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Room acoustics meets TABS (Thermally Activated Building System) – Practical results for strip absorbers in concrete ceilings

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ABSTRACT

Due to steadily rising energy costs and the increasing planning requirements for sustainable building concepts, more and more architects are considering TABS (**T**hermally **A**ctivated **B**uilding **S**ystems) in the ceilings and walls of their projects. It is precisely this use of large-area concrete components with integrated cooling and heating pipes that leads to major challenges in achieving room acoustical requirements according to national standards. The objective of ensuring both thermal and room acoustic comfort is only possible through targeted and solution-oriented cooperation between architects and acoustic planners. This article discusses the reverberation time results obtained from a series of practical projects for a strip absorber principle integrated directly in the concrete ceiling. It will be shown how successful the different solution concepts perform in relation to the room acoustic requirements.

Keywords: Room acoustics, Reverberation Time, Thermally Activated Building System

1. INTRODUCTION

Thermally Activated Building Systems (TABS) hereinafter referred to as concrete core activation has become an established solution in architecture. From an energetic and climatic point of view, concrete core activation of concrete ceilings makes sense. But in office and administration buildings, the sound-reflecting property of concrete has a negative effect on room acoustics.

On the other hand, field studies repeatedly make it clear, that people feel disturbed at their workplaces in particular because of the noise and temperature conditions [1]. In order to react to these negative user feedback, different acoustic measures can be used in buildings with concrete core activation. Over the past 10 years, so-called strip absorbers integrated directly into the concrete ceiling have become established on the market. The results presented here mainly show practical results that were determined only with strip absorbers or in combination with strip absorbers.

2. BACKGROUND

2.1 Absorber principle

The strip absorber was developed at the Fraunhofer Institute for Building Physics (IBP) in Stuttgart [2]. With a homogenous surface, only geometric reflections occur (see Figure 1). As soon as an inhomogenous surface or periodically arranged strip absorber principle [3] is selected, scattered waves are additionally generated (see Figure 2). This installation principle achieves a significantly higher sound absorption performance than the area average of the absorber and concrete surface suggests. As a result, higher acoustic efficiency can be achieved with a small number of sound absorbers. The negative influence on thermal efficiency can be kept very low by 3% to 8%.

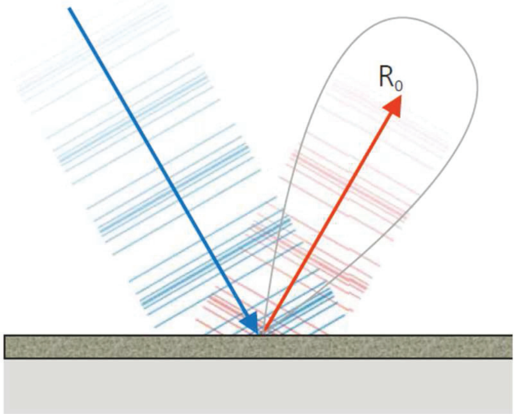


Figure 1 – Reflections on a homogeneous surface

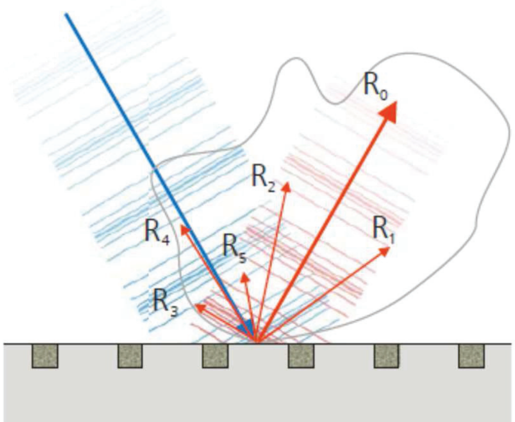


Figure 2 – Reflections on an inhomogeneous surface

2.2 Absorber properties and installation principle

The sound absorber Sorp 10® consists of a pressure-resistant fiber concrete U-profile in which a sound-absorbing expanded glass granulate element is glued. The Sorp 10® elements are simultaneously spacers and sound absorbers in one. The absorber elements have the dimensions 1200 x 70 x 36mm (see Figure 3). They are simply glued to the formwork panels with a center distance of a = 250mm at a very early stage of the construction site. The weighted sound absorption coefficient for this installation arrangement is $\alpha_w = 0.40$ (see Figure 4). The area occupied by sound absorbers varies between 15% and 25%.

