Movable Goalposts - A review of on-site performance of operable walls and folding partitions by Joe Bear of Adrian James Acoustics

1 BACKGROUND

As specialists in buildings for education and the arts, we frequently come across schemes that incorporate sliding, folding, movable or otherwise operable partitions. The ability to change the size and shape of a room and the flexibility that this offers has obvious appeals to architects and clients alike. However, in our experience these elements generally fall short of the manufacturer's advertised performance figures when tested on site.

The problem of underperformance of operable walls on site has become more obvious in recent years with the increase in commissioning sound insulation measurements, as required to achieve BREEAM credits for internal acoustics. As project acousticians it is important that we are able to provide a realistic prediction of the expected performance to architects and client teams for them to make informed decisions.

This article presents the results of our investigation of the site performance of operable walls and comparison of this data against the manufacturers' published performance figures. This analysis does not seek to differentiate between individual systems or manufacturer's products and for that reason all references to specific products or manufacturers have been omitted.

The content in this article was originally presented at the IOA Measurement and Instrumentation Group conference "Trials and tribulations of overcoming acoustic challenges" in June 2013.

2 SOUND INSULATION DESCRIPTORS – LAB VS SITE

The performance of sound insulating elements is assessed in a laboratory by measuring the Sound Reduction Index, R, in accordance with BS EN ISO 140-3 and weighting to a single figure index, R_w using the rating methodology set out in BS EN ISO 717-1. Laboratory measurements are conducted in a transmission suite, where all of the potential paths for flanking transmission are suppressed so it can be reliably assumed that all of the acoustic energy transferred between the rooms is transmitted through the test specimen alone.

On site, sound insulation is measured in terms of the Standardised Level Difference, D_{nT}, in accordance with BS EN ISO 140-4 and weighted to a single figure index, $D_{nT,w}$ using the rating methodology set out in BS EN ISO 717-1. The Standardised Level Difference is a measure of the acoustic energy transferred between the two spaces via all transmission paths, direct and indirect and standardised to a receiver room reverberation time of 0.5 seconds. In principle, if the all of the acoustic energy transmitted between two spaces passes directly though a single separating element, with no transmission via flanking paths, the Weighted Standardised Level Difference is related to the Weighted Sound Reduction Index as follows:

$$D_{nT,w} = R_w + 10 \log(V/S) - 5 \text{ dB} \quad (1)$$

Of course this is never the case in practice and it is common to include an allowance of around 7 dB for reductions in site performance due to detailing weaknesses, transmission via flanking paths and other non-ideal conditions. This gives rise to the following relationship which is used to estimate the required specification of a sound insulating element to achieve a required performance standard on site.

$$D_{nT,w} \approx R_w + 10 \log(V/S) - 12 \text{ dB} \quad (2)$$

This is of course not an exact relationship but in our experience works adequately as an approximate rule of thumb to predict the performance of conventional fixed constructions on site. But in the case of operable walls we have found that this relationship does not accurately predict the performance that can be expected on site. This is demonstrated in the two recent examples, described in the following case studies.

3 CASE STUDY 1 – SCHOOL

We worked on a project to relocate three existing schools into a single, purpose-built school campus building. The scheme made extensive use of operable walls including twelve sliding or folding partitions between classrooms and group rooms and five moveable walls sub-dividing 'flexible' hall / dining hall / music and drama teaching spaces.

