Static Shear testing of 3M VHB 4611F and VHB 4941P Tape in the construction of Acoustic Movable Partition Wall panels

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Abstract:

This paper has been written to investigate the viability of using Very High Bond (VHB) tape in the construction of Acoustic Movable Partition Walls (AMPW). Traditionally AMPW products have been constructed with an internal steel frame, this provides rigidity to the product but makes it extremely heavy. This causes problems in manual handling, transportation and installation. The construction of this frame also contributes significantly to the manufacturing time, and cost of constructing an AMPW. With these contributing factors in mind an investigation was undertaken to construct a frameless AMPW.

During this investigation the possibility of using a VHB tape in the construction was highlighted. This construction method would be favourable as it would allow for pre-constructed product elements to be used in the construction process, with a view to speeding up the products assembly. The second favourable attribute of VHB tape is that it is made from aerated acrylic foam, this may provide some acoustic dampening between the products faces and hopefully benefit the acoustic performance of the product. As the characteristics of VHB tape have never been tested in this capacity, bonding to these specific materials this viability study was carried out for this application.

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1) Introduction

The work presented here was undertaken as part of a Knowledge Transfer Partnership (KTP) between De Montfort University and Nusing Manufacturing (UK) Ltd (NMUK). This partnership was established to embed a design potential within NMUK and aid in the development of new products, furthering the business potential of the commercial partner. NMUK produce Acoustic Movable Partition Walls (AMPW) which are commonly used to divide space in Schools, Conference Halls and Hotels, where a high level of acoustic separation and privacy is required. An example of an installed product can be seen in figure 1.1.

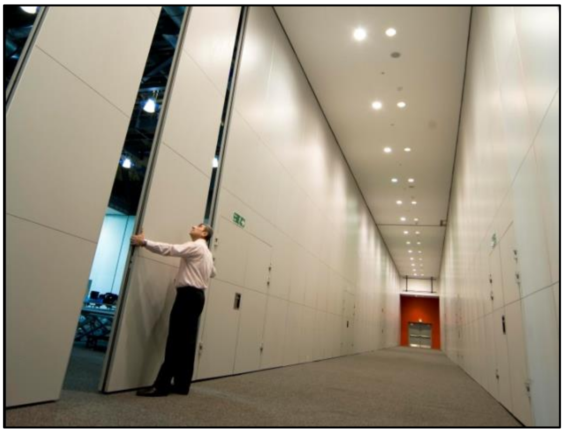

Figure 1.1 - An installed partition at the Liverpool Convention Centre (LCC)

Providing this acoustic separation, dense acoustic cladding is added to the AMPW, this additional mass helps reduce transmission at the low to mid frequencies (50 – 1,500 Hz) where only mass, material resonance and stiffness can positively affect the transmission loss. This is illustrated in figure 1.2 the acoustic characteristics of sound transmission through a partition (Sharland, 1973, p115).

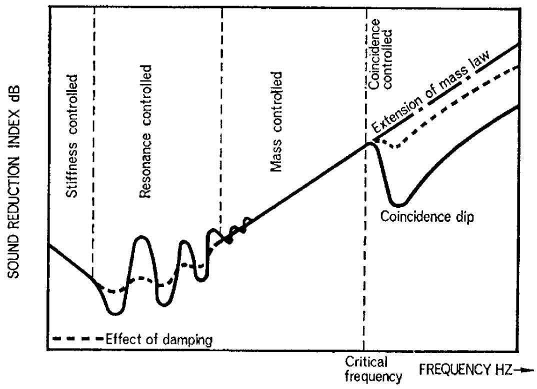

Figure 1.2 - The characteristics of transmission loss through a partition.

Although this high level of sound reduction is a desirable feature of the product, the increased mass ultimately creates logistical problems in manual handling, transportation and installation. Ideally, a solution could be reached where the overall weight of this produce could be reduced without having a detrimental effect on performance of the product.

