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A POSSIBLE SINGLE NUMBER UNIVERSAL CLASSROOM ACOUSTIC CRITERION

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ABSTRACT

In the UK Building Bulletin 93 is part of the Building Regulations. BB93 was last updated in 2015 where it specified the acoustic performance for new or refurbished primary and secondary schools for both normal and complex needs students. This paper describes a justification for a universal classroom acoustic criterion for educational spaces. This would include nursery, primary, secondary and further education colleges. The adult voice is the primary sound source for classroom-based learning. The sound spectrum of the voice is well known, as is the ratio of male to female teachers. This will form, along with familiarity, the basis for a universal single number classroom acoustic criterion based on reverberation time. This simple criterion will allow architects and acousticians to work together to specify appropriate materials at the earliest possible design stage

Keywords: *reverberation time, learning, schools.*

1. INTRODUCTION

In the UK Building Bulletin 93 [1] is part of the Building Regulations. BB93 was last updated in 2015 where it specified the acoustic performance for new or refurbished primary and secondary schools for both normal and complex needs students. This paper offers a proposal to simply the unoccupied reverberation time criterion to the benefit of teachers, pupils, acousticians, architects, construction companies and local government. The justification for a universal classroom acoustic criterion for learning environments suitable for all is presented logically. The widening of the scope of educational space is also considered.

2. GUIDANCE AND STANDARDS

The Building Bulletin [2] initially set out a primary and secondary school criteria based on Tmf (an average of 500, 1000 and 2000 Hz) reverberation times, see Table 1. The reasoning being the development state of a child changes over time with higher concentration levels at short reverberation times [3]. The reasoning behind the selection of the Tmf parameter is less clear.

Table 1. Acoustic criteria in Building Bulletin 2003

Classroom type	Reverberation time T_{mf} (seconds)	Internal ambient noise level $L_{Aeq,\ 30\ minutes}$ dB
Primary school (children aged 5-11)	≤ 0.6	≤ 35
Secondary school (children aged 11-18)	≤ 0.8	≤ 35

For the update to BB93 [1] the reverberation time was kept the same but an allowance was made for new built and refurbished schools in the criterion, see Table 2.

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Table 2 Acoustic criteria in Building Bulletin 2015

Classroom type	Reverberation time T_{mf} (seconds)	
	New classroom	Refurbished classroom
Primary school (children aged 5-11)	≤ 0.6	≤ 0.8
Secondary school (children aged 11-18)	≤ 0.8	≤ 1.0

The same reverberation time parameter was kept but there was a 0.2 second allowance for refurbished classrooms. In addition, after the Equality Act [4] there was a requirement to consider those children with specific hearing or communications needs, see Table 3.

Table 3 Acoustic criteria for children with hearing or communication needs in BB93 2015

Classroom type	Reverberation time $T_{125\text{-}4k}$	Reverberation Time T (undefined)
	New Classroom	Refurbished classroom
School (hearing or comm impaired)	≤0.4 (no Octave Band >0.6	≤0.4

It can be seen from table 3 that the criteria has changed with a lower reverberation time specified for both newly built and refurbished classrooms. This follows the work of Canning on [5] The frequency range is much wider (125 Hz to 4 kHz) for the new built, but unspecified for the refurbished classroom.

More recently a new Italian standard has been introduced with a much wider scope and prescriptive methodology [6]. This standard plugs-in to DIN 18041 [7] and allow for room size, use, type of child and provides a range of appropriate reverberation times, figure 1 shows a reverberation time example for a 200m^3 classroom, which are then converted into a range of frequencies using DIN 18041 (63 Hz to 8 kHz), see figure 2.

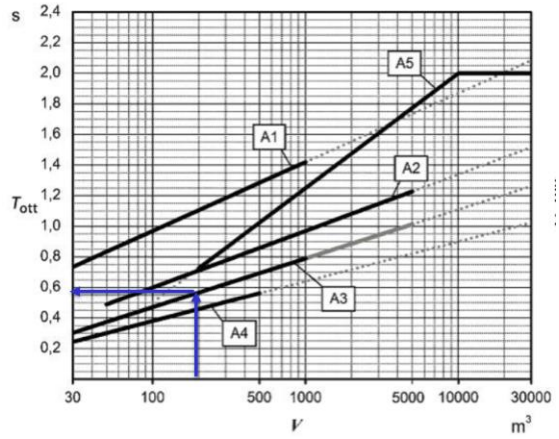

Figure 1. The recommend reverberation time for a 200m^3 classroom [UNI 11532]

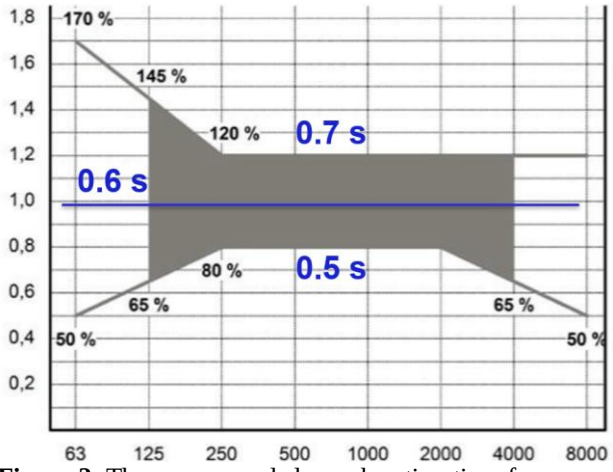

Figure 2. The recommended reverberation time frequency range [DIN 18041]

It can be seen from figure 2 that the focus is on the frequency range 125 Hz to 4 kHz with ±20% on the reverberation time (250-4 kHz) widening to ±40% at 125 Hz. This thus provides a very detailed classroom acoustic specification.

