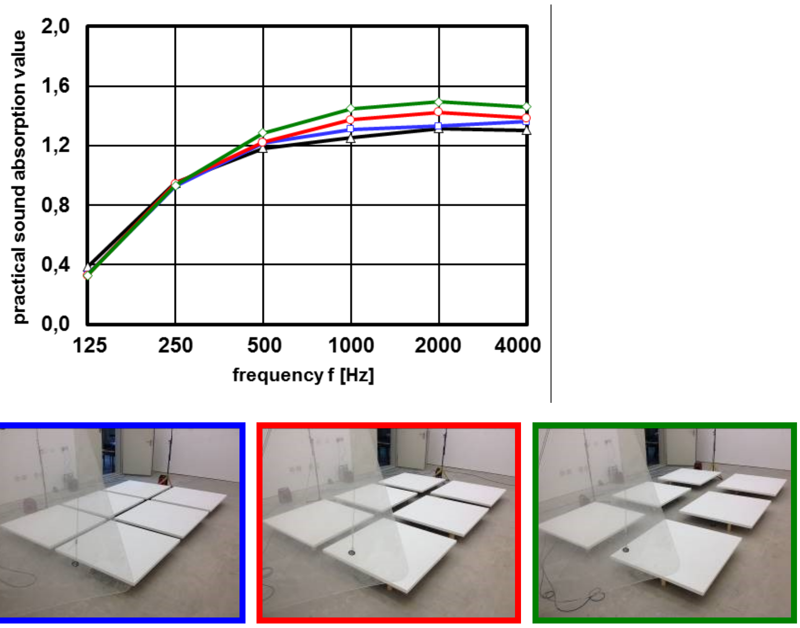

Figure 4 – practical sound absorption value for different distances between the canopies (canopy 1.2 x 1.2 m)

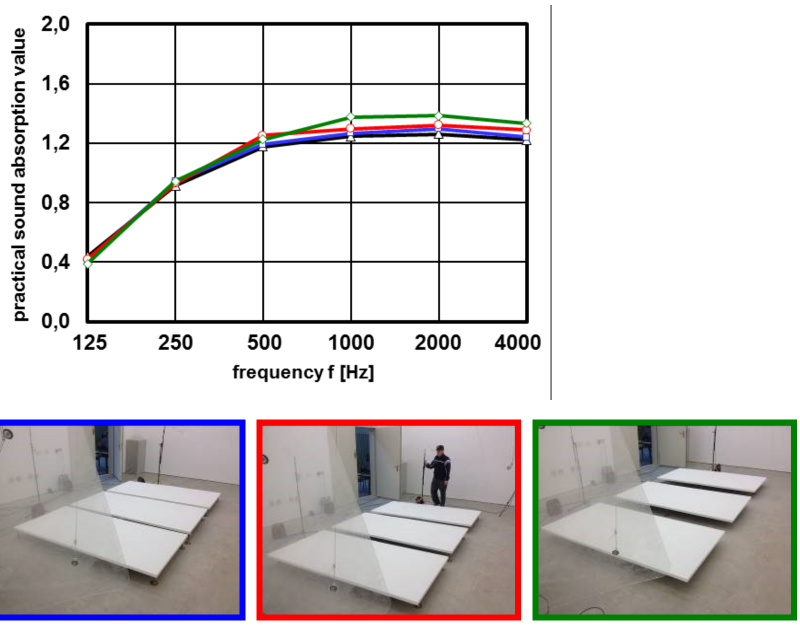

Figure 5 – practical sound absorption value for different distances between the canopies (canopy 2.4 x 1.2 m)

Result: As shown in figure 4 and figure 5 a systematic installation has a negative effect for the absorption because the gap between the elements limited the riverside absorption. A slot of 5 cm offers a performance similar to no distance between the elements (as illustrated in blue curve at figure 1). By increase the slot distance the performance moving more and more to the diffuse installation as pictured at the red curve on figure 2 for canopy 1.2 x 1.2 m and figure 3 for canopy dimension 2.4 x 1.2 m.