2) Objective

With this in mind, an investigation was undertaken to try and reduce the overall weight of an AMPW whilst still achieving comparable acoustic performance results to that of existing products.

3) Initial Research

During the initial research an area identified for potential weight reduction was within the construction methodology of the partition panels. Existing products produced by NMUK have an internal steel support frame which is central to the construction of the partition, although this frame provides the geometry for the construction of each panel, acoustically it was theorised it actually had limited value within the construction. This led to an investigation into the feasibility of removing the steel frame from the construction (as seen in Figure 3.1) and replacing it with a series of steel brackets.

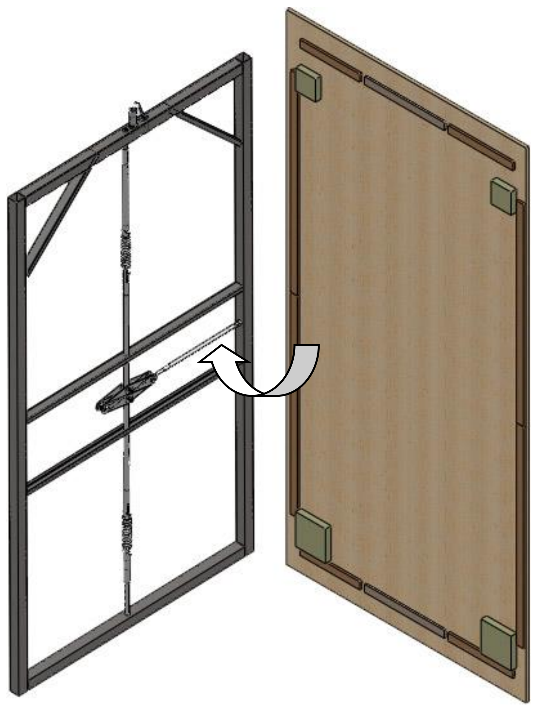

Figure 3.1 - Removing the frame from a partition panel

Within the construction, to provide acoustic strength, the surfaces of the partition must be isolated from each other, to reduce acoustical bridging. However the construction must be rigid in order to perform at the lowest measured frequencies (50 – 125 Hz), with these specific design criteria the traditional mechanical fixing methodologies (screwing and gluing) were not viable. This led to an investigation to source an innovative fixing technique which not only provided adequate strength for the construction but also provided a degree of isolation between the product elements. During this study a 3M product, Very High Bond (VHB) tape was sourced [1], this aerated acrylic foam tape appeared to have the desirable qualities needed for this situation. However, its application within this specific construction has never been tested before, this led to the following investigation into the viability of using the VHB tape within this construction methodology.

4) Abstract

These experiments have been carried out to test the viability of using 3M VHB 4611F and 4941P tape in the construction of AMPW's. The proposition for using 3M VHB tape has been made not only for its bond strength but also because the foam acrylic construction of the bond helps to isolate both surfaces of the partition. This isolation of the partition faces should benefit the products acoustic performance.

5) Tape tested

3M VHB Acrylic Foam Tape 4611F [2]

3M VHB Acrylic Foam Tape 4941P [2]

6) Sample test bracket

The test samples were assembled as per the technical drawing in Figure 6.1. All samples were cleaned / prepared as described in section 7 sample assembly.

