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## **LIGHTWEIGHT PARTITIONS HAVING IMPROVED LOW FREQUENCY SOUND INSULATIONS**

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Research and Development Department  
Technical Resources Division  
**THE BRITISH BROADCASTING CORPORATION**

## LIGHTWEIGHT PARTITIONS HAVING IMPROVED LOW FREQUENCY SOUND INSULATIONS

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### Summary

*The sound insulations were measured of a range of single, double and triple leaf partitions. For the single leaf partitions, a staggered stud configuration was used. For the double and triple leaf partitions, the configuration of the boards was different from that in the conventional Camdens.*

*At low frequencies, the partitions tested generally had higher sound insulations than comparable metal-framed Camdens. They also had higher sound insulations at low frequencies than comparable all-plasterboard partitions having the same numbers of layers of boards as in the metal-framed Camdens.*

*The partitions will be suitable for use in studio constructions where lightweight partitions would previously have been ruled out on sound insulation grounds. This should enable considerable savings in construction costs.*

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# LIGHTWEIGHT PARTITIONS HAVING IMPROVED LOW FREQUENCY SOUND INSULATIONS

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## 1. INTRODUCTION

The overall sound insulations of lightweight plaster-board partitions<sup>1-6</sup> are generally very high for their weights. However, the sound insulations of lightweight partitions at low frequencies are typically quite small because of the low masses of the partitions. In many studios, more expensive masonry walls will have to be constructed to meet the sound insulation requirements at low frequencies.

It would be possible to increase the sound insulations of the lightweight partitions at low frequencies by increasing their masses. But this would be undesirable, because it would increase the loadbearing requirements of the building structure. Some increase in the sound insulations at low frequencies could also be achieved by increasing the cavity widths to increase the overall thicknesses of the partitions. However, this would be undesirable because it would reduce the available floor areas in studios.

In single leaf partitions, the sound insulations at low frequencies can be increased by reducing the acoustic coupling through the studs (for example, by using a staggered stud form of construction). In multi-leaf partitions, repositioning the boards towards the outer faces of the partitions can improve the sound insulations at low frequencies because the fundamental resonant frequencies of the partitions will be reduced. These techniques form the basis of the work described in this Report.

## 2. ALTERNATIVES TO THE SINGLE CAMDEN

It was difficult to identify a simple way of improving the low frequency sound insulations of single leaf partitions. Adding mass to partitions usually increases their sound insulations. Recently investigated all-plasterboard partitions<sup>5</sup> have higher sound insulations than metal-framed Camdens<sup>2</sup> because the plasterboard-fibreboard combination in the metal-framed Camden has been replaced by a more massive double plasterboard layer. However, more massive partitions than these all-plasterboard partitions would be undesirable because of the structural constraints imposed upon the surrounding building. It is also difficult to reposition the boards in a single leaf partition in a way that would result in altered performances near the fundamental resonant frequency.

One method that has been employed before<sup>7</sup> is to use a staggered stud form of construction. In this type of construction, each side of the partition is secured to a separate set of relatively independent studs. The studs are spaced from the opposing side by means of special clips fitted at the perimeter of the partition. Unfortunately, the two leaves of the partition cannot be fully independent at the perimeter of the partition. The staggered stud partition contains twice as many studs as a conventional partition.

Staggering the studs results in a vibration break which reduces transmission of sound through the partition and also alters the performance near the fundamental resonance frequency by allowing the two leaves to resonate almost independently of each other. Nevertheless, it must be borne in mind that, at lower frequencies, the air in the cavity is quite effective at coupling and this may be more significant than the mechanical coupling through the studs. The mechanical coupling at the perimeter of the partition