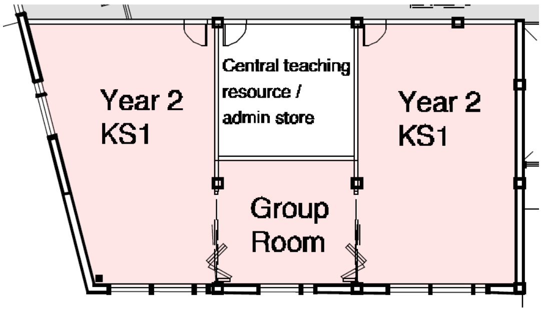

Figure 1 –Operable walls between classrooms and a group room

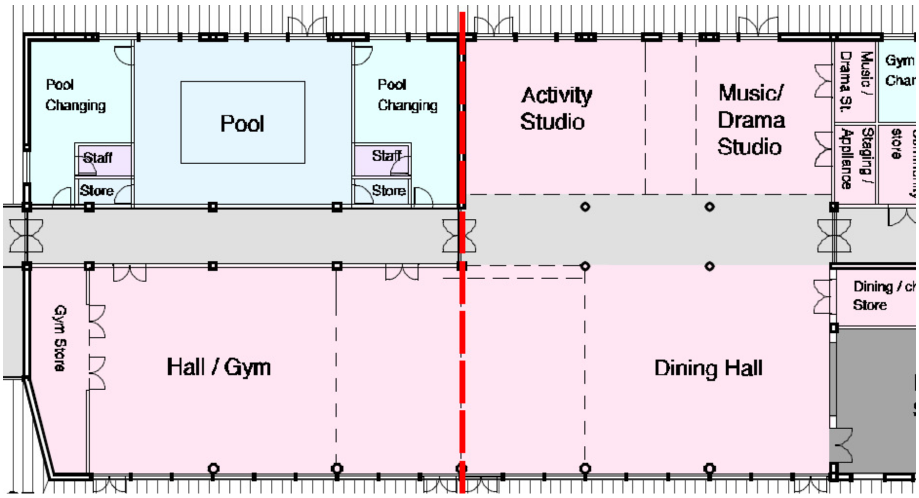

Figure 2 - Operable walls in hall and music and drama teaching spaces (denoted by dashed grey lines)

Despite lengthy discussions with the design team to explain the potential problems with the arrangements shown, it was determined they were essential to the teaching ethos of the new combined school campus and that they were to be retained within the scheme. We therefore recommended that the supplier of the partitions should be required to guarantee that the partitions installed would meet the required performance standards when tested on site.

Between classrooms and group rooms the supplier specified folding partitions rated at 48 dB R_w to meet the Building Bulletin 93 sound insulation requirement of 45 dB $D_{nT(Tmf,max),w}$. Between the various 'flexible' hall / dining hall / music and drama teaching spaces the supplier specified folding partitions rated at 57 dB R_w to meet our recommended Alternative Performance Requirement of 45 dB $D_{nT(Tmf,max),w}$.

Applying the rule of thumb set out in equation 2 suggests that the partitions should achieve around 44 dB $D_{nT(Tmf,max),w}$ between classrooms and around 53 dB $D_{nT(Tmf,max),w}$ between the flexible hall spaces. In practice the partitions achieved between 26 and 35 dB $D_{nT(Tmf,max),w}$ between classrooms and 26 to 28 dB $D_{nT(Tmf,max),w}$ between flexible hall / studio spaces. In order to allow a direct comparison between site test data the lab data provided by the manufacturers we converted the results to Apparent Sound Reduction Indices using the following formula.

$$R'_w = D_{nT,w} - 10\log(V/S) + 5 \quad (3)$$

The graphs in Figures 3 and 4 show the published R_w lab data for two of the partitions types installed along with the R'_w site measurement results. The 48 dB R_w partitions consistently achieved between 22 and 25 dB below the published laboratory performance. This is well below the allowance for reduction in performance due to site conditions. Subjectively, the main path for noise transmission between the test rooms was through weaknesses at the joints between panels and around the perimeter of the partitions and through the partition panels themselves. There was no significant audible noise transmitted via the surrounding building elements.

The results for the partitions tested in the 'flexible' hall / dining hall / music and drama teaching spaces were 33 and 35 dB below the stated performance of 57 dB R_w. In this case, the main path for noise transmission was via open gaps around the perimeter of the partitions and around pass doors contained within the partitions.

Some of the problems experienced at this school were due to poor installation but we consider that the wider consistency of the results suggests that the maximum achievable performance of partitions as installed is well below the performance stated in the manufacturer's published data.