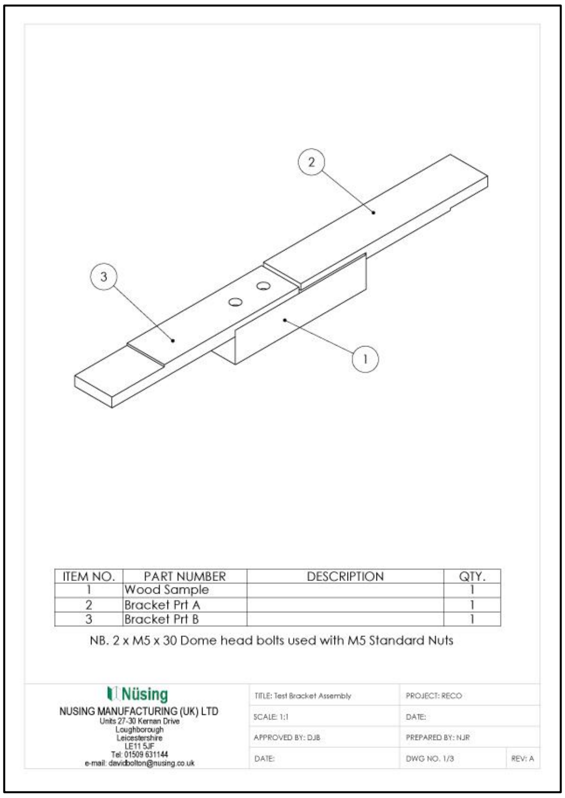

Figure 6.1 – The produced test bracket

7) Sample assembly

The samples surfaces were prepared in all cases (except where the preparation method was being tested) as per the instructions in; 3M Surface Preparation for 3m VHB Tape Applications, Technical Bulletin, April 2007 [3]

Surface cleaner used:
- 3M Surface Cleaner, DV-1070-0109-6/0609

Primer used:
- 3M 94 Primer, 70-0160-5478-8 / 34-8702-3242-7

All samples were allowed 72 hours to cure before testing as recommended in the product data sheets.

8) Tests proposed

1. The primary aim of this experiment was to determine if the bond strength of the 3M VHB tape is linear in this application and to investigate its viability in this construction methodology.

2. The secondary aim of this investigation is to test if the recommended cleaner can be substituted in the sample assembly for a non-flammable alternative. If at all possible NMUK wish to avoid using a solvent based flammable cleaner, like IPO (isopropyl alcohol)/water which is recommended by 3M. Currently NMUK use a Dichloromethane based solution. The purpose of this test will be to ascertain if there are any negative effects of preparing the surfaces with this cleaner.

3. The tertiary aim of this investigation was to quantify if there is any improvement in adhesion by using the recommended 3M primer. 3M 94 Primer is also solvent based, highly flammable and carcinogenic; if possible for these reasons NMUK would wish not to have this chemical on site.

9) Equipment used

Sample test bracket, Figure 6.1

Hounsfield H20K-W, Tensile tester,
Queen's Building,
Faculty of Technology,
De Montfort University

10) Methodology

1. To determine the static sheer strength of the VHB 4611 Tape three sample sizes of 10mm x 19mm, 20mm x 19mm and 30mm x 19mm were used. For each sample size five individual samples were tested to determine an average value. By testing three sample sizes a fair determination of the bond strength of the VHB 4611 tape can be made. This result determines whether bond area is proportional to bond strength and calculate a bonding area needed to support a movable partition wall panel.

2. To determine the need / value of using the recommended 3M cleaner / primer a further 15 samples were tested to calculate any detrimental readings associated with not using these products. 5 samples with neither primer nor recommended cleaner, 5 samples cleaned with the cleaner but not primer and 5 samples primed but not cleaned with the recommended cleaner.

11) Test parameters used

The test parameters used in this test were;

- 50.0mm/min feed rate
- 0 – 20,000 N range

12) Results

The following figures show the data gathered by carrying out this investigation.

