Less sound absorption is (almost) just as good - practical comparison in classrooms

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Summary

The results of a large number of room acoustics studies, especially in classrooms, have repeatedly shown how overestimated the sound absorption coefficient of suspended ceiling systems is handled. The legend / argument of "the higher the degree of absorption the better" hasn't been confirmed in practical investigations. In the rooms studied, the inadequate sound diffusion of the examined rooms was often much more decisive than the pure absorption level. The previous findings make it clear that classroom acoustics require a properly balanced concept of ceiling and wall rather than the general use of highly absorbent acoustic products.

With acoustic concepts that are oriented towards project-related requirements, even more economical acoustic concepts for schools are possible. The practical experience gained over the years and the presentation based on different study results.

1. Introduction

The obtainable reduction in reverberation time in classrooms has become a battlefield for acoustic product providers. The ongoing discussion about absorber classifications and decimal points is confusing, OWA and the Fraunhofer-IBP did a research regarding the influence of various room damping methods. The result: The requirements made in DIN 18041 (DIN = German Institute for Standardization) can be upheld, by using extremely varied product quality-levels.

The acoustic planning of classrooms has been given special emphasis in the new edition of the DIN 18041 "Acoustic quality in rooms – Specifications and instructions for the room acoustic design", released in March 2016 emphasizes the planning of classrooms with focus on the acoustic. Since worldwide studies have shown that teaching and learning conditions can be positively influenced by creating an acoustic which is adapted to the function of the room. The new edition of the DIN 18041 had to address the issue. With the specification of so-called preferred reverberation times in regard to room function and volume, appropriate acoustics should now be guaranteed. The introduction of the DIN 18041, allows the planners to choose from a multitude of product solutions surrounding classroom acoustics. In this regard, the indispensability of the so-called "A-class products" is often emphasized. But in terms of granted preferred reverberation times, the DIN 18041 never deals with the sound absorber classifications when speaking of guaranteeing preferred reverberation times. Finally this variety consulting strategies have led to a noticeable uncertainty, especially among planners. This is the reason why OWA a provider of acoustic products, has contracted the Fraunhofer Institute for Building Physics (IBP) to launch comprehensive practical studies.

These examinations should demonstrate the effects of the various solution concepts with regard to:

- Reverberation time RT [s]
- Clarity level D_{50} [%]
- Speech Transmission Index STI [-]

By examining the technical measurement results of classrooms with varying acoustic equipment, answers will be found to the following questions:

1. What influence do false ceilings with differing sound absorption qualities have on the examined assessment criteria (for ex., reverberation RT, clarity level D_{50}), when no other surfaces (for ex., walls) are covered in sound absorbent materials?
2. How are acoustic criteria affected when, in addition to the dropped ceiling, an absorbent pin board is attached to the rear wall?
3. Are solutions conform to DIN regulations, only possible by using materials with the absorption classification A, or can the requirements listed in the DIN 18041 also be fulfilled by using materials of another classification?

Figure 1. Classroom with acoustic ceilings.

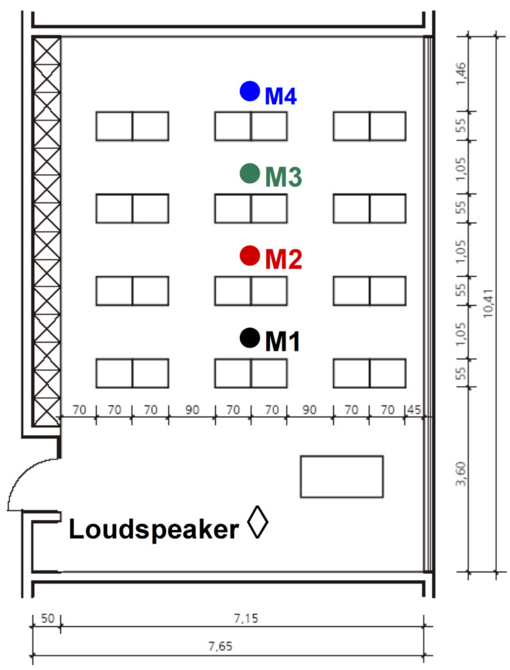

Figure 2. Floor plan and furnishing of the classrooms (S = 71 m², V = 220 m³). Measurement points M1 – M4 and positioning of the loudspeaker for D_{50} and STI.

2. Measurements

The practical testing was conducted at a secondary school at the “Klostergarten” in Sindelfingen, Germany. All rooms have been with identical furnishings, shape, and equipment (see Fig. 1 and 2). A variety of configurations of acoustic altering measures were implemented, for which the reverberation and the monaural impulse responses were determined metrological. In the following a selection of input from the comprehensive testing by Fraunhofer-IBP is shown which represents some of the most significant results and test configurations. Essentially, two elements were used to create differing situations in the classrooms:

- first, varying ceiling concepts, without any additional rear-wall absorption,
- and second, identical ceiling concepts with rear-wall absorption (magnet pin board absorber).

Table I. Test comparison of 10 variations for ceilings and wall.

Test Variations	*Sound absorption classification*	
Reference test in an untreated classroom	Ceiling	Wall
E-class absorber	0.15	-
E-class absorber	0.15	0.70
D-class absorber	0.55	-
D-class absorber	0.55	0.70
C-class absorber	0.70	-
C-class absorber	0.70	0.70
B-class absorber	0.80	-
B-class absorber	0.80	0.70
A-class absorber	0.90	-
A-class absorber	0.90	0.70

Table 1 shows an overview of the acoustical solution concepts. In conclusion it can be said that, based on the test results, the acoustic situation has drastically improved by integrating an absorbent dropped ceiling. Nonetheless, the motto "more sound absorption delivers more reverberation improvement" must be qualified.

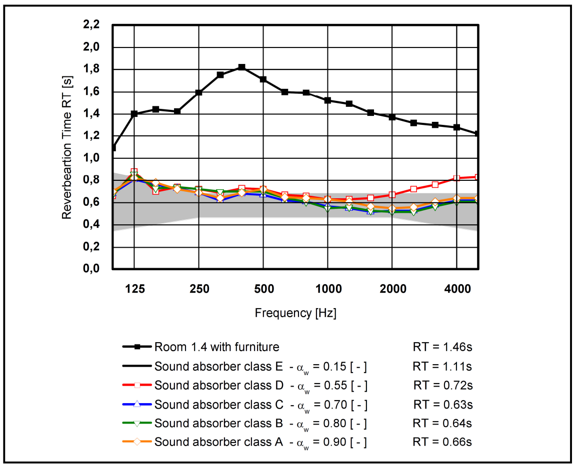

Figure 3. RT with 5 different ceiling types.

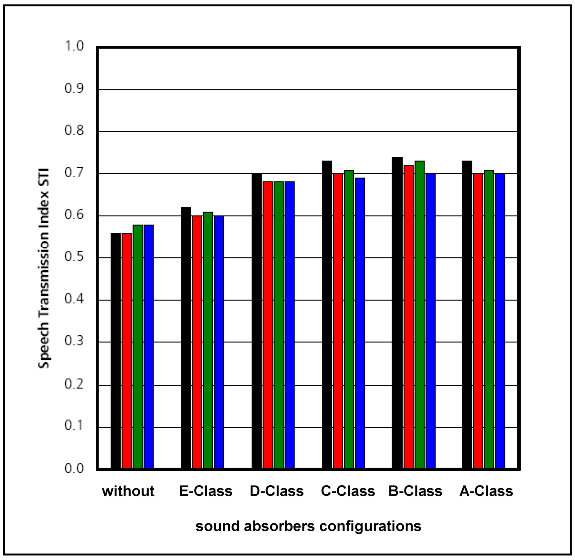

Figure 4. STI with 5 different ceiling types.

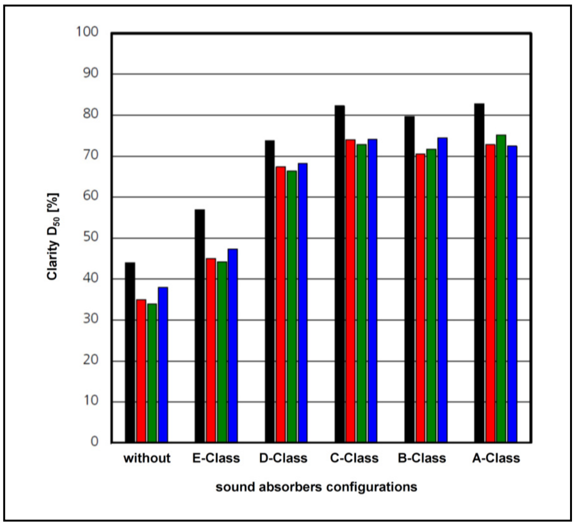

Figure 5. D_{50} with 5 different ceiling types.

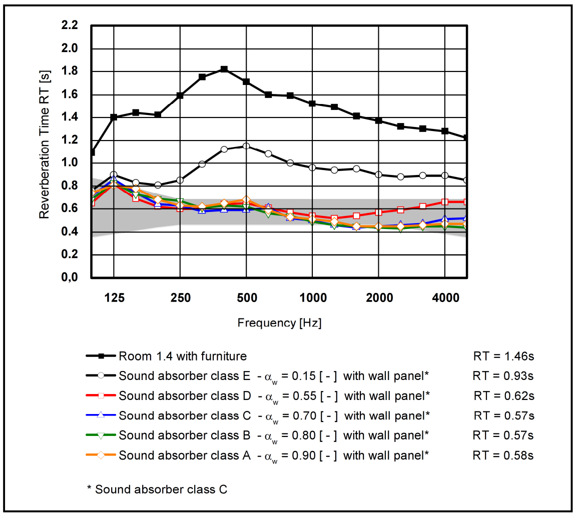

Figure 6. RT with different ceilings plus wall absorber.

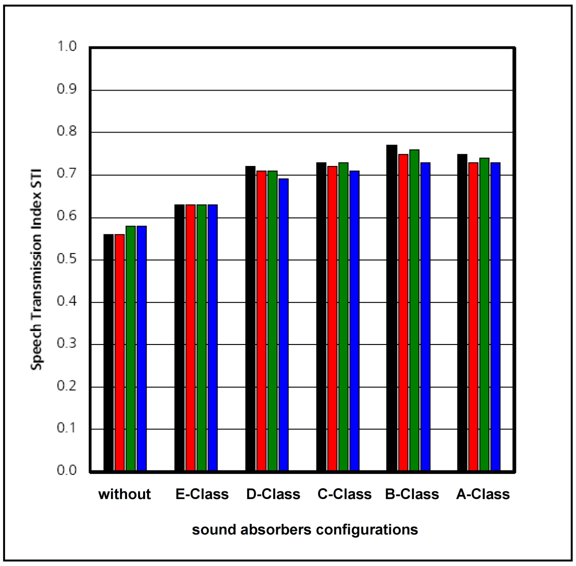

Figure 7. STI with different ceilings plus wall absorber.

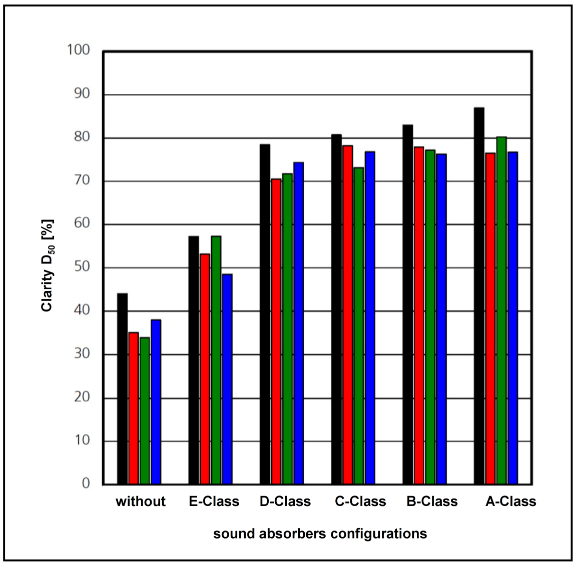

Figure 8. D_{50} with different ceilings plus wall absorber.

The comprehensive testing conducted by Fraunhofer-IBP clearly demonstrates that even with a suspended ceiling that absorbs 55% (type absorption class D!), adequate reverberation improvements could be achieved achieved. By using a false ceiling with more than 55% absorption, such as

- C-class absorber with $\alpha_w = 0.70$
- B-class absorber with $\alpha_w = 0.80$
- A-class absorber with $\alpha_w = 0.90$

then only minimal reverberation improvements have been obtained, in comparison to the 55% panel. Similar effects for the STI and D_{50} values.

3. Conclusions

Fig. 9 shows the development of reverberation time RT [s] depending on the equivalent sound absorption area A [m²] for a classroom with 205 m³.

The area shown in grey demonstrates the equivalent sound absorption areas A [m²] which fulfills the requirements of DIN 18041. The black curve shows that the larger the equivalent sound absorption area A is, the shorter is the expected mid reverberation time. But, the crucial fact is that the average reverberation time of an acoustically untreated room:

This Initial Situation 1 (green dot)

- mid reverberation time $RT_m \approx 1.5$ s
- equivalent absorption area $A \approx 22$ m²

caused by an additional equivalent sound absorption area of A = 8 m² can be reduced by ΔRT_m = 0.39 s.

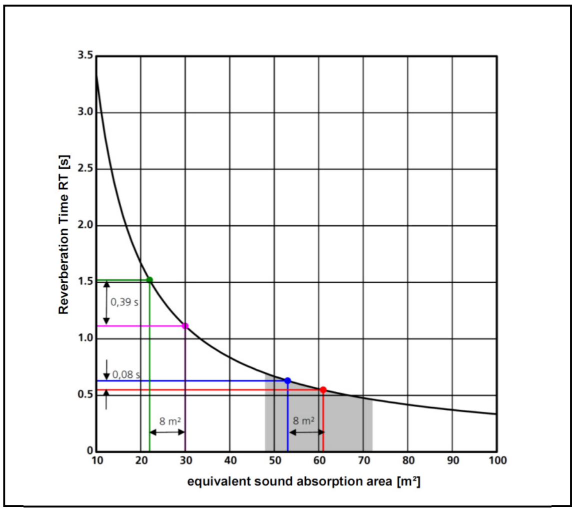

Figure 9. Relationship RT [s] and A [m²].

Whereas in an acoustically treated classroom (for ex., dropped ceiling with a C-class absorber)

Initial Situation 2 (blue dot)

- mid reverberation time $RT_m \approx 0.65$ s
- equivalent absorption area $A \approx 54$ m²

with an additional equivalent sound absorption area of $A = 8$ m² can only achieve a further reverberation improvement of $\Delta RT_m = 0.08$ s.

Initially, great reverberation, improvements are possible by implementing appropriate absorption measures. But as of a certain point, only small improvements can be achieved by using more absorbent products or adding an additional sound absorbing surface area. As shown in the tests, by using an additional pin board absorbing surface at the rear wall, better results can be achieved. All further measures applied to the walls are causing only marginal increase regarding the ceiling absorption.

In conclusion a combined solution for ceiling and wall obtains the best results. In case that no wall absorption is desired, there should not be implemented a highly absorbent solution. Because of the "one-sided" absorption surface arrangement, the flutter echo is amplified in many rooms.