ODEON APPLICATION NOTE

Modelling baffles

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Scope

In this application note we show what is the best way to model baffles inside ODEON.

Terms and definitions

Practical absorption coefficient, α_p

It is calculated from the 1/3-octave-band absorption coefficient, measured in a reverberation chamber according to ISO 354 [1]. It is expressed in 1/1 octave bands as an average of the three 1/3 bands that constitute a full 1/1 octave and it is truncated to 1, for values greater than 1 [2].

Weighted absorption coefficient, α_w

It is a broadband value, calculated from the practical absorption coefficient upon comparison with a reference curve [2].

Sound absorption classes

These are five classes, from A to E, which are derived according to the value of α_w. Class A corresponds to α_w equal or higher than 0.9, while class E corresponds to values between 0.15 and 0.25. Anything below 0.15 is not classified [2].

Equivalent absorption area

It is the area that a fully absorptive surface would occupy to offer the same amount of absorption as the actual surface. The unit is m^2 or occasionally *Sabines* (which refers to the famous Sabine reverberation time formula, that uses the equivalent absorption area in the denominator).

Use of baffles in general

Baffles (or *free-hanging units*) are basically absorption panels, which are hanged freely in space, either horizontally or vertically. Their most important benefit is that a larger area of absorption is exposed to the sound field (2 sides exposed), in contrast to simple absorbing panels mounted directly on the ceiling or wall (1 side exposed).

Using baffles is a good solution when it comes to localised acoustic treatment in a large venue. For example, baffles can be concentrated above the check-in desks inside a noisy airport to provide better speech intelligibility. Another important application is in open-plan offices, where baffles can be installed above the workplaces to reduce the sound propagation and increase the privacy from one desk to another.

Calculating Absorption Coefficient

Usually baffles are often specified by the *equivalent absorption area* (or simply *absorption area*). This is the area that a fully absorptive surface would occupy to offer the same amount of absorption as the actual surface. The unit is m^2. The *equivalent absorption area* A, is calculated by multiplying the absorption coefficient, α, with the area S. Therefore, if we know the equivalent area A of baffle whose surface is S, the absorption coefficient to be used in ODEON will be:

$$\alpha = \frac{A}{S}$$

For this equation it is important to make sure whether the given A corresponds to **one** side of the baffle or to **both** of them. This can be informed by the manufacturer of the baffle and the way the absorption area was measured (usually supplied in the datasheet). If *A* corresponds to both sides, then *S* is two times the area of the baffle.

A typical case where *A* corresponds to one side of the baffle would be if the sample has been laid on floor during absorption measurement in the *Reverberation Chamber*. If the baffle was suspended free in space during the measurement, then *A* corresponds to both sides.
The overall area *S* should include the area of the edge (thickness) of the baffle, as it can have some impact in the final absorption coefficient especially for the thickest baffles.

If the *absorption coefficient* is provided instead of the absorption area, then we can use this directly. Any value higher than 1 must be truncated to 1 for use in ODEON or even better to 0.95, as it is practically unrealistic to have a surface that absorbs the entire sound energy that impinges on it. If the *practical absorption coefficient* is given, it can be used directly in ODEON, by applying the same recommended limit 0.95.

This data is typically given in 1/1 Octave bands from 125Hz to 4000Hz. In such case, the missing bands 63Hz and 8000 Hz in ODEON can be copied from 125Hz to 4000Hz respectively.

How to model a single baffle in ODEON

Baffles should generally be modelled as they are. However, if their thickness is less than 10 cm, they can be modelled as surfaces without thickness. Note that the absorption coefficient in ODEON is always assigned to both sides of the surface. It is good to remember that the absorption coefficient is independent from the size of the surface.

It is important to understand that even if the thickness is not modelled in the geometry of the baffle, the effect in absorption should be still taken into account in the calculation of the overall area *S*, as described in the previous section.

Regarding scattering coefficient, there is typically no reason to assign a value other than the default in ODEON. Baffles are usually very smooth, therefore no roughness would excuse high scattering coefficient. However, a minimum degree of scattering is necessary for any surface, that is why the ODEON's default value is a good recommendation.