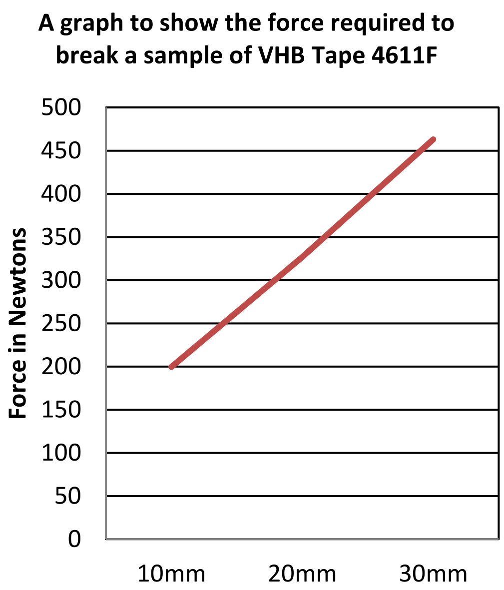

Figure 12.1 – The results from VHB 4611F

A graph to show the force required to break a sample of VHB Tape 4941P

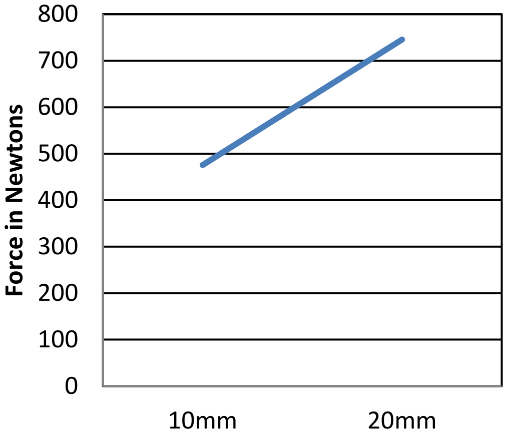

Figure 12.2 – The results from VHB 4941P

Unfortunately in the testing of the 30mm VHB 4941P the Melamine Faced Chipboard (MFC) failed before the VHB sample so no data could be gathered for these samples. The point of fail was at the bolted mechanical fixing to the second bracket, this can be seen in figure 12.3.

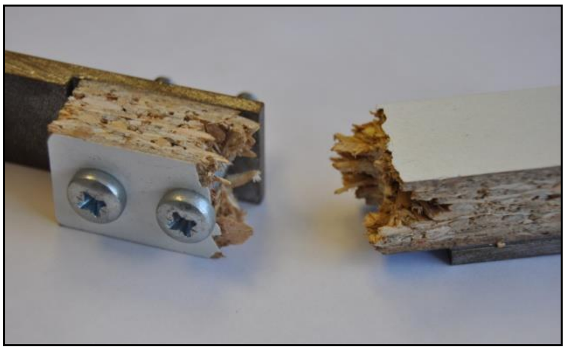

Figure 12.3 – An example of a test bracket failing

Sample area of VHB 4611F

10mm x 12mm x 2 = 240mm^2 or 2.4x10^{-4} m^2
20mm x 12mm x 2 = 480mm^2 or 4.8x10^{-4} m^2
30mm x 12mm x 2 = 720mm^2 or 7.2x10^{-4} m^2

Average force/area per sample VHB 4611F:

199.4 / 240 = 0.83 N/mm^2
327 / 480 = 0.68 N/mm^2
463 / 720 = 0.64 N/mm^2

Average = 0.72 N/mm^2

17.28 N/mm^2 per mm of tape used
(12mm wide roll as provided)

Sample areas of the VHB 4941P

10mm x 19mm = 380mm^2 or 3.8x10^{-4} m^2
20mm x 19mm = 760mm^2 or 7.6x10^{-4} m^2

Average force/area per sample VHB 4941P

475.5 / 380 = 1.25 N/mm^2
745.4 / 760 = 0.98 N/mm^2

Average = 1.12 N/mm^2

45.98 N/mm^2 per mm of tape used
(19mm wide roll as provided)

From this data it can be seen that the bond strength of the VHB tape is generally linear. A suitable length of tape can also be calculated to allow the manufacturers factor of safety in the construction of these products.

The following information is relevant to the secondary aim of this investigation: to determine is a non-solvent based cleaner can be used in this application.