3. OTHER RESEARCH / RELEVANT STANDARDS

In the UK the ratio of male to female teachers has changed significant in recent years [8]. It is now 24:76% respectively. This rises to 13:87% for primary school teachers, respectively. The voice of a female has no content at 125 Hz [9]. For the male voice the 125 Hz band has the smallest weighting factor [9], see Table 4.

Table 4. Frequency weighting factors (MTF) used to calculate the Speech Transmission Index

	125	250	500	1000	2000	4000	8000
Male	0.085	0.127	0.230	0.233	0.309	0.224	0.173
Female		0.117	0.223	0.216	0.328	0.250	0.194

Building Regulations Approved Document E [10] specifies a reverberation time of 0.5 seconds. This represents the RT in residential dwellings. This is where most children spend most of their time and hence are very familiar to this environment. The frequency range covered is 100 Hz to 3150 Hz for this normalisation. Hence, this is also the frequency range that sound source needs to produce.

ISO 11654:1997 is the standard to rate sound absorbers [11]. Sound absorbers are the traditional method to control reverberation in rooms. The rating method classifies

absorbers (A-E) based on their practical absorption coefficient at 250 Hz to 4 kHz

4. PROPOSAL

As the aim of the proposal is streamlining and simplify alignment has been found in the frequency range of interest for the parameter, RT, between the above standards and guidance. Hence, it is suggested that 250 Hz to 4000 Hz be averaged for the RT with a target of 0.5 seconds. This is very close to the tightest specification for a typical classroom as illustrated in Figure 2. It also has the added benefit for acousticians in that predicting reverberation times at frequencies below the Schroeder frequency is known to be difficult to achieve accurately. For typical classrooms this is approximately 250 Hz.

The scope of learning environments would also be simplified as much as possible. It would be for both new buildings and for refurbished schools; for both normal hearing and those with communication difficulties; and apply to nursery, primary, secondary schools and further education colleges.

Although the criterion is not as broad (frequency) or as tight in term of Reverberation time as the current BB93 standard, see Table 3, in the near future hearing assistance technology using Bluetooth will be widely available [12]. However, the proposed criterion, T_{female}<0.5 is believed to provide the optimal teaching and learning environment.

5. CONCLUSION

The proposed criterion for all non-tertiary classrooms is simple to understand and has the advantage of unifying school design for both new builds and major refurbishments. This aid architects, whilst providing a perfect learning environment for both teachers and pupils of all types. As well as having an additional advantage to acousticians as it uses a very similar frequency range as is used for sound insulation testing and hence equipment is readily available for assessing compliance with the specification. The proposal aids the construction industry as materials (Class A) allow for an optimised noise control solution. Finally, the proposal reduces the level of management required from local government. The result would be a higher quality environment for children of all ages to learn and teachers to teach in a streamlined process.

6. ACKNOWLEDGMENTS

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7. REFERENCES

[1] Department of Education. Building Bulletin 93 – Acoustic Design of Schools: Performance Standards, 2015 www.gov.uk/government/uploads/system/uploads/attachment_data/file/400784/BB93_February_2015.pdf.

[2] Department of Education and Skills. Building Bulletin 93 – Acoustic Design of Schools: A Design Guide, 2004

[3] E. Greenland, B. Shield, “Towards acoustic criteria for inclusion in mainstream classrooms”, Proc IoA, 41(1), 2019

[4] Equality Act [2010] www.legislation.gov.uk/ukpga/2010/15/contents

[5] The British Association of Teachers of the Deaf, *Classroom Acoustics -recommended standards Information Sheet*. High Wycombe: BATOD, 2001 www.batod.org.uk/content/resources/audiology/magazine/acousticstandards.

[6] UNI 11532-2:2020. Internal Acoustical Characteristics of Confined Spaces. Design Methods and Evaluation Techniques. Part 2: Educational Sector, Italian Standardisation Body (UNI).

[7] DIN 18041:2016 Acoustic quality in rooms—specifications and instructions for the room acoustic design, German Institute for Standardisation, Berlin.

[8] UK Government School Teacher Workforce, 2024 www.ethnicity-facts-figures.service.gov.uk/workforce-and-business/workforce-diversity/school-teacher-workforce/latest/

[9] IEC 60268-16:2011 Objective rating of speech intelligibility by speech transmission index, 2011

[10] Building Regulations 2003 Approved Document E, Resistance to the passage of sound. 2003

[11] ISO 11654:1997 Rating of sound absorbers, 1997

[12] Bluetooth, 2025 www.bluetooth.com/auracast/