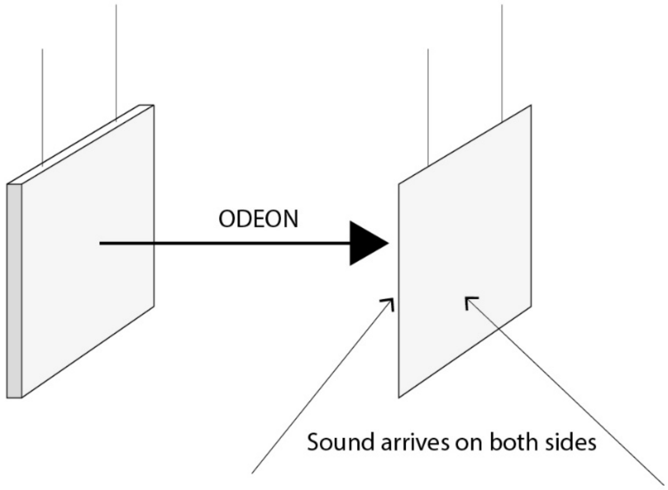

Figure 1: A thin baffle (less than 10cm thick) can be modelled as a surface without thickness in ODEON. ODEON automatically takes both sides into consideration.

Spacing

Manufacturers often specify the absorption area or the absorption coefficient based on a specific distance between the baffles. Therefore, pay attention to place your baffles in same distance in your ODEON model and use the corresponding absorption data. Different spacing between the baffles can change the absorption characteristics significantly.

For *horizontal* configurations, the baffles should be placed typically **less than 50 cm** from each other, in order for a compound absorption effect to take place. For distances longer than 50 cm, the absorption area per baffle will correspond to a single unit [3].

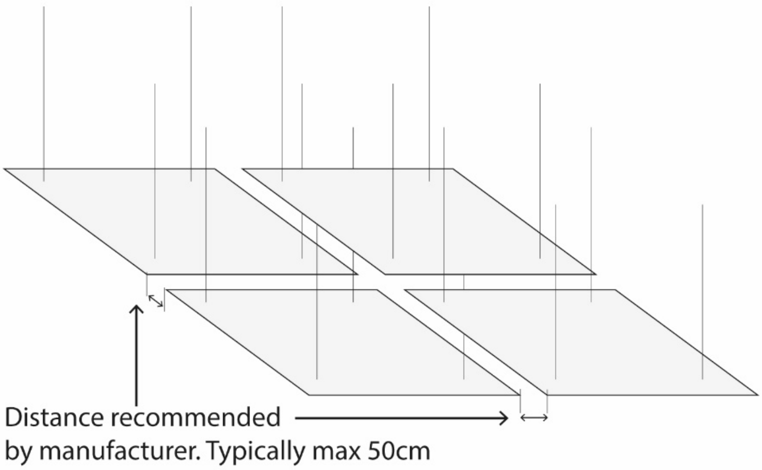

Figure 2: Spacing of horizontal baffles (modelled as plain surfaces) in an ODEON model.

For *vertical* configurations, the maximum distance between the baffles can typically be larger than 50cm, but it is always advisable to keep the exact recommendation by the manufacturer.

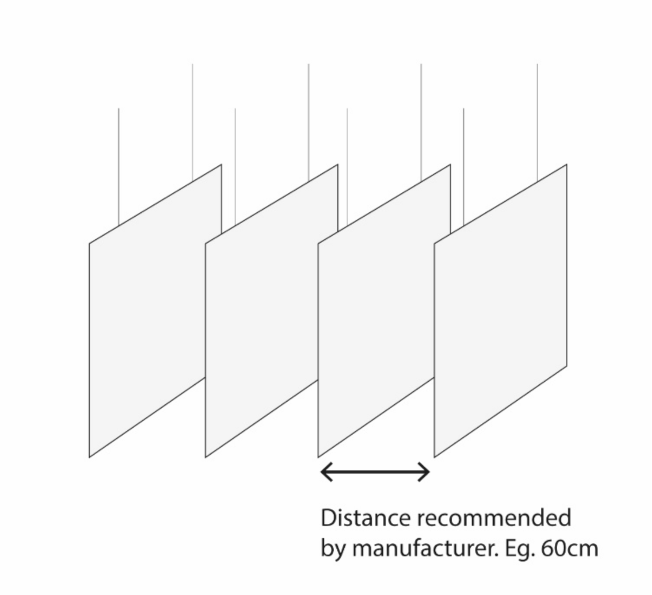

Figure 3: Spacing of vertical baffles (modelled as plain surfaces) in an ODEON model.

