Regulation of school acoustic design in the UK: recent revision of Building and School Premises Regulations and their application

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Summary

Problems of noise in educational establishments have been recognised for over a century. In the UK guidance on the acoustic design of schools has been available since the 1930s, initially contained within text books and subsequently in British Standards and Codes of Practice relating to sound insulation, and in guidance documents (Building Bulletins) issued by the government department responsible for education. Nevertheless, problems of noise and excessive reverberation in classrooms and other school spaces continued to cause problems for pupils and teachers throughout the 20th century. For this reason, in 2003, the acoustic design of schools became subject to legislation incorporated into the Building Regulations for England and Wales and School Premises Regulations. New school designs had to meet criteria for noise, reverberation and sound insulation which were specified in the publication Building Bulletin 93 (BB93). The legislation, and BB93, were revised in 2015, requiring cooperation between acousticians, architects, and the Department of Education. This paper will give a brief overview of previous standards, in particular BB93 (2003), and will summarise changes which were introduced in the latest version of BB93. The political problems that had to be surmounted, and the consequent lobbying of the UK Parliament, in order to proceed with the revision of BB93 will be briefly described. There is currently concern that compliance with the revised regulations is not being adequately monitored; schools are again being built which may not meet the regulations and which will have acoustic conditions that are unsuitable for teaching and learning. The paper will therefore conclude by examining the application of, and adherence to, the latest version of BB93.

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1. Introduction

The problems of noise and poor acoustics in school buildings and classrooms have been recognised for over 100 years [1]. In the UK guidance on the acoustic design of schools has been available since the 1930s, in text books and British Standards and Codes of Practice relating to sound insulation. Since the 1940s the government department responsible for education (originally the Ministry for Education, currently the Department for Education) has issued guidance documents, known as Building Bulletins, covering various aspects of design relating to schools. Building Bulletins 1 and 2, on primary and secondary schools and published in 1949 and 1950 respectively [2,3], contained recommendations for the reduction of noise.

A later, more detailed, Building Bulletin was published in 1975 [4] to cover specifically the acoustic design of school buildings; recommendations were given for noise levels, reverberation times, noise control strategies and the design of open plan spaces. In the 1990s acoustics was incorporated into Building Bulletin 87 [5] which covered all environmental aspects of the design of school buildings, and contained detailed recommendations for providing optimum acoustic conditions for a range of school spaces. Nevertheless, despite the available

guidance and recommendations, excessive noise and reverberation in schools continued to cause problems for pupils and teachers throughout the 20th century. For this reason the government decided to incorporate the acoustic design of new school buildings into the Building Regulations early in the 21st century.

2. Regulations on school buildings

2.1 Building Regulations

Since the 1990s the acoustic design of domestic dwellings had been covered by Part E of the Building Regulations in England and Wales. In order to improve the acoustic standards in new school buildings it was decided by the then Department of Education and Skills (DfES) that a new section would be introduced into Part E to cover the acoustic design of new schools. This was incorporated into the Building Regulations in 2003, with the required performance standards being specified in Building Bulletin 93 [6]. Part E was amended to include the statement '*Each room or other space in a school building shall be designed and constructed in such a way that it has the acoustic conditions and the insulation against disturbance by noise appropriate to its intended use*'. Furthermore, it is stated that the normal way of satisfying this requirement will be to '*meet the values … in Section 1 of Building Bulletin 93'*.
The regulations applied to the design of new school buildings but not to refurbishments, temporary buildings, nursery schools, 6th form colleges, universities or colleges of further education.

2.2 School Premises Regulations

At the time that Building Bulletin 93 (BB93) was published there were also other regulations, the School Premises Regulations (SPR), which applied to new and existing buildings and covered many aspects of a school building when in operation such as heating and lighting as well as acoustics. The SPR contained a similar statement to that in Part E4 of the Building Regulations stating that school spaces should have acoustic conditions appropriate to their use.