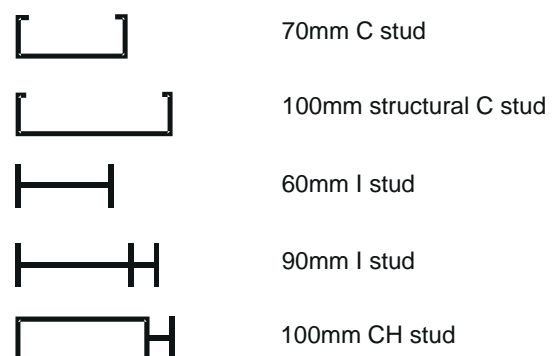
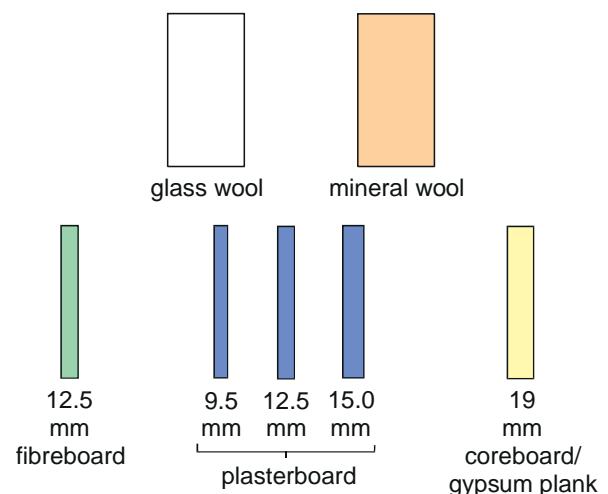
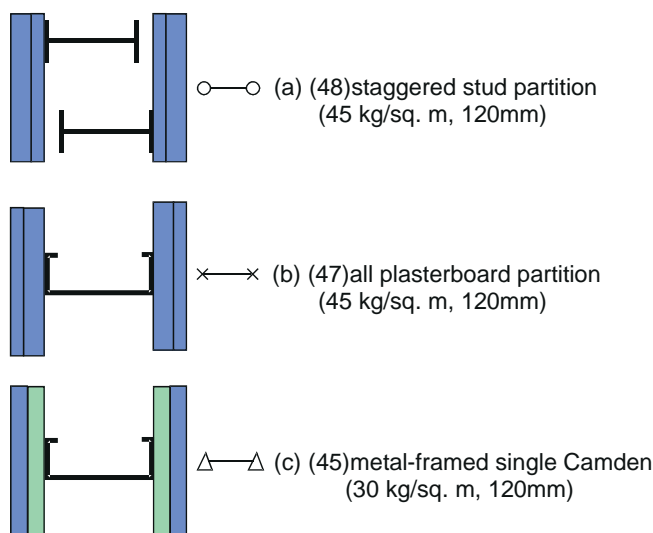
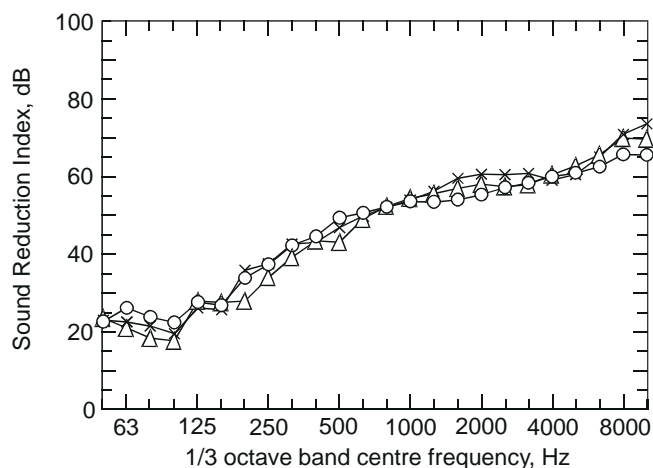
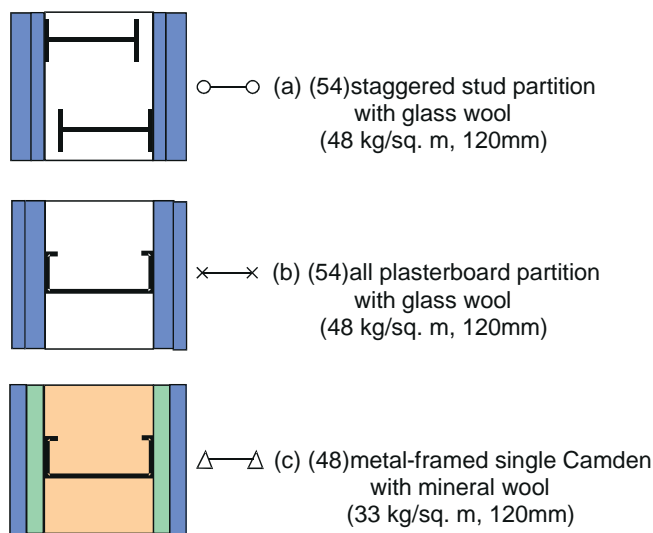
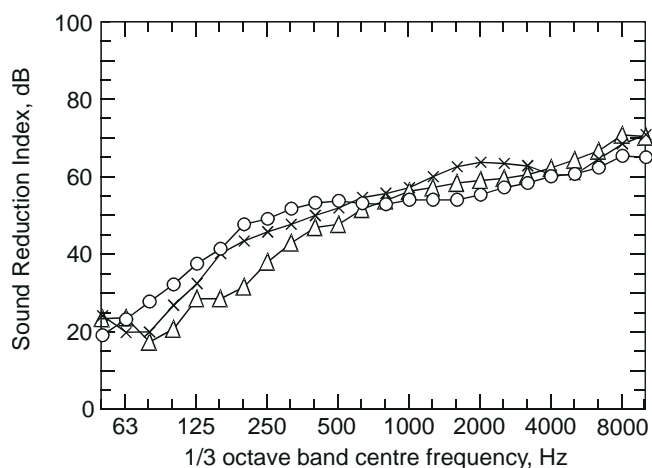


Fig. 1 - Symbols used in the keys to the graphs.



(Rw values are shown in brackets)

Fig. 2 - The sound insulations of single leaf, metal-framed partitions.



(Rw values are shown in brackets)

Fig. 3 - The sound insulations of single leaf, metal-framed partitions with treated cavities.

will also be a significant factor.

Fig. 1 (previous page) shows the meanings of the symbols used in the keys to the subsequent graphs of measurements. Fig. 2 shows the sound insulation of a staggered stud partition compared with those of other single leaf partitions. For the partitions of Fig. 2(a) and Fig. 2(b), one layer of 15 mm plasterboard and one layer of 9.5 mm plasterboard were fitted each side. The differences between the three curves are relatively small, although they exceed the differences that would be expected for a repeat construction and measurement on the same type of partition. The staggered stud partition has the best overall performance of the three partitions and it has significantly better sound insulations between 63 Hz and 100 Hz. Above 1 kHz, the partition having staggered studs had poorer sound insulations. This may have been because of inadequate acoustic sealing at the perimeter of the partition.

Fig. 3 shows the sound insulation of a staggered stud

partition with 75 mm thick glass wool batts installed in the cavity. Between 80 Hz and 500 Hz, the sound insulations of the partition having staggered studs were the highest of those shown. However, above 800 Hz, the converse was true. The overall performance of the staggered stud partition was approximately comparable to that of the partition with 'C' studs and two layers of plasterboard each side. However, the improved low frequency performance could be very worthwhile. The addition of the glass wool to the staggered stud partition (compare Fig. 2(a) and Fig. 3(a)) significantly increased the sound insulations between 80 Hz and 630 Hz. The glass wool damps the motion of the boards and absorbs sound that has leaked into the cavities.

For both of the staggered stud partitions, it will be necessary to consider whether the additional cost and complexity of the partitions are justified in return for the improvements in the sound insulations. It would also be necessary to investigate further the loadbearing

capacities of the partitions because the staggered studs have boards fitted to only one side and therefore the studs would be less well braced.

### 3. ALTERNATIVES TO THE DOUBLE CAMDEN

#### 3.1. Coupled-stud partitions

A coupled-stud partition<sup>7</sup> is often recommended for use in fire walls. It has a significant structural strength for a lightweight construction. This design was modified to incorporate 100 mm thick structural steel studs<sup>8</sup> and different board thicknesses (namely 15 mm and 9.5 mm plasterboard). Fig. 4 shows the sound insulation of the coupled-stud partition compared with that of the metal-framed double Camden (Fig. 4(c)) and an alternative design to the metal-framed double Camden made using only plasterboard (Fig. 4(b)).

Because the studs are coupled by the centre leaf of the partition, the sound insulations above 200 Hz were considerably lower than for the other two partitions. Below 125 Hz, the coupled-stud partition had a higher sound insulation than that of the metal-framed double Camden. This is due in part to the extra mass of the coupled-stud partition and in part to the fact that the different types of boards used and their different distributions result in a different behaviour near the fundamental resonant frequency. However, the coupled-stud partition had comparable low frequency sound insulations to those of the (albeit heavier) all-plasterboard alternative to the metal-framed double Camden. Because of its relatively poor sound insulation, the coupled-stud partition would only be useful in situations where a significant loadbearing capacity was required.

Fig. 5(a) (*overleaf*) shows the sound insulation of the coupled-stud partition with glass wool batts installed in the cavities. Once again, the sound insulations above 200 Hz are considerably lower than for the other two partitions because of vibration transmission through the studs. But, in this case, the coupled-stud partition has appreciably higher sound insulations than the other two partitions below 125 Hz. The damping to the fundamental resonance provided by the glass wool is more effective when the board separation is greater, as in the coupled-stud partition. Because of the relatively poor performance at higher frequencies, the overall sound insulation performance of the coupled-stud partition with treated cavities is probably still too low for the partition to be used as an alternative to the metal-framed double Camden.

The addition of glass wool to the cavities of the coupled-stud partition (compare Fig. 4(a) and

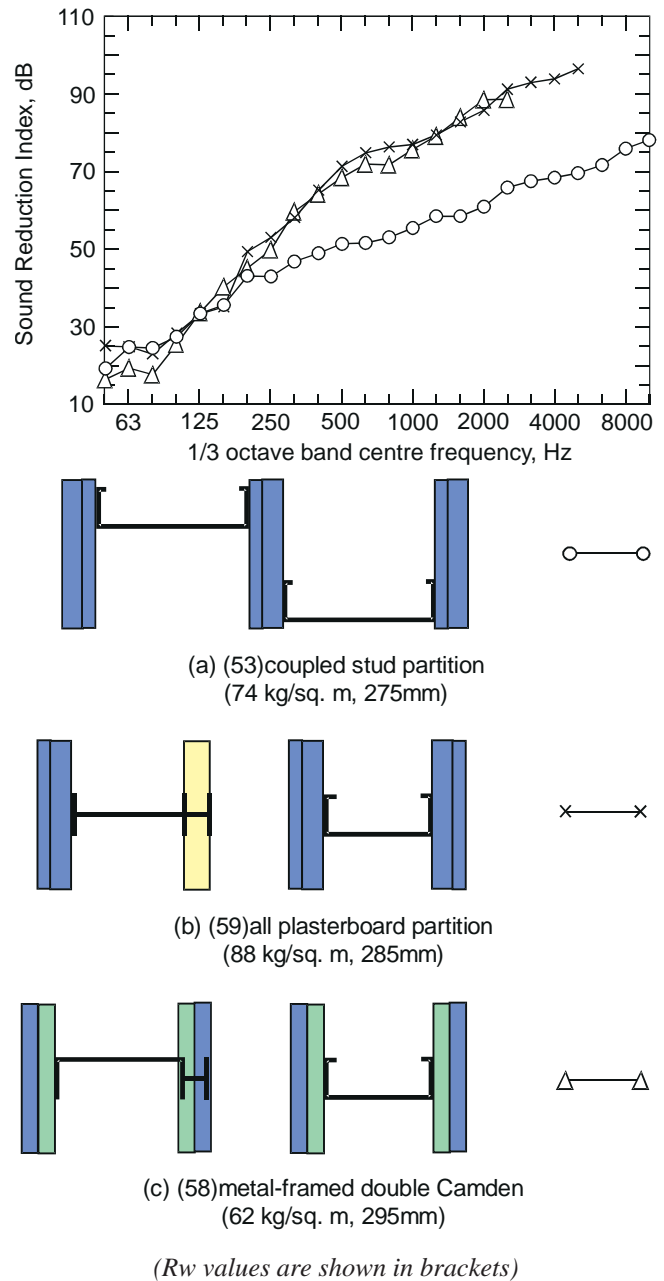
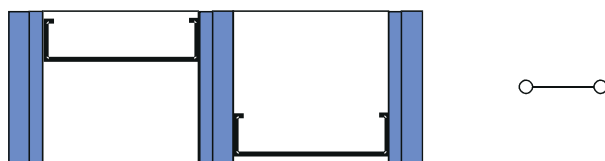
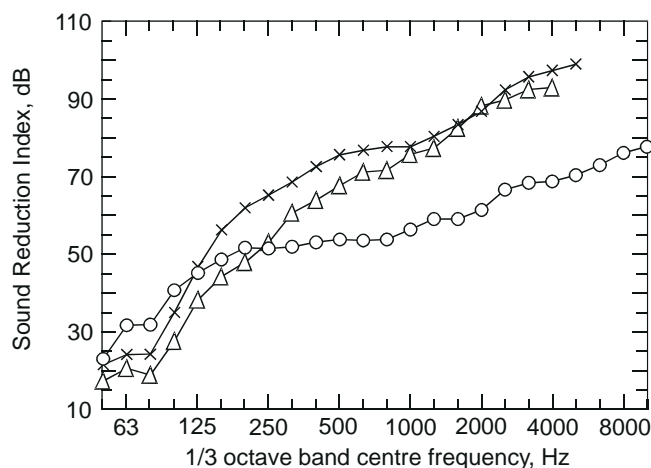


Fig. 4 - The sound insulations of double-leaf, metal-framed partitions.

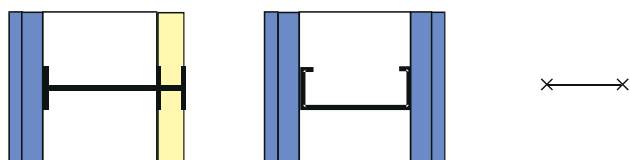
Fig. 5(a)) resulted in large increases in the measured sound insulations up to 1 kHz. This is because the glass wool damps the motion of the boards and absorbs sound that has leaked into the cavity. Above 1 kHz, the glass wool had very little effect, as at higher frequencies, the sound insulation of the partition is being limited by vibration transmission through the studs of the partition.

#### 3.2. Single-sided partitions

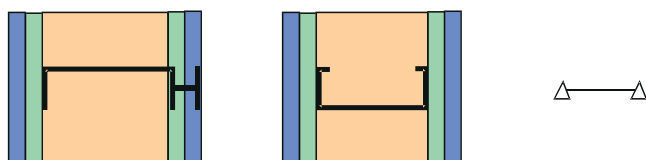
For a lightweight, multi-leaf partition of a fixed weight, the low frequency sound insulations are generally higher if all the boards are on the outer faces



(a) (58) coupled stud partition with glass wool (80 kg/sq. m, 275mm)



(b) (72) all plasterboard partition with glass wool (93 kg/sq. m, 285mm)



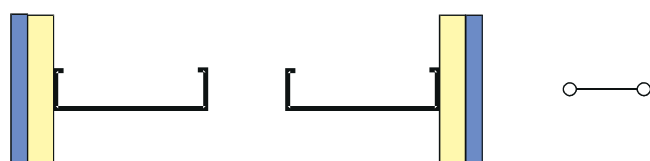