Example

Each baffle in a *vertical* configuration has dimensions 1.8m x 0.6m x 4cm and absorption area 0.9 m^2 at 1kHz for the whole baffle (both sides). The spacing of the baffles must be 60 cm – according to manufacturer's recommendation. The geometric area *S* of the baffle, including the edges is:

$$2 \text{ (sides) } x\ 1.8\ x\ 0.6 + 2x1.8x0.04 + 2x0.6x0.04 = 2.35\ m^2$$

The absorption coefficient is calculated as 0.9/2.35=0.38 at 1 kHz. The same calculation is performed for the rest octave bands. We should model the baffle as a plain surface 1.8m x 0.6m and assign the calculated absorption coefficient. Any other baffle should be placed 60 cm away from its neighbouring ones.

How to model a group of baffles

So far, we have seen a straightforward way of modelling baffles by placing them one by one in our geometry. However, some manufacturers provide data for a specific configuration of baffles, as a whole – in terms of absorption coefficient. This is typically the case for dense spacing (small distance between them).

In such a case the best way to model the baffles in ODEON is to make a big box that encapsulates the whole baffle configuration. Assign the absorption coefficient as supplied for the baffles and a high scattering coefficient of about 0.7 to account for the high degree of roughness from the configuration. See more in chapter 2 in the ODEON manual [4].

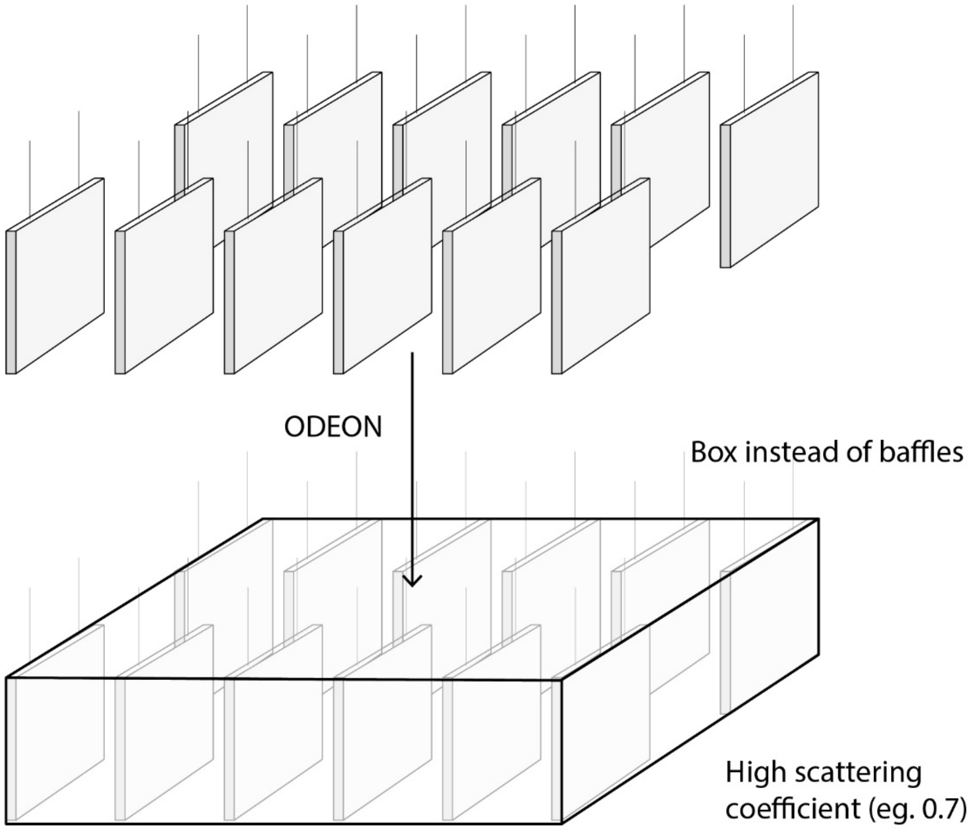

Figure 4: Baffles modelled as one box, if the absorption coefficient is given for the whole ensemble.

References

1. ISO standard 354, Acoustics – Measurement of sound absorption in a reverberation room.
2. ISO standard 11654, Acoustics – Sound absorbers for use in buildings – Rating of sound absorption.
3. Ecophon – Saint-Gobain. Knowledge Guide: Sound absorption – free hanging units vs. full ceiling.
4. ODEON Room Acoustics Software: Manual, version 16, Odeon A/S, Denmark 2020 (https://odeon.dk/download/Version16/OdeonManual.pdf).