A graph to compare the relative bond strength of two cleaning solutions

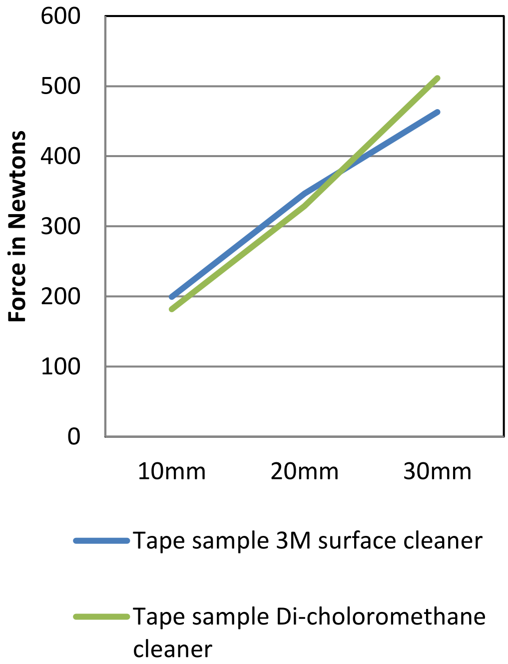

Figure 12.3 – The results from the comparison testing of the cleaners

From this data it can be seen that there are no detrimental effects in using a non-solvent based cleaner in the preparation of the samples.

The following information is relevant to the tertiary objective of this investigation: to determine if there is a definable improvement in adhesion if the surfaces are primed, with the recommended 3M primer, before the VHB tape is applied.

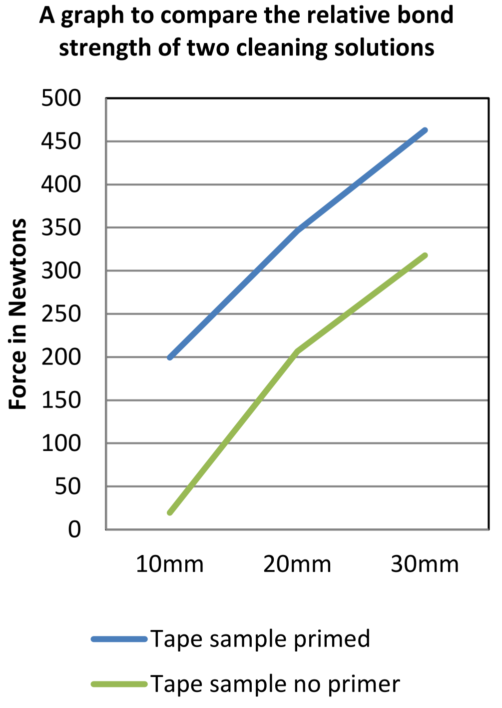

Figure 12.4 – The results from the comparison tests with / without primer

From this data it can clearly be seen that there is a detrimental effect on the bond strength of the VHB tape is the primer is not used.

13) Conclusions

As previously concluded in section 12 there is a linear correlation between the length of tape used and the bond strength provided. From this data a suitable length of tape can also be calculated to allow the manufacturers factor of safety in the construction of these products. With this data it can now be recommended that VHB 4611F and 4941P are both suitable for use in the construction of AMPW's.

The opportunity to use a non-solvent based cleaner in the construction of this new design of partition is a desirable outcome for NMUK as it allows them to maintain a safer working environment for employees.

However the dramatic loss in performance illustrated in Figure 12.3 when no surface primer is used means, that despite the solvent base of the primer solution, its inclusion must be insisted upon within the construction methodology. Or the methodology would no longer be viable.

14) Further product development

Since this study was undertaken, the optimisation of this frameless system has been realised and prototype partitions produced. The construction methodology has withstood mechanical testing in a comparable usage environment and the design realised to a point where the construction could be independently acoustically tested at a UKAS accredited laboratory.

15) Acoustic performance

This product design methodology was independently tested at Salford University in July 2010, with the aim of getting three products tested under BS ISO 140:3. The desired R values (Sound Reduction Index) for three products were 42, 45 and 48 dB, dependant on the products acoustic infill, not the construction methodology. In Figure 15.1 the frameless partition can be seen being installed.

Figure 15.1 – The installation of a partition at Salford University

The results of this testing can be seen in the table 15.1.

System	Kg/m²	R
System 1	25.5	41
System 2	33.9	46
System 3	45.6	48

Table 15.1 – The results of the tested systems

(Kg/m² is an expression of the system mass divided over the total surface area and not panel specific)

As can be seen from the results in table 15.1 the construction methodology achieved or exceeded the desired acoustic performance in two out of the three product configurations. This means that the production methodology can be considered a success in terms of its design for acoustic performance. In figure 15.2 the acoustic performance of the 48 dB partition can be seen as reported in the test certificate, Report No 18-55.

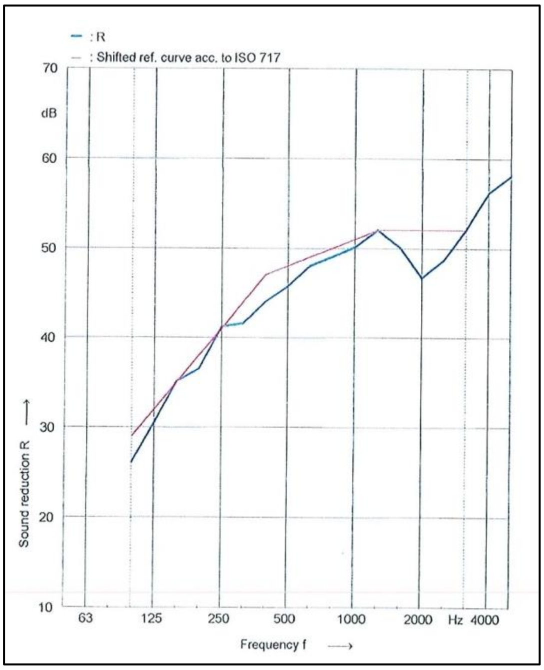

Figure 15.2 – The reported performance of the 48 dB partition

Comparison can be made at this time to Figure 1.2, the acoustic performance of a partition, as it can be seen the performance of the tested partition closely resembles this ideal performance. This close resemblance, with lack of any great deviations adds further weight to the statement: the revised construction methodology performs strongly acoustically.

16) Comparison with traditional product

Initially this project was established with the objectives of producing a lighter more commercially viable partition, in Table 16.1 comparisons have been drawn between partitions constructed under the traditional and new construction methodologies.

System	Kg/m²	R
System 1	25.5	41
100S – 42 dB	37	42
System 2	33.9	46
100S – 46 dB	39	46
System 3	45.5	48
100S – 49 dB	47	49

Table 16.1 – A comparison of the traditional and newly developed systems

As illustrated in Table 16.1 the new construction methodology achieved comparable acoustic performance to the traditional product but at reduced weight. This meets the initial design criteria for the system and logistically makes the product easier to handle, transport and install.

Alternatively the point could be made that with the weight saved by removing the frame, more acoustic mass could be added to the partition. This would bring improved acoustic performance to the partition at the same system weights stated for the comparable existing products.

There are also additional commercial benefits to this revised construction methodology, the panel construction time is reduced because the frame no longer has to be processed and assembled. Also the bracketing system is less expensive than constructing the frame adding further benefit to this construction methodology.

However, this new construction methodology comes with its own limitations: it is stated that the system can only be produced up to 4m high, where as existing systems have been constructed up to 13m in height. This is to avoid having to join the face boards on a frameless system as this construction has not yet been tested. Although 4m in height will cover the vast majority of orders this is a further area of testing and development which can be investigated.

17) Bibliography

A practical guide to noise control – I, Sharland
Publisher: Woods of Colchester (Dec 1972)
ISBN-10: 095029411X
ISBN-13: 978-0950294117

18) References

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3 3M Technical bulletin provided by manufacturer