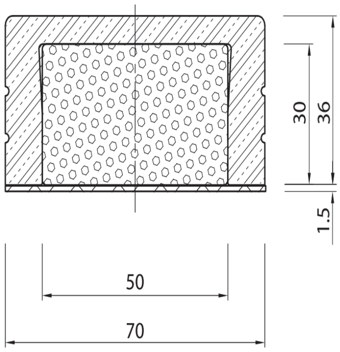


Figure 3 – Sectional drawing and dimensions of Sorp 10®

2.3 Determination of sound absorption properties

The sound absorption properties of the Sorp 10® elements were measured according DIN EN ISO 354 [4] in a chamber room. To determine the sound absorption properties, 42 strip absorbers each measuring 1200 x 70 x 36mm were laid out directly on the LAB floor in 14 x 3 strips. The test surface was 3.32 x 3.60m ≈ approx. 12m². The centre distance between the absorbers was 250mm. The clear distance between the absorbers is 180mm and was designed with sound reflective chipboard. Figure 4 shows the frequency-dependent sound absorption data determined for the Sorp 10® during these LAB measurements. With the test setup shown in Figure 5, a weighted sound absorption coefficient of $\alpha_w = 0.40$ was determined.

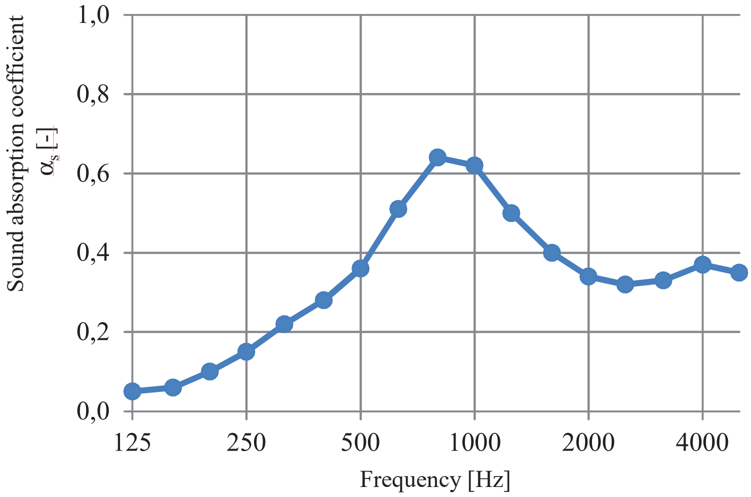


Figure 4 – Sound absorption curve

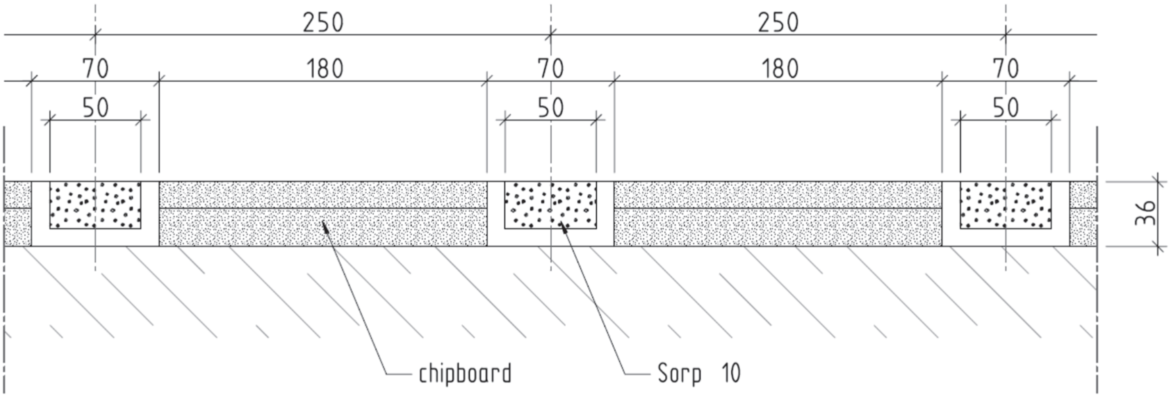


Figure 5 – Sectional drawing of the laboratory test setup

3. RESULTS AND DISCUSSION

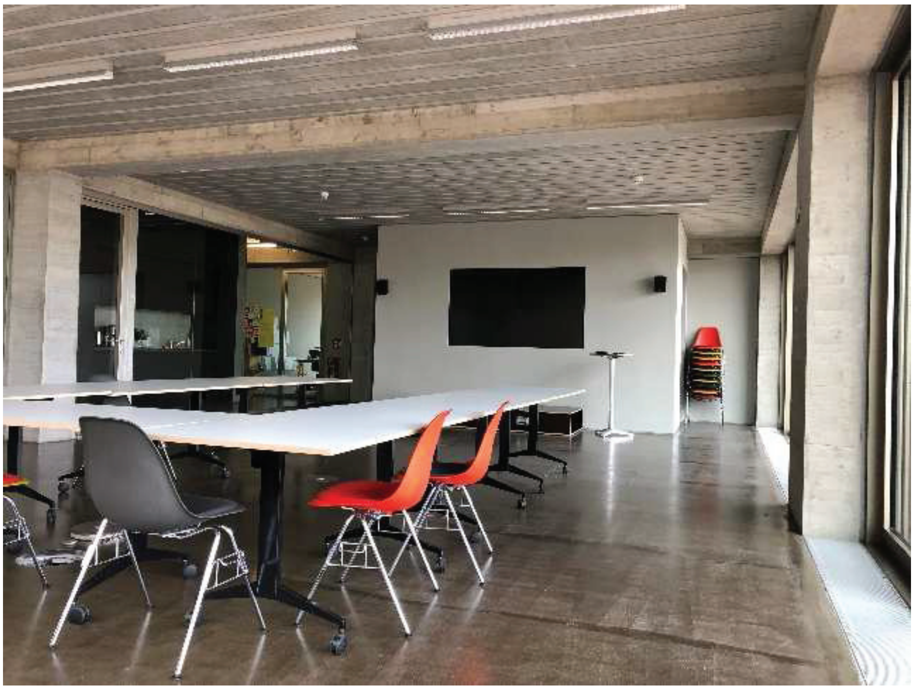
The presented reverberation time results were carried out in accordance with ISO 3382-2 [5]. The evaluation of the reverberation time results were carried out in accordance with DIN 18041 [6].