2.5 Reverse side absorption

To carry out the effect of the reverse side absorption we cover the front and reverse side of the canopies with a 10 mm MDF tile (density 700 kg/m³; mass per unit area of 7 kg/m²). The result of the following build up (E200) are shown in figure 6:

- **10 mm (0.4 in) MDF tile only**
- **1.2 x 1.2 m canopy without MDF tile**
- **Canopy rear side covered with 10 mm MDF tile**
- **Canopy front side covered with 10 mm MDF tile**

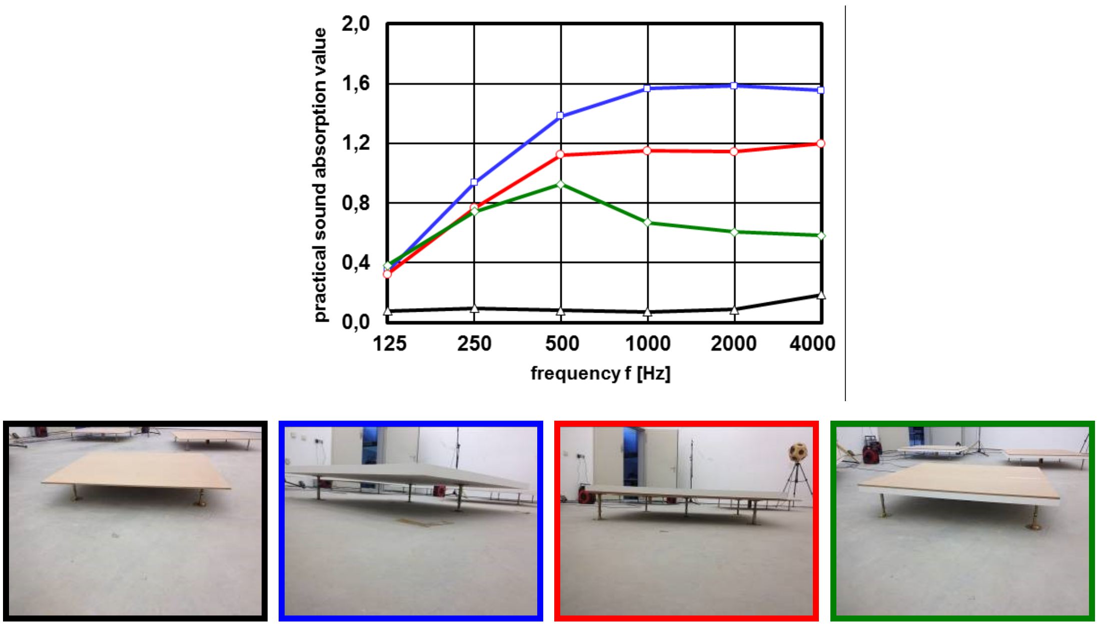

Figure 6 – practical sound absorption value of the full canopy, only the front side and only the reverse side

Result: The reverse side absorption generate a 20 up to 40 % higher performance in the middle and high frequency range. For the low frequency range the reverse side absorption plays no roll.

By covering the front side with a MDF tile it's possible to generate a kind of resonance absorber with a peak at 400 and 500 Hz. The high frequency performance drops down to 60 %.

If you compare the result of the reverse side covered canopy (E200) and the measurement where the elements are directly fixed on the floor (E40), you can see that the results are very close to each other.

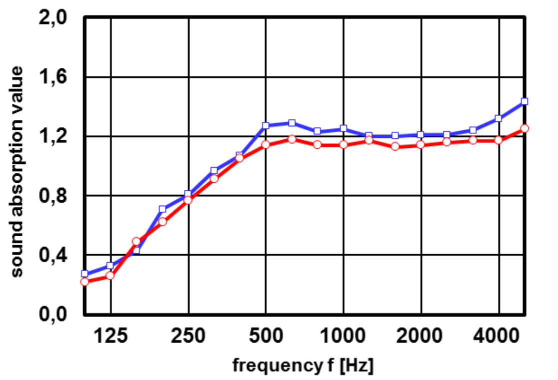

Figure 7 – sound absorption of **canopy E40** vs. **rear side covered with 10 MDF tile (E200)**

2.6 Edge absorption

Not only the front and reverse side can absorb sound energy maybe also the fleece covered edges could have an effect on the performance. Therefore we cover the edge with a 10 mm MDF tile to compare it. The next diagram shows the results for the settings (E200):

- **1.2 x 1.2 m canopy**
- **1.2 x 1.2 m canopy with MDF tile covered edges**
- **Canopy front side covered with 10 mm MDF tile**
- **Canopy front side and edges covered with 10 mm MDF tile**