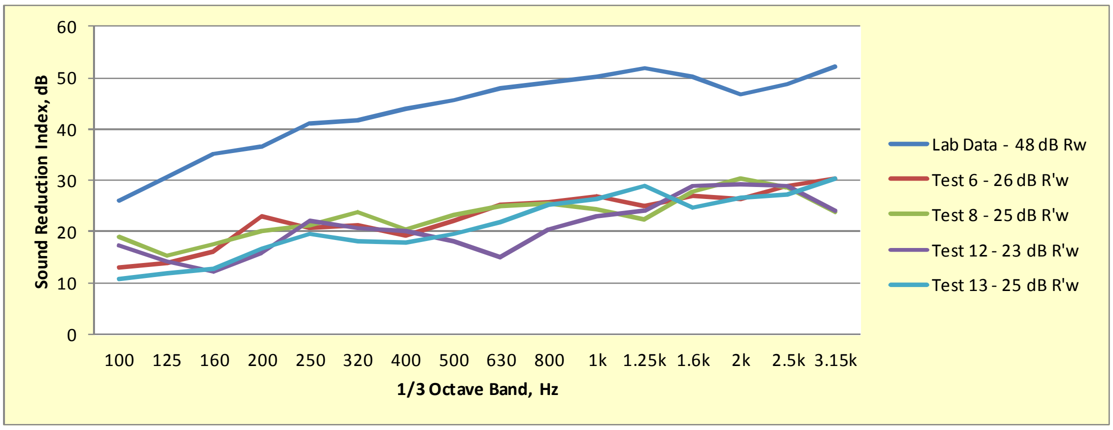

Figure 3 – R_w48 Partition Lab vs. Site Data

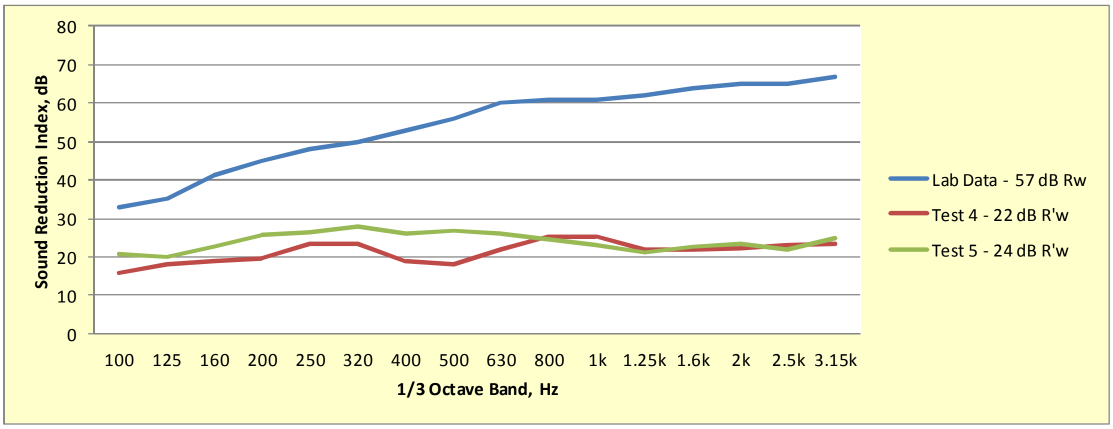

Figure 4 - R_w57 Partition Lab vs. Site Data

The school was completed and handed over at the time of our tests and despite the client's insistence on the specific need for flexible spaces, the majority of the partitions were found with furniture installed in front of them which had to be moved before the partitions could be opened. The school staff also had to conduct a lengthy search to locate the hex tools which are supplied with the partitions and required to operate them. This suggests to us that in practice the movable partitions are opened infrequently, if ever, and are therefore probably not required.

4 CASE STUDY 2 - PRIMARY CARE CENTRE

Another example of a project where we encountered problems with folding partitions is a new Primary Care Centre building designed to provide accommodation for GPs, health visitors and other community-based health professionals. The project included 3 pairs of group/meeting rooms, each sub-divided with operable partitions, two pairs of which are shown in Figure 5.