3.1 Conference room

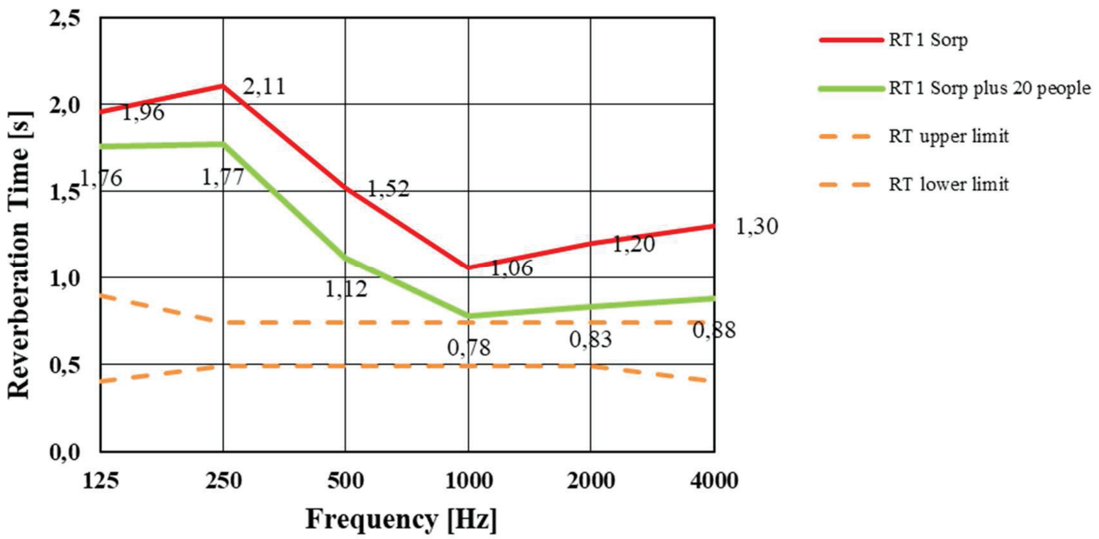
Table 1 – Key information for the conference room

Key information	
Floor area	95m^2
Room height	3,05m
Room volume	290m^3
Type of usage according DIN 18041	education communication
Required Reverberation Time (RT)	0,62s
Measured average Reverberation Time (125Hz-4000Hz)	1,53s Sorp 10®
Acoustic measures	19m^2 (20%) strip absorber Sorp 10®

Photo 1 – C-CON Conference room, C-HUB Mannheim, Germany



The conference room was acoustically not designed by an acoustician. In this project, Sorp 10® was the only considered sound absorbing measure. Unfortunately, there were no comparison room without Sorp 10® in this project. We could have carried out a reverberation time calculation. But the reverberation time calculation assumes a diffuse room condition. In the present case, however, we had a room with little or insufficient sound diffusivity. For this reason, we don't show the calculation results for a bare concrete ceiling. We believe that a comparison of results only enables a reliable product assessment if it has been carried out under the same building site conditions. It can be assumed, however, that the use of strip absorbers provides significantly better reverberation time results compared to a sound-reflecting concrete ceiling. But that alone isn't enough to meet the high reverberation time requirements according to DIN 18041 (see Graphic 1). On the other hand, the room-acoustic contribution of the strip absorber will have to be investigated even more closely in the future.



Graphic 1 – Reverberation time results for the conference room (with/without people)