3. Building Bulletin 93: 2003 edition

Section 1 of the 2003 edition of Building Bulletin 93 (BB93:2003) [6] contained the performance standards for compliance with the Building Regulations while the remaining sections provided guidance on acoustic design of spaces for different purposes, and case studies.

3.1 Performance standards

The performance standards in Section 1 of BB93:2003 consisted of criteria for unoccupied noise levels, reverberation times (RT), and sound insulation in a wide range of school spaces including primary and secondary school classrooms. Maximum permitted noise levels were specified in terms of 'indoor ambient noise levels' (IANL), that is, the level of noise when rooms are finished but unfurnished and unoccupied. The IANL was specified as a 30 minute L_{Aeq}. Reverberation time was specified as the mid-frequency reverberation time, T_{mf}, that is the average of values at 500, 1k and 2k Hz.
Examples of the standards for IANL and T_{mf} for some spaces are shown in Table 1.

Table 1. Examples of BB93:2003 performance standards

Space	*IANL dB $L_{Aeq,30min}$*	*T_{mf} (s)*
Classroom (primary)	35	<0.6
Classroom (secondary)	35	<0.8
Open plan classroom	40	<0.8
Large lecture room	30	<1.0
Art room	40	<0.8
Sports hall	40	<1.5

Criteria for sound insulation were specified by a 4 x 4 matrix relating noise tolerance in the receiving room (very low, low, medium, high) and activity noise in the source room (low, average, high, very high).
BB93:2003 also provides calculation methods for determining the amount of absorption required to control noise and reverberation in corridors, entrance halls and stairwells.

3.1.1 Open plan classrooms

As well as noise and reverberation time criteria for open plan classrooms, BB93:2003 specified minimum speech intelligibility requirements in terms of the speech transmission index (STI). STI was required to exceed 0.6 and was to be calculated by modelling of the space at the design stage.

3.1.2 Testing

Many of the expert drafting panel wished to introduce compulsory post construction testing into the regulations so that it could be seen whether or not schools complied with the standards when built. However, the government would not agree to this. There was therefore no way of assessing whether or not schools complied with the regulations.

3.2 Alternative performance standards

BB93:2003 included provision for alternative performance standards (APS) which could be applied where the normal performance standards were inappropriate for particular educational, environmental or health and safety reasons.

3.3 Compliance with BB93:2003

There was considerable anecdotal evidence among acoustic consultants involved with the design of schools suggesting that the acoustic design improved considerably following the introduction of the Building Regulations and BB93:2003. A survey of acoustic conditions in secondary schools in England, conducted between 2009 and 2012, confirmed that many more of the school spaces designed post 2003 complied with the requirements of BB93:2003 than those built pre 2003 [7]. Of the spaces measured, 87% of those built after the regulations were introduced complied with the noise and RT requirements, compared with 44% of those built earlier. The percentages of enclosed classrooms meeting the criteria increased from 36% pre 2003 to 86% post 2003, science rooms from 50% to 91%, and open plan spaces from 71% to 100%. Average IANLs decreased by between 6 and 10 dBA and average T_{mf} s by around 0.1 s

Thus the introduction of the regulations in 2003 appeared to lead to an overall improvement in acoustic standards. Nevertheless there was concern that APS were being applied too frequently when not genuinely justified, in order to lower standards and hence reduce costs.

4. Revision of Building Bulletin 93

4.1 Timescale of the revision

When BB93:2003 was published it was agreed by the DfES that the document would be revised after five years. Thus, in 2008, the drafting panel for BB93:2003 reconvened to discuss a revision; all the criteria were re-examined to decide whether any needed to be changed.

However, the political will at the time was not in favour of a review and, following a general election in 2010, the new government announced that it was removing all regulations related to school building, and abolishing all Building Bulletins.