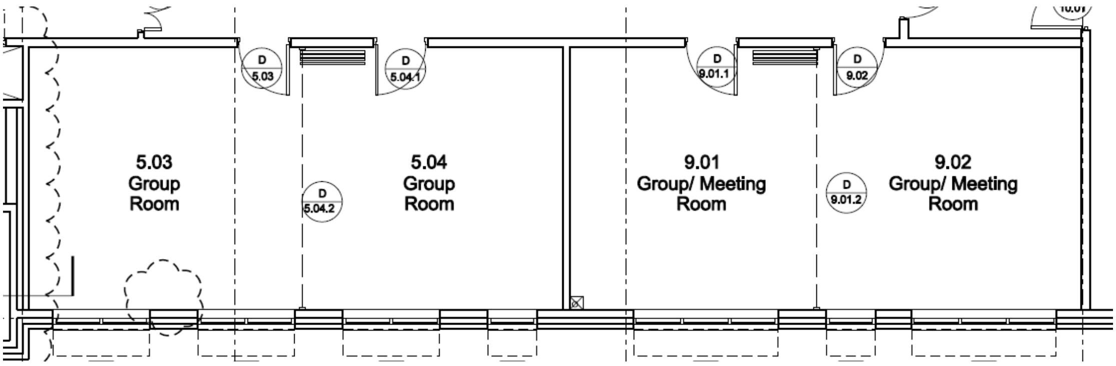

Figure 5 - Layout showing two pairs of group / meeting rooms with operable walls denoted in dashed grey lines

To comply with requirements on Health Technical Memorandum 08-01 and BREEAM Healthcare 2008 the required standard of sound insulation between each pair of sub-divided meeting rooms is 42 dB $D_{nT,w}$. The contractor specified partitions rated at 51 dB R_w. The relationship set out in equation 2 suggests that if these partitions perform as claimed these units should achieve at least 45 dB $D_{nT,w}$.

An initial measurement between one of the pairs of sub-divided rooms achieved 24 dB $D_{nT,w}$, which is 18 dB below the required standard. The main paths of transmission all appeared to be related to the seals between the hinged panels and the seal between the overall partition and the surrounding building elements. There were no prominent paths of flanking transmission via the surrounding building structure itself.

The installers were recalled to site to undertake remedial work on the partition to install seal sets that were left out at the time of the original installation. The result of the retest following the remedial work was 29 dB $D_{nT,w}$, which is 13 dB below the required standard. A meeting with the supplier's representative then revealed that the wrong partition type had been installed. The suppliers agreed to remove all three partitions and install replacements partitions capable of achieving the 42 dB $D_{nT,w}$ performance criterion. Measurements across the replacement partitions achieved between 31 and 37 dB $D_{nT,w}$. This is a significant improvement but the results were still 5 to 11 dB below the standard required to comply with HTM 08-01 and BREEAM.

Some months later we were contacted by the client who asked us to check data from a further set of measurements conducted by the supplier following more remedial work. The test results supplied were quoted as 41.6, 41.8 and 43 dB $D_{nT,w}$. It is important to note that BS EN ISO 717-1 specifies single figure indices (R_w, R'_w $D_{nT,w}$) as whole numbers and provides clear guidance on the correct sequence of rounding calculation results. Where the above results are quoted to 1 decimal place they cannot simply be assumed to round up to 42 dB $D_{nT,w}$ and comply with the criterion.

We re-calculated the weighted results using the supplied third octave band D_{nT} results and found the results of the suppliers tests were in fact 41, 41 and 43 dB $D_{nT,w}$. The partitions installed were not capable of achieving the required performance on site, even after three attempts to remedy the situation.

5 WIDER DATA REVIEW

Our experience of folding partitions was limited to partitions from a small number of suppliers and manufacturers. We were curious to investigate whether the problems we have encountered were isolated instances or indicative of wider underperformance from these types of products. We contacted fellow member organisations of the Association of Noise Consultants and requested data from their site measurements across operable partitions.

Data was kindly supplied by Apex Acoustics, AECOM, Azymuth Acoustics, Miller Goodall, Paragon Acoustic Consultants, Red Twin Limited and Spectrum Acoustic Consultants.

Figure 6 - Organisations that kindly assisted in supplying site test data

In total we now have test data for measurements across 49 partitions and Figure 7 shows a distribution of all of the R'_w test results. This highest measurement result was 49 dB R'_w, although we understand that this was achieved by installing two partitions back to back to create a lobby zone between the two. The results for single partition installations show a spread of R'w results from 22 dB up to 46 dB with a mean result of around 34 dB R'_w. We do not know the specification of all the partitions tested but these results appear to show that it is generally not possible to achieve an R'_w above 46 dB R'_w with a single operable wall. To put this into context, only the very highest-performing partitions of those tested would meet the BB93 criterion of 45 dB $D_{nT,w}$ between two conventionally sized classrooms (7 x 7 x 3 m). However, we do not have sufficient data to determine any statistically significant variations in performance of products from different suppliers.

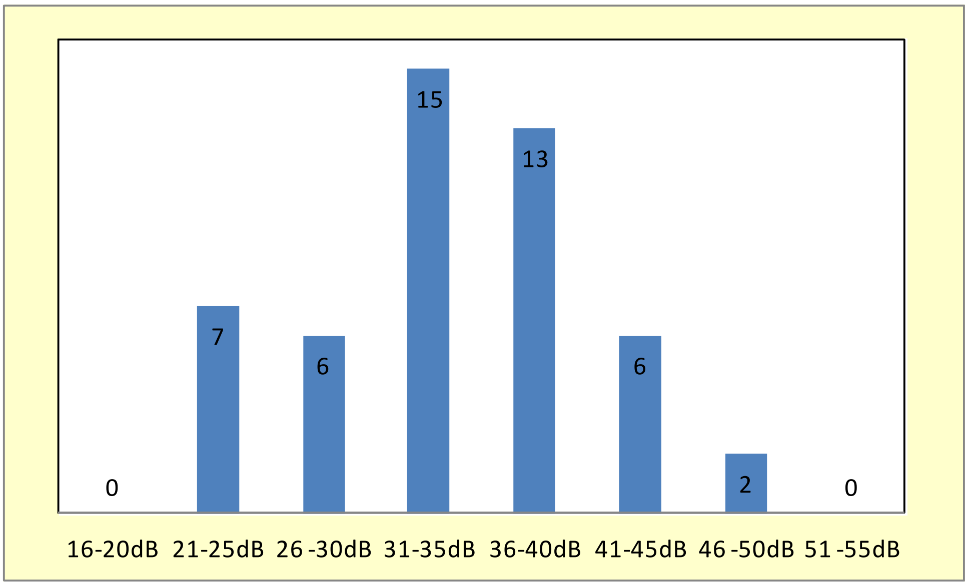

Figure 7 - Distribution of all of the R'_w results

We do not know the specification of all of the partitions tested within this wider data set. Furthermore, some of the tests were identified as being limited by installation problems such as gaps around partitions. We revised the data set to only include measurements on known partitions and excluded any tests where the test specimen was known to have specific installation problems that would limit the performance below what could normally be expected.

Figure 8 shows the measured R'_w result plotted against the published R_w performance in each case. This appears to show a systematic problem of operable partitions failing to achieve the stated performance on site. The mean difference between R_w measured in a lab and R'_w measured on site is around 18 dB. It is possible that this mean result is being unduly biased by undiagnosed installation problems on the lowest performing partitions. However, if we omit results below 30 dB R'_w from the data set, the mean difference between the site and lab data is still 17 dB.

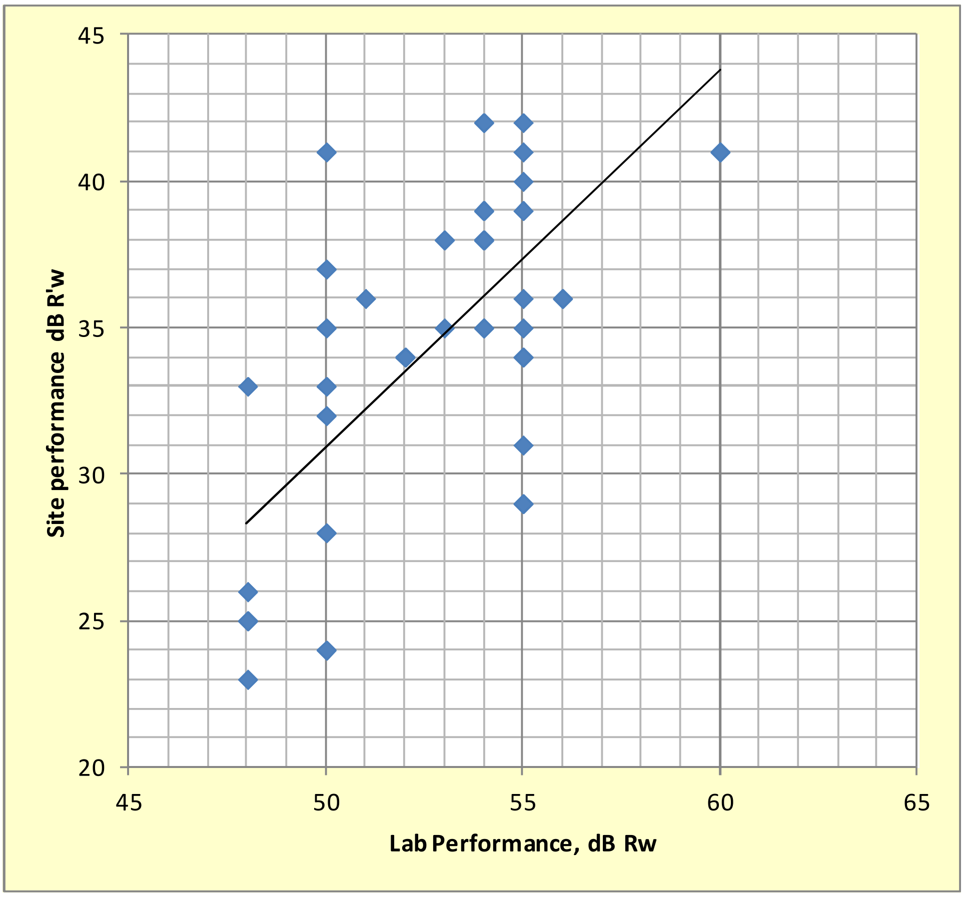

Figure 8 - Lab performance (R_w) vs. Site performance (R'_w) for individual partitions

The complied data suggests that if an operable partition is installed and operated correctly the R'_w performance achieved is likely to be around 18 dB below the published R_w performance. This suggests that rule of thumb relationship set out in equation 2 should be amended as follows when specifying operable partitions.

$$D_{nT,w} \approx R_w + 10 \log(V/S) - 23 \text{ dB} \quad (4)$$

This is of course an over-simplification but it goes some way to highlighting the magnitude of the problem.

6 REASONS FOR UNDERPERFORMANCE

We have raised the subject of underperformance with a number of suppliers and manufacturers of operable walls. A typical response to this question is to blame flanking transmission via surrounding building elements. It is true that transmission via the surrounding structures must be considered in the specification of any sound insulating construction. This would typically include the specification of appropriate bulkhead constructions above the head track and detailing of interfaces with the surrounding structures. However, tith the exception of partitions with insufficient sealing due to poor installation we have yet to witness an operable wall installation where the performance has been limited by flanking transmission via the surrounding building elements. Even if we exclude the tests where the operable partitions tested have been identified as having, or likely to have problems with the installation the data still appears to be suggest a systematic shortfall on site.

This leads us to question how well the lab test data represents the installations on site? Operable walls are generally bespoke constructions, custom made to fit the specific opening. It is therefore possible that the partitions constructed within transmission suites have fundamental differences to the specific installations on site which make the performance measured in the lab simply unattainable on site.

In our experience, there seems to be a problem of sales staff failing to properly interpret the test data and understand how the test installations compare to the site installations. For example, we have had two projects where suppliers have quoted performance figures for high-rated partitions without taking account of the inherent reduction in performance caused by the addition of a pass door in the partition on site. In another example, we found literature from a manufacturer where R_w performance figures had been quoted as R'_w figures.

7 FURTHER WORK

This brief study has identified what appears to be a systematic difference between the claimed lab performance of operable walls and the sound insulation test results achieved on site. The simple answer for us as acousticians is to recommend that our clients do not use these types of products. Operable walls are no substitute for a proper design brief for the use of the different spaces within a building and a non specific desire for flexibility can place unintended limitations of use on to spaces separated by movable partitions. However, in the right circumstances operable walls can offer significant advantages to the clients and end users of buildings in terms of flexibility of use. We must be able to accurately predict the levels of performance that can be achieved in practice so we can allow our clients to make informed decisions on the appropriate specification of operable partitions. It is therefore important that we, as an industry, put pressure on the manufacturers and suppliers of operable partitions to provide reliable test data for the lab and site performance of their products.