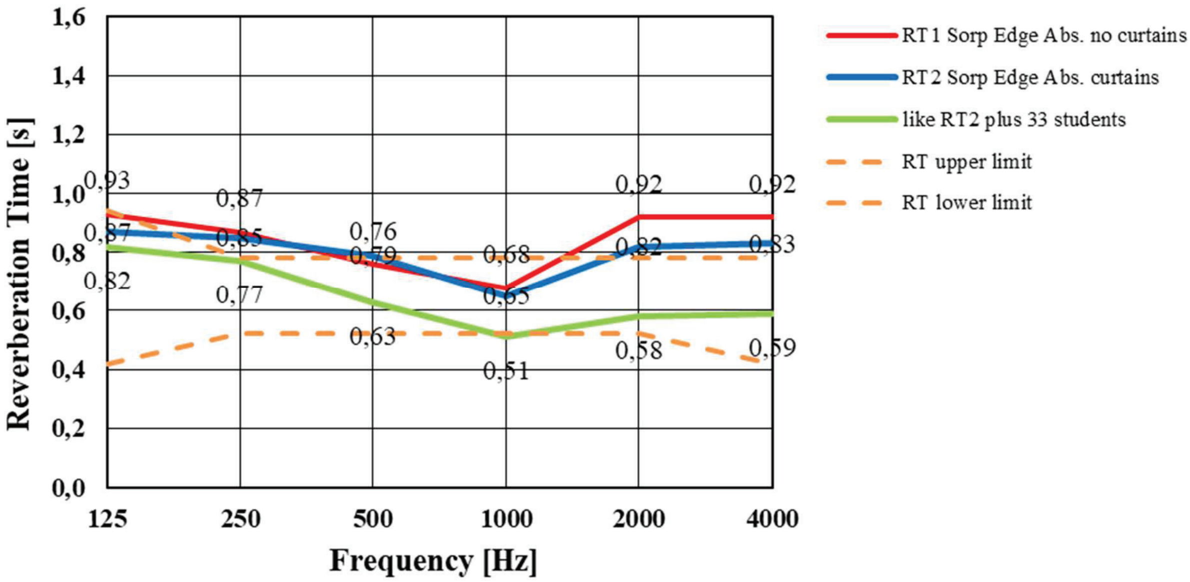
3.2 Lecture hall

Table 2 – Key information for the lecture hall

Key information	
Floor area	120m^2
Room height	3,04m
Room volume	365m^3
Type of usage according DIN 18041	education communication
Required Reverberation Time (RT)	0,65s
Measured average Reverberation Time (125Hz-4000Hz)	0,85s Sorp 10® + Edge abs.
Acoustic measures	24m^2 (20%) strip absorber Sorp 10®
	sound absorbing curtains and blinds
	edge absorbers made of perforated metal

Photo 2 – Lecture hall 105, Zeppelin University Friedrichshafen, Germany

To achieve the high requirements according to DIN 18041 the acoustic concept of the lecture hall was designed by an acoustician. The concept was not only based on strip absorbers. Linear edge absorbers based on perforated metal elements with acoustic fleece and glass wool layer plus sound absorbing curtains and blinds were also considered. This combination allows a significant improvement in the reverberation time and meets the requirements (see Graphic 2).



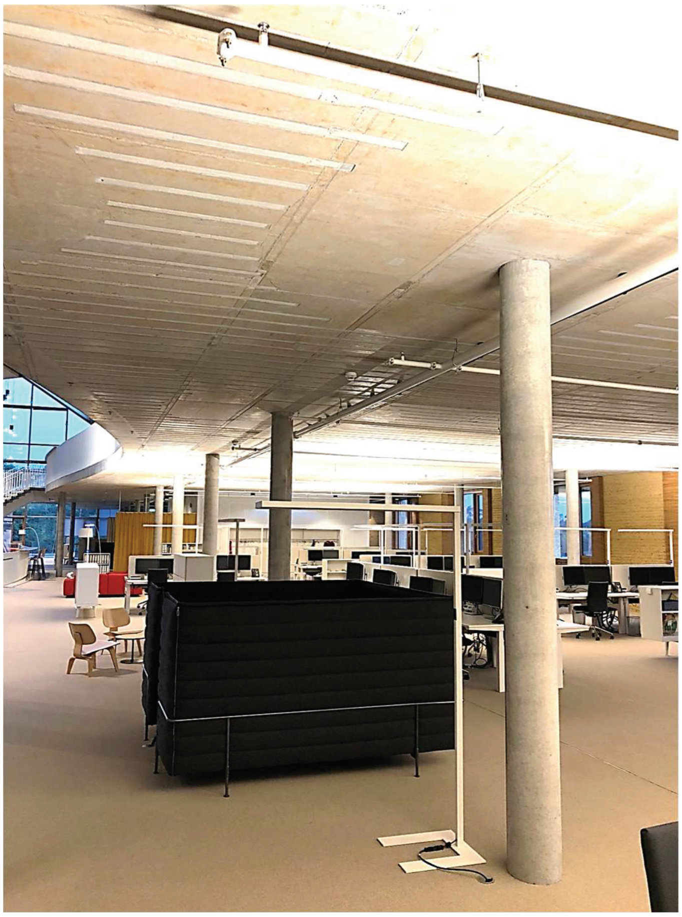
Graphic 2 – Reverberation time results for the lecture hall (with/without people)