There followed intense lobbying of Parliament and the Department for Education by the Institute of Acoustics (IOA), the Association of Noise Consultants (ANC) and the National Deaf Children's Society (NDCS). Evidence was produced to show that noise and poor acoustics in the classroom have detrimental impacts upon pupils and teachers, particularly hearing impaired children, and showing how listening conditions could be improved by attention to acoustic detail. The lobbying was successful and it was finally agreed that school acoustics would remain within the Building Regulations and the SPR, and that BB93:2003 would undergo a full revision.

5. Building Bulletin 93: 2015 edition

The revised version of BB93 (BB93:2015) was published in February 2015 [8]. Unlike the 2003 edition, the document contains only the performance standards required to meet the Building Regulations. Guidance on the acoustic design for schools to accompany BB93:2015 is provided in a separate document published by the IOA and ANC [9]. The main differences between the 2003 and 2015 editions are described below.

- Some room classifications and nomenclature have been changed to reflect current teaching and design practices and simplify the text.
- The regulations now apply to refurbishments as well as to new buildings. In general, standards for refurbishment are less stringent than those for new build. For example, refurbishment IANLs for all spaces except those for use by pupils with special needs are 5 dBA higher than those for new buildings. Similarly, for some (but not all) spaces, the RT standard for refurbishment is lower, by between 0.2 and 0.5 seconds, than that for new buildings. However, the refurbishment standard should be regarded as a minimum standard and, particularly where new building elements are installed, the standard for new buildings should be the target.
- In BB93: 2003 the performance standards applied to unoccupied rooms that were unfurnished whereas in BB93:2015 they apply to unoccupied but furnished rooms.
- The IANL can be relaxed by 5 dB for particular types and conditions of ventilation.

- Alternative performance standards must now normally not be less stringent than the corresponding standards for refurbishment.
- In addition to complying with the Building Regulations by meeting IANL and RT requirements in BB93:2015, open plan spaces must also satisfy STI standards in order to comply with the School Premises Regulations. There are two STI requirements aimed at providing both sufficient speech intelligibility within groups and suitable speech privacy between groups.
- The 4 x 4 noise tolerance/activity noise matrix used to specify sound insulation between spaces has been reduced to a 3 x 4 matrix. The values for refurbishments are 5 or 10 dB $D_{nT,W}$ lower than those for new buildings.
- In catering for pupils with special needs, BB93:2003 contained provision only for hearing impaired pupils and classrooms designed specifically for their use. BB93:2015 refers to pupils with special hearing or communication needs, such as those with autistic spectrum disorder (ASD) or attention deficit hyperactivity disorder (ADHD), or visual impairments. Under current equality legislation, schools must be accessible for these pupils and hence the acoustic design must be appropriate to their needs. The reverberation time criterion for rooms for teaching hearing impaired pupils is more detailed and more stringent than previously.
- Roofs and roof glazing should be designed such that rain noise does not increase the noise levels in a space to more than 25 dB above the IANL standard for that space.

5.1 Changes to performance standards

There was considerable pressure from architects, building contractors and some acoustics consultants to relax many of the performance standards in BB93:2003. In particular there was extensive debate on the appropriate IANL standard for classrooms, with many arguing that it should be raised from 35 to 40 dB L_{Aeq}. However, it was decided to keep it at the lower level. Subsequent research has shown that 35 dB IANL corresponds to an average level of classroom noise of 64 dB L_{Aeq} [7], which level has a detrimental impact upon pupils performance in the classroom [10,11].
The IANL and T_{mf} performance standards which were changed are shown in Table 2.

Table 2. Changes to performance standards

Changes to IANL dB L_{Aeq}, 30min		
	2003	2015
Music performance/recital room	30	35
Lecture room, small	35	35
Lecture room, large	30	
SEN calming room	-	35
Individual study rooms	35	40
Library study area	35	40
Interview/counselling room	35	40
Changing area	45	50
Changes to T_{mf}, seconds		
Open plan teaching area	< 0.8	≤ 0.5
Open plan resource area	< 1.0	≤ 1.2
Music practice room≤ 30m^3	< 0.8	≤ 0.6
Music practice room >30m^3	-	≤ 0.8
Rooms for use by hearing impaired students	< 0.4	≤ 0.4* ≤ 0.6 every oct band
Indoor sports hall	< 1.5	≤ 1.5-2**
Swimming pool	< 2.0	
STI for open plan spaces		
Within a group	>0.6	≥ 0.6***
Between groups		≤ 0.3**