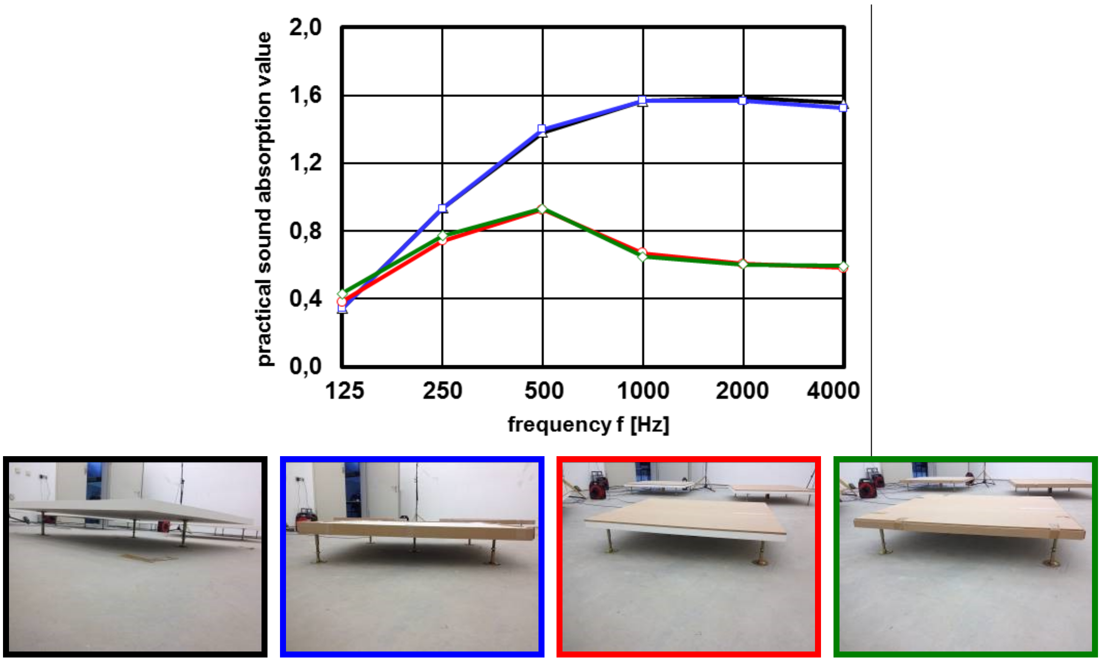

Figure 8 – practical sound absorption value to determine the edge effect

<u>Result:</u> The edges didn't affect the sound absorption performance because the glue on the edges reduces the porosity of the fleece on a low level.

2.7 Plate resonator

By covering both sites of the canopy with a MDF tile we would like to find out if it's possible to generate a low frequency absorber / plate resonator. Therefore we cover the front and reverse site with a **3 mm HDF tile** (density 856 kg/m³; mass per unit area 2.57 kg/m²) and **10 mm MDF tile** (density 700 kg/m³).

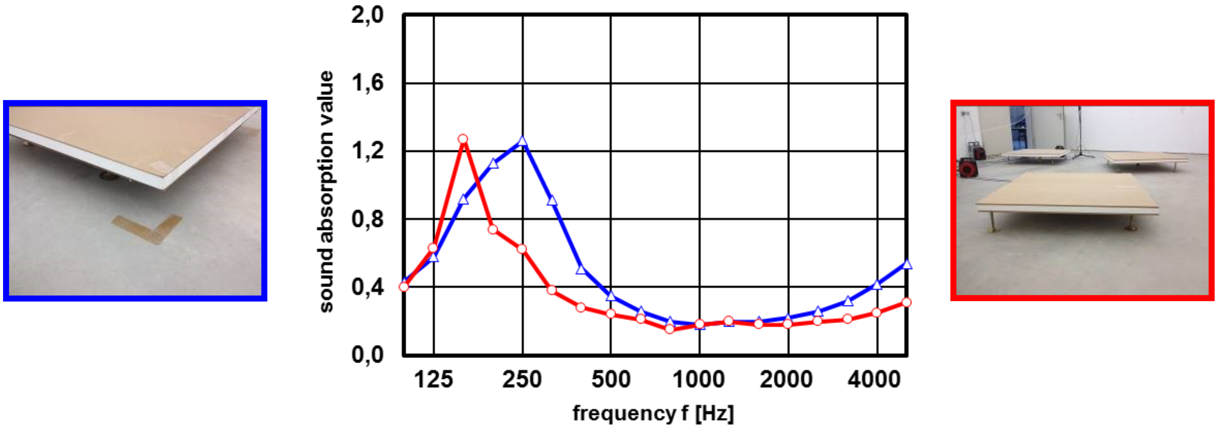

Figure 9 – sound absorption value by covered front and reverse site

Result: By covering both sites with a timber tile (edge will not absorb sound as shown in figure 8) it's possible to generate a low frequency resonator at 160 Hz (with 10 mm MDF tile) or at 250 Hz (with 3 mm HDF tile) with an outstanding performance of more than 100 %.

3. CONCLUSIONS

This paper shows in 9 figures the most important effects on the absorption performance of modular acoustic canopies. In the presentation we will show more details and results.

In the near future we would like to improve the low frequency absorption of the modular canopies. First results has been shown in figure 8 and 9. Further research is necessary because we need more facts for the relation between laboratory values and building site results.