3.3 Open-Plan Office

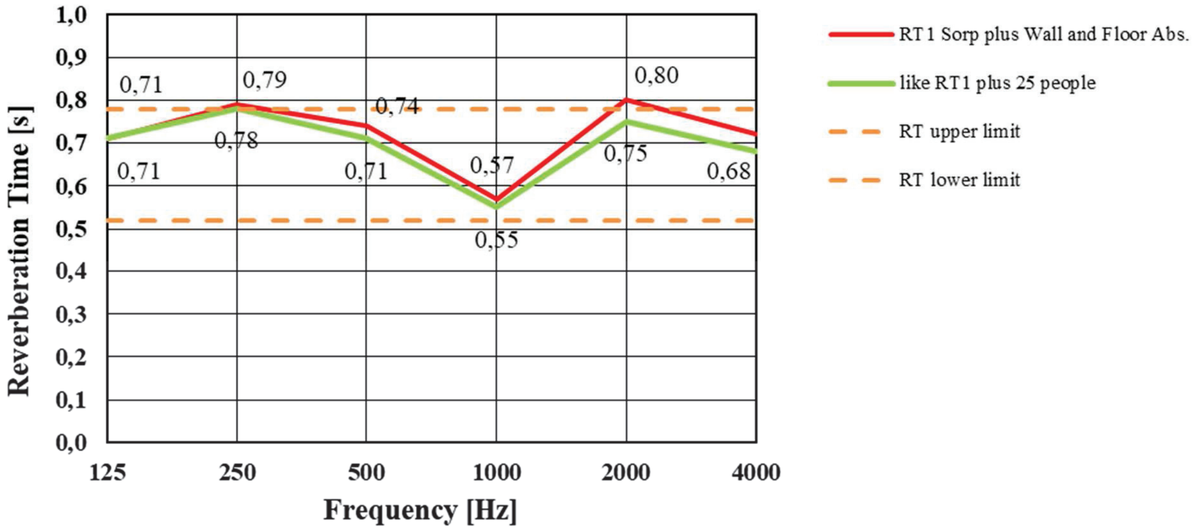
Table 3 – Key information for the open-plan office

Key information	
Floor area	472m^2
Room height	3,50m
Room volume	1648m^3
Type of usage according DIN 18041	open plan office
Recommended Reverberation Time (RT)	0,65s
Measured average Reverberation Time (125Hz-4000Hz)	0,72s Sorp 10®+ walls and floor
Acoustic measures	71m^2 (15%) strip absorber Sorp 10®
	sound absorbing clay walls and slotted wood
	carpet

Photo 3 – Open-Plan Office, Alnatura Campus Darmstadt, Germany



The acoustic concept of the open-plan office was designed by an acoustician. The room acoustic concept is based on a combination of different acoustic products. While the sound absorber Sorp 10® was used on the ceiling, sound-absorbing clay walls and slotted wooden panels were used in the wall area. The floor was covered with carpet. In this building, all rooms are connected to a large volume. Even though the sound-absorbing surfaces in the wall and ceiling areas were not very large, it was possible to achieve good room acoustics for the employees due to the well distributed arrangement of the absorption measures and their efficiencies (see Graphic 3).



Graphic 3 – Reverberation time results for the open-plan office (with/without people)

4. CONCLUSION

In this paper the room acoustic measurement results of strip absorbers in concrete core activated buildings were presented. The results clearly show that strip absorbers have a good contribution to reverberation time reduction, despite the low surface area. Since the room acoustical requirements in a lot of buildings are quite high, it's highly recommended to involve an acoustician at an early stage of the planning. In the future, comparisons of bare concrete slabs and strip absorbers should be investigated. The comparison with other sound absorbing concepts in concrete core activated buildings would also be very useful.

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