* average of 125 to 4k Hz octave bands

** depending on floor area

***to comply with School Premises regulations

6. Compliance with BB93:2015

6.1 Design and building of new schools

In the past the provision of schools and school buildings was the responsibility of local educational authorities (LEAs), but, although it is the responsibility of LEAs to ensure that every child has a school place, they no longer have the authority to commission new schools, nor to compel other providers to expand. Currently in the UK there are many different models of commissioning and financing school buildings, with many bodies such as businesses and charities providing funding as well as central government. A particular current initiative is the Priority Schools Building Programme (PSBP) which aims to rebuild and/or refurbish the school buildings in the worst condition across the country.
As the acoustic performance of school buildings is governed by the Building Regulations, the acoustic acceptability of a completed building must be approved by a building control inspector. The

inspector must take reasonable steps to satisfy themselves that the building work complies with Building Regulations throughout the process. In practice this generally means ensuring that the minimum standards set out in BB93 are adhered to. However, it is worth noting that this is the *normal* way of satisfying the regulations (see section 2.1) and the final assessment is at the discretion of the inspector. This flexibility allows for atypical situations where the normal requirement is not appropriate. For example, the sound insulation required between two spaces to ensure appropriate acoustic conditions may exceed the highest required value in BB93 (55 dB $D_{nT,w}$).

The Building Regulations requirements are minimum standards and there are various situations in which it can be beneficial to improve upon these, for both educational purposes and to enable more flexible community/commercial use of the buildings, where improved standards may make them a more useful local resource.

Where educational, environmental or health and safety reasons dictate that the minimum standards cannot be met, the APS procedure may be applied. Any proposed APS must be justified on a technical basis by an acoustician and agreed as part of the design process, with all stakeholders accepting the justification and new standard. Critically, there is no situation in which it is acceptable for the minimum standards to be simply ignored, or the standard to be set retrospectively at whatever is eventually achieved.

6.2 Non-compliance

Many practitioners in the school design disciplines, from architects to acoustics consultants, have examples of school projects where acoustic design standards have not been complied with. Unfortunately, commercial pressures tend to dictate that any discussions about these projects take place in secret, or are quoted anonymously. Acousticians who have published the results of commissioning testing on schools where the relevant standards have not been met, have found that subsequent acoustic contracts have been awarded elsewhere.

The authors are aware of schools where, despite all the relevant acoustic treatments being specified at the design stage, some (or all) treatments have not actually been installed on-site. In many cases acoustic treatment is seen as an unnecessary extravagance and eliminating acoustic treatment provides an 'easy' way of reducing costs. This often occurs as a result of ignorance on the part of the school body itself, for example the head teacher and/or the school governing body, who may be unaware of the consequences of not adhering to good acoustic standards.

An example of this occurred in a school specifically for pupils of all ages with special educational needs (SEN). All additional acoustic wall panels, specified to achieve the more stringent SEN reverberation time standards in BB93:2015, were found to have been omitted. This was only discovered when the acoustician, undertaking testing at his own cost, visited the school. Despite this, the building was signed-off by the building control inspector and handed over to the school, even though it did not meet the relevant criteria.

In some cases unscrupulous contractors or builders omit or modify the specified materials in order to reduce costs. A further problem is that some of the country's most noted architects consider acoustic requirements to be secondary to the visual aesthetic of a building.

6.3 Testing

As discussed in section 3.1.2, testing of a completed building to ensure that it meets the required standards is not included in the regulations. The only schools where testing is required are those built under the PSPB programme, for which testing is an obligatory contractual requirement. Under all other contractual models, although testing is "strongly recommended", it is regularly not undertaken. Evidence from the residential sector suggests that a lack of post-construction commissioning has a material effect on the performance of the school at handover.

The standards for sound insulation between dwellings under the Building Regulations were amended in 2003 to require testing of airborne and impact sound insulation in new or converted residential developments. The effect of this was profound. In 2001 the Building Research Establishment estimated that '40% of new separating floors and up to 25% of new separating walls may fail to meet the [current] standards'. Within 3 years of introducing the requirement to test, the pass rates (walls and floors combined) had risen to 95%.

This suggests that, if testing for schools were to be introduced, the majority of new school buildings would be forced to comply with current standards

6.4 Failure to comply with standards for pupils with hearing and communication needs

According to the NDCS, around 85% of pupils with a permanent hearing impairment in the UK, that is around 30,000 pupils, are educated in mainstream schools. Given that there are around 24,000 schools in the UK, this equates to 1.25 children per school. Further to this are pupils with other special hearing and communication needs requirements such as visual impairments, attention ADHD, or ASD, all of whom benefit from improved acoustic conditions. It has been estimated that between 62 and 116 in every 10,000 children have ASD, suggesting up to 4 children in every school.

Unfortunately, many examples of schools not meeting current requirements relate to the provision of suitable accommodation for the education of SEN pupils, in both special SEN schools and SEN accommodation in mainstream schools.

In a mainstream school the SEN requirement may be defined very narrowly, leading to the required treatments being limited or considered unnecessary. For example, in one school SEN was defined as relating only to hearing impairments, and as there were currently no hearing impaired children in the school it was considered unnecessary to provide a space with appropriate acoustic conditions. Not only did this mean that any hearing impaired children entering the school at a later date would not be catered for, but neither were children with other special educational needs already at the school.

6.5 Open plan spaces

Another area of concern is the current fashion for providing large open plan spaces which are intended for use by several teaching groups simultaneously. Many new schools incorporate such spaces, which provide challenging acoustic conditions for teaching and learning, despite the new STI requirements in BB93:2015 and the general recognition by teachers of the difficulties of teaching in such environments.

7. Discussion

As mentioned above, the failure of schools to meet the required acoustic standards is often due to a lack of awareness by the school itself of the importance of good acoustic design, and the consequences for pupils and teachers of poor acoustic design.

Although BB93 recognises that pupils with special educational needs are affected more by poor acoustic conditions than those without such needs, little guidance is given as to how a school may typically implement the requirements to accommodate a pupil's individual needs, or how to plan for the inclusion of pupils with special needs in future when new accommodation is being designed. The BB93 minimum performance standards for spaces specifically for students with "special hearing or communication needs" tend to result in separate rooms which are dedicated solely to the education of SEN pupils, rather than maximising the opportunities for their inclusion in mainstream classes by improving the acoustic conditions in standard teaching spaces. There are many who argue that such a policy is inherently discriminatory. Whilst accepting that financial considerations may make the universal implementation of SEN acoustic standards impractical, there is space for further guidance for schools and designers in interpreting the minimum standards and suggesting ways in which greater inclusion might be achieved. For example, a secondary school might have a minimum of one classroom in each subject area constructed to SEN standards, enabling a school to timetable classes for a pupil with special educational needs to use these areas.

8. Conclusions

Despite attempts in the UK to improve acoustic conditions in schools in recent years, particularly with the 2015 revision of BB93, there are still many instances where new schools are being constructed that do not meet the required standards. There are several reasons for this including a lack of understanding of the consequences for both pupils and teachers of poor acoustic environments in schools, a desire to reduce the costs of school building works, and prioritising the visual aspects of a school's design over the acoustic performance.

A way to overcome the current failings in the design and building process, and to ensure that school buildings meet the current standards, would be to introduce compulsory acoustic testing of new school buildings and refurbishments. Experience in the UK shows that regulations which only specify performance criteria without introducing any means of checking that they are being applied, are inadequate and fail the nation's pupils, particularly those with hearing impairments and other special needs.

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