



Classroom acoustics design beyond BB93 - refurbishment of a hearing impaired unit in a mainstream primary school

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ABSTRACT

Benchmark acoustic testing was carried out for an existing hearing impairment unit within a mainstream primary school, as part of a feasibility study investigating potential for refurbishment versus. Rebuild or relocation. Acoustic measurements comprised reverberation time, internal airborne sound insulation and indoor ambient noise level. Although the benchmark testing largely demonstrated compliance with the acoustic performance standards outlined in Building Bulletin 93 for refurbishments, it was also important to consider the results in the wider context of individual school operation and management, and beyond the scope of Building Bulletin 93 performance standards. Interviews with staff and students were carried out to supplement the acoustic measurements and evaluate performance in use. This process revealed additional acoustic problems which were outside the scope of BB93 but were nonetheless challenging for the children and staff learning in the space. Results are discussed against the scope of BB93 and findings will be useful to inform future design standards, given the Department for Education's refocus on refurbishment of school buildings as part of its target to achieve net zero carbon by 2050.

1. INTRODUCTION

This case study details the findings of an acoustic condition survey which was carried out for a specialist hearing impairment unit within an existing mainstream primary school in a London Borough, UK.

The reason for the interest in this case study is that it highlights discrepancies between compliance with acoustic performance standards for schools in the UK and the needs and expectations of the users, staff and children operating in the space.

Following complaints from the school, the Local Authority undertook a feasibility study to understand whether refurbishment upgrades were possible or whether the unit should be relocated and rebuilt.

The school was built before 2003, prior to acoustic performance standards being regulated via Requirement E4 of the Building Regulations¹. However Building Bulletin 93 (BB93)² states that “where there is a need to upgrade the acoustic performance of an existing building or when refurbishment is undertaken for other reasons, then the refurbished elements should meet, as far as reasonably practicable, the acoustic performance given in these guidelines to satisfy the School Premises Regulations³⁻⁴ and the Equality Act⁵”.

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Anderson Acoustics visited the school to conduct sound insulation tests for crosswalls between classrooms and romfronts. 9 no. airborne sound insulation tests were performed, together with measurements of indoor ambient noise levels and reverberation times, using the testing methodology described in Building Bulletin 93)² and in the Association of Noise Consultants [Good Practice Guide. Acoustic Testing of Schools](#) (Version 2 November 2015)⁶.

In addition, a separate site visit was undertaken to inspect the acoustic conditions in use and discuss classroom operation and management, subjective assessment of noise and identification of noise sources and noise annoyance with users in the space, including the head of the Hearing Impairment unit, children using the space, and teaching assistants.

2. USER CONSULTATION

The site was visited to conduct a site walkaround when the school was in use and consult with the School Business Manager, Head of the HI Unit, Teaching assistants in the HI unit and Children using the space. The interviews with staff and children were very informative to understand the types of acoustic issues and noise problems that would not normally be identified within the scope of the requirements of Building Bulletin 93 Acoustic performance standards.

An assessment of the mainstream classrooms was not conducted however it was noted during the walkaround the mainstream classrooms did not have any dedicated sound absorbent treatment and listening conditions are likely to be significantly worse for children when operating outside the HI unit.

The HI unit is a 16 place Specially Resourced Provision (SRP) for Children with moderate to severe-to-profound hearing loss. Most students use a hearing aid or Cochlear Implant (CI), and access the HI Unit for the majority of the time for core subjects. Children tend to return to mainstream spaces in the afternoon for practical subjects (Art/PE etc).

In the unit, the children normally wear a personal listening device (Phonak Roger MyLink personal radio aid directly connected to Hearing Aid or CI input), but will sometimes remove their hearing aids or devices in order to provide respite as listening for long periods via a device can be tiring. Communication distances between the teacher and pupils are normally very short (0.5 to 3 m), and pupils are normally taught in a small group of no more than 3 pupils.

Because of problems with noise ingress, windows and doors are rarely opened for ventilation in the HI unit, and old ventilators are no longer in use. This can result in uncomfortable conditions but even with windows and doors fully closed, noise ingress is still disruptive and problematic.

The HI unit is directly adjacent to the west side playground at the front of the school, and breaktimes are staggered such that teaching in the HI occurs when the playground is in use. Although the HI unit does not use the adjacent playground, classroom exit door opens directly onto the playground and the play area extends to directly outside the door. This is a major source of noise and disruption during teaching in the HI unit.

The HI unit is also directly adjacent to the Year 1 classroom. Staff and children in the HI classrooms reported significant noise ingress, annoyance, disruption and distraction from the adjacent Y1 classroom when an individual in the Y1 classroom was having an episode including shouting and crying within the classroom. Typical classroom noise levels such as raised speech arising from the Y1 classroom was not usually reported to be audible by occupants with severe to profound hearing loss, but was audible and occasionally distracting for teachers without hearing impairment (and hence potentially for children with mild to moderate hearing loss). During the visit, normal classroom activity noise was present in the Y1 classroom and low levels of transmitted speech and impact sounds (such as drawers opening) was audible, although not disruptive.

Occupants in the HI unit were not affected by noise ingress from the offices on the other side of the unit, however admin staff in the adjacent offices have reported that noise transmission from the HI unit is clearly audible. Noise ingress from the corridor was not reported to be a major problem when doors were closed (but was distracting when doors were opened. However the TA reported that noise ingress from the adjacent resource area via closed doors was sometimes a problem.

Equipment noise (such as computers and the projector) was not normally a problem and not reported by Hearing Impaired staff, however children noted that the projector noise was occasionally audible. The electric pencil sharpener was also a source of noise annoyance however this was managed within the classroom.

Rain drumming noise on the lightweight roof was not reported to be an issue by staff or children. Similarly, environmental noise ingress was rarely a problem except occasionally when delivery trucks were reversing.

Room acoustics and reverberation were not identified as being a barrier to listening in the classroom.

The children consistently identified similar problematic noise sources to the staff operating in the space.

Child's Voice

Q. What noise sources in the unit bother you?

A. *When a child is crying and screaming in Year 1*

A. *From the playground*

Q. What noise sources in your mainstream classroom bother you?

A. Noise from all the other children in the classroom

2. ACOUSTIC SURVEY

Indoor ambient noise levels, airborne sound insulation and reverberation times were measured using the testing methodology described in BB93 and in the Association of Noise Consultants [Good Practice Guide. Acoustic Testing of Schools](#) (Version 2 November 2015)⁶.

2.1. External environmental noise

A 15-minute sample noise level was recorded during the survey visit during suitable weather conditions in a free field position outside the classroom. This was considered to be representative of ambient noise level conditions defined in BB93, in the absence of school activity noise, with the following notable sources of noise:

- distant road traffic
- occasional traffic on local residential roads
- birdsong
- light breeze in trees
- occasional distant aircraft passing over

The measured external ambient noise level was 43 dB $L_{Aeq,15min}$ and 62 dB $L_{AFmax,15min}$.

Staff confirmed that ambient noise levels during the survey visit were consistent with long term prevailing conditions.

2.2. Indoor Ambient Noise

Sample measurements of the indoor ambient noise level were measured using the parameter $L_{Aeq,5min}$ in all three spaces in accordance with the conditions described in BB93 and the IoA ANC Design Guide⁷:

- Rooms unoccupied
- Adjacent spaces unoccupied
- School Activity noise excluded (playground noise, activity in adjacent spaces, equipment noise)
- External noise conditions representative of typical environmental noise conditions.
- Test scenario 1: Windows Closed
(representing normal use as confirmed by the Head of HI Unit, albeit this condition would affect adequate ventilation provision)
- Test Scenario 2: Windows/Rooflights open 100 mm
(representing normal natural ventilation condition).

Results are presented in Table 1. A single measurement position was selected in each room as a sample measurement given the time constraints for the survey period. Subjectively there was no significant variation in noise level throughout the classrooms.

The results demonstrate that the target indoor ambient noise level limits of 30 dBA (new build) and 35 dBA (refurbishment) are comfortably achieved.

Table 1: Measured Indoor Ambient Noise Levels

Room	Indoor Ambient Noise Level L_{Aeq} , dB	
	Windows closed	Windows open
016 Hearing Impaired Classroom	23	27
019 Hearing Impaired Classroom	N/A	29
016a Hearing Impaired Office (also a teaching room)	23	30

2.3. Equipment Noise

The only notable source of fixed equipment noise in the space was the projector in room 16a.

The measured noise level at 1 m from the operating projector was 40 dB L_{Aeq} .

*Acoustics of Schools: A Design Guide November 2015*⁷ recommends a noise limit for equipment of +3 dB above the target indoor ambient noise level. The maximum target is therefore 33 dB L_{Aeq} for new build and 38 dB L_{Aeq} for refurbishments. The measured level would suggest an exceedance of at least 2 dB above the recommended limit. However projector noise was not identified by the users of the space to be problematic.

2.3. Playground noise

Playground noise was identified by the users of the space to be the most disruptive source of noise ingress into the classrooms. The playground space is directly outside room 016a, and during playtime children venture into the space directly outside the window of room 016a during playtime. As breaktimes are staggered, playground noise can regularly disrupt teaching activities in room

016a, even with all windows and doors closed, and is also audible in rooms 019 and 016 (via the closed rooflights).

Whilst playground noise activity was not measured during the survey as it is outside the scope of BB93 performance standards, its impact can be estimated on the basis of the synchronised outdoor and indoor ambient noise level measurements, which crudely suggest an attenuation of around 20 dBA is achieved when windows are closed, and 13 dBA is achieved with windows open. This agrees with the available design guidance for openable window attenuation.

On the basis of playground noise levels potentially being up to 82 dBA outside the window (Shouted Vocal Effort), playground noise ingress levels could be around 62 dBA with windows and doors closed as per current use. This could result in signal-to-noise ratio being reduced from +20 dB (under typical ambient noise levels) to around 5 dB (assuming ISO Raised voice of 67 dBA at 1m is used), although a more comfortable speaking level in a room with a small number of occupants would be around 60-62 dBA at 1m, resulting in a further reduced signal-to-noise ratio of around 0 dB.

Based on previous research⁸, the estimated potential listening disadvantage arising when the adjacent playground is in use could be around 10-20% for mild-to-moderate hearing loss and around 65% for Severe-to-Profound hearing loss.

2.4. Reverberation Times

Sound absorbent wall panels (Ecophon Texona 40 mm panels or similar) and suspended discrete 1200x1200 rafts (Ecophon Solo or similar) were installed below the soffit in all three rooms. Rooms were measured unoccupied and heavily furnished according to the normal use of the space. All floor finishes were fully carpeted. Since the number of occupants in the teaching spaces is normally low, occupied conditions are not expected to differ significantly from that measured.

The measured reverberation times in all three rooms 016, 019 and 016a comfortably achieved the BB93 maximum limits for both new build and refurbishment standards ($T_{125-4kHz} \leq 0.4$ s; $T \leq 0.6$ s in any octave band), indicating that the room acoustics are capable of supporting good listening conditions to minimise listening disadvantage arising from room acoustics (provided that good control of noise ingress is also achieved).

2.5. Airborne Sound Insulation

Airborne test results on the wall and roomfront constructions are summarised below in Table 2.

Crosswalls comprise lightweight drywall/composite panel partitions with gaps at the underside of the crinkly tin soffit. These partitions were also weakened by the presence of standard unsealed doors (with single glazed vision panels), and thin single glazed internal screens (approximately 4 mm thick).

The tested separating walls between classrooms without interconnecting doors/glazed screens present met the minimum BB93 performance standard for refurbished rooms (40 dB $D_{nT,w}$), however fell significantly short of the target BB93 performance standard for new build (50 dB $D_{nT,w}$), by 7-8 dB.

Occupants in the HI classrooms reported significant noise ingress, annoyance, disruption and distraction from the adjacent Y1 classroom when an individual in the Y1 classroom with ASD needs was shouting and crying within the classroom. Whilst this activity was not observed during the visit it is likely that shouted speech (typically 82 dBA) or screams (87 dBA) would result in noise ingress levels of around 40-45 dBA arising in the HI classrooms, which would be audible and potentially distracting for listeners with hearing impairment.

Typical classroom noise levels such as raised speech arising from the Y1 classroom was not usually reported to be audible to occupants with severe to profound hearing loss, but was audible and occasionally distracting for teachers without hearing impairment (and hence potentially for children with mild to moderate hearing loss). Typical classroom activity noise levels arising in the Y1 classrooms (up to around 74 dBA reported for Y1 classrooms) could result in noise ingress levels of around 32 dBA in the HI classrooms, which would still be audible for occupants with mild or no

hearing loss, given the low ambient (unoccupied) noise levels within the classrooms, but is less likely to be distracting..

Similarly tested separating walls between classrooms and offices (without interconnecting doors/glazed screens present) met the minimum BB93 performance standard for refurbished rooms (35 dB $D_{nT,w}$), however they fell significantly short of the target BB93 performance standard for new build (45 dB $D_{nT,w}$), by 6-8 dB.

Occupants in the HI classrooms were not affected by noise ingress from the adjacent offices, however office workers are occasionally reported to be disturbed by noise transmission from the HI classrooms (particularly structureborne noise such as stapling into the display boards and loud speech from AV/presentations).

Table 2: Measured Airborne Sound Insulation

Test No.	Source Room	Receiving Room	Description	D_w dB	Minimum BB93 Target, D_w dB (refurbishment) ¹	Minimum BB93 Target, D_w dB (new build) ¹
1	16a Hearing Impaired Office	16 Hearing Impaired Classroom	Separating wall with door + glazed screen	28	BB93 common exception 1.2.3c: 35 dB R_w door 45 dB R_w composite wall/glazing	
2	16a Hearing Impaired Office	019 Hearing Impaired Classroom	Separating wall (solid)	43	40	50
3	16 Hearing Impaired Classroom	019 Hearing Impaired Classroom	Separating wall with door + glazed screen	25	BB93 common exception 1.2.3c: 35 dB R_w door 45 dB R_w composite wall/glazing	
4	024 Medical Welfare	019 Hearing Impaired Classroom	Separating wall (solid)	39	35	45
5	025 Parents Room (Office)	16a Hearing Impaired Office	Separating wall (solid)	37	35	45
6	025 Parents Room (Office)	019 Hearing Impaired Classroom	Separating wall (solid)	43	35	45
7	013 Classroom 6 (Year 1)	16a Hearing Impaired Office	Separating wall (solid)	43	40	50
8	013 Classroom 6 (Year 1)	16 Hearing Impaired Classroom	Separating wall (solid)	42	40	50
9	Corridor	16 Hearing Impaired Classroom	Separating wall with door	29	35 dB R_w door, 40 dB R_w composite wall/glazing	35 dB R_w door, 45 dB R_w composite wall/glazing
10	Corridor	019 Hearing Impaired Classroom	Separating wall with door	30	35 dB R_w door, 40 dB R_w composite wall/glazing	35 dB R_w door, 45 dB R_w composite wall/glazing

The tested walls between HI classrooms with interconnecting doors/glazed screens were not commensurate with the BB93 common exception 1.2.3c target of 35 dB R_w doors (albeit this is a

laboratory performance, the overall lab-to-site reduction would not normally be expected to exceed 2-3 dB for a good installation), such that the tested performance fell short by at least 5-8 dB.

Occupants in the HI classrooms reported occasional noise ingress, and annoyance from the adjacent HI classrooms during normal classroom activity, particularly by teachers without hearing impairment (and hence children with mild to moderate HI), although some adjacent activities such as amplified sound were also audible for teachers with severe to profound hearing impairment. For typical normal to raised speech levels of 60-67 dB in the Y1 classroom, noise ingress levels of around 42 dBA would arise in the adjacent HI classrooms, which would be clearly audible and potentially distracting for listeners including those with hearing impairment. However this activity noise would be more manageable from within the HI unit itself, which may be why this noise ingress was reported to be less of an issue than noise ingress from outside the unit.

The tested roomfronts between HI classrooms and the corridor also fell short of the BB93 standard by around 3-5 dB. Whilst this would appear to be a smaller shortfall than for between teaching rooms, it is also noted that the circulation space adjacent to the HI classrooms is also used as a resource area in which case noise ingress could become a more significant problem during lesson time. Noise ingress from the corridors/circulation space to HI Classrooms was not noted to be a significant problem by HI staff with severe to profound hearing loss, however it was noted by staff without hearing impairment to be noticeable and occasionally a problem.

2. DISCUSSION AND CONCLUSION

The results of the acoustic survey coupled with the are interesting because they reveal the limitations of the current scope of Building Bulletin 93², which focuses on compliance for unoccupied conditions.

Whilst good control of environmental noise ingress was achieved, with BB93 compliance meeting the acoustic performance standards for new build rooms designed specifically for users with special hearing and communication needs, the location of the playground (used by others during lessons in the HI unit) caused significant noise ingress, disruption and disturbance. This could be mitigated by better planning and organisation of breaktimes, provision of sound attenuated hybrid ventilation units and, where staggered breaktimes are necessary, acoustic fencing could be installed.

Although compliance with the BB93 refurbishment standards for airborne sound insulation were achieved for separating crosswalls (not containing doors), the use feedback highlights that the performance standards do not consider activity noise beyond natural speech levels, whereas in practice significantly higher activity noise levels can arise (for example from children with additional behavioural needs). The feedback from the users of the space provides evidence that there is benefit to upgrading sound insulation performance standards for existing/refurbished hearing impaired classrooms to 50 dB $D_{nT,w}$ where possible.

Whilst upgrades to interconnecting doors and glazed screens would improve room to room sound insulation, it is notable that the users of the space considered sound insulation between rooms within the unit (which is easily managed) to be less of a concern than noise ingress from other parts of the building.

Other considerations for noise mitigation revealed by this case study which would fall outside the scope of BB93 include:

- Slow closers to avoid banging doors
- Independent wall linings to control horizontal impact sound from adjacent spaces
- Provide rubber stops to chairs to control furniture impact noise (or ensure a carpeted floor covering)
- Provide resilient mounts on cupboards and slow closing drawers to control furniture noise
- Avoid noisy blind mechanisms such as roller blinds

6. REFERENCES

1. Approved Document E – ‘Resistance to the passage of sound’. 2010 (2003 edition incorporating 2004, 2010, 2013 and 2015 amendments). ISBN 978 1 85946 204 1.
2. [Building Bulletin 93](https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/400784/BB93_February_2015.pdf). Acoustic design of schools: performance standards.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/400784/BB93_February_2015.pdf
3. Statutory Instrument: No.1943 [The Education \(School Premises\) Regulations 2012](#), Education England and Wales. ISBN 978 0 11 152768 9.
4. Department for Education. Advice on Standards for School Premises. 2015.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/410294/Advice_on_standards_for_school_premises.pdf
5. Department for Education (2014). The Equality Act 2010 and schools. Departmental advice for school leaders, school staff governing bodies and local authorities. May 2014.
6. Association of Noise Consultants [Good Practice Guide. Acoustic Testing of Schools](#) Version 2 November 2015.
7. Institute of Acoustics/Association of Noise consultants: ‘Acoustics of Schools: a design guide.’ November 2015.
https://www.ioa.org.uk/sites/default/files/Acoustics%20of%20Schools%20-%20a%20design%20guide%20November%202015_1.pdf
8. [Anderson Acoustics: Improving Access to Listening in Mainstream Schools](#) (available from andersonacoustics.co.uk/resources)