# Investigation of the Influence of Incident Angle and Frequency Dependence of a Ceiling Absorber on Room Acoustic Descriptors

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*This thesis is about how ceiling absorbers can help with acoustical design in classrooms.*

*The study shows that knowing the reverberation time is not enough when designing a good studying environment. More parameters must be used, for instance the sound pressure level.*

Sound has a great impact on people's life. It is important to be comfortable when working, playing or studying. In this thesis, the concern is the classroom. Noisy studying environment can be stressful and good sound quality can improve concentration, memory and speech clarity. Controlling sound in a classroom is the key to making this happen and absorbers play an important role. It is important to investigate how the different parameters of acoustics can be used and controlled to make the environment as good as possible for studying.

The aim of this thesis was to see how ceiling absorbers influence room acoustic descriptors like sound pressure level and reverberation time, the angle and frequency dependency of the ceiling absorbers and how the furniture affect the sound. The scattering effect of furniture were investigated as well.

The main work of the thesis has two parts, calculations and measurements. In addition the thesis also contains the theory of acoustic parameters and different standards and regulations.

The first main part is the calculations. They were made with the software package WinFlag. The incidence angle and frequency dependence of the absorption coefficient were calculated for different types of absorbers, with different frequency absorbing characteristics and thicknesses.

The second main part  is the measurements. A model of a classroom with removable furniture was made of wood in the scale 1:3. The measurements were made for different ceiling absorbers, which was changed before every measurement. Each ceiling absorber had different sound absorption characteristics. This was done to investigate how acoustic parameters chance with different absorbing characteristics and thicknesses.

Measurements were made for both classroom with furniture and in an empty room. This was done to investigate the scattering effect of the furniture.

The calculations show both frequency dependence and the angle dependence of the sound absorbers. It shows as well that if the surface layer is denser the absorption coefficient is lower, at least for the higher frequencies. For a given density, the thickness of an absorber affects the behavior of the absorption coefficient: if the absorber is thicker than the sound absorption is higher, but if the absorber is thinner it reflects more. The measurements show that reverberation time and sound pressure level are affected by the furniture, especially in lower frequencies. The scattering effect of the furniture is more for the higher frequencies.

Evaluating the acoustics in rooms with absorbent ceilings generally requires the use of several room acoustic parameters, related to acoustical qualities such as sound strengths, speech clarity and reverberance.

When using reverberation time to estimate the decrease in sound pressure level in rooms with absorbent ceilings the sound pressure level achieved is generally underestimated. It is therefore important to evaluate the reverberation time and sound pressure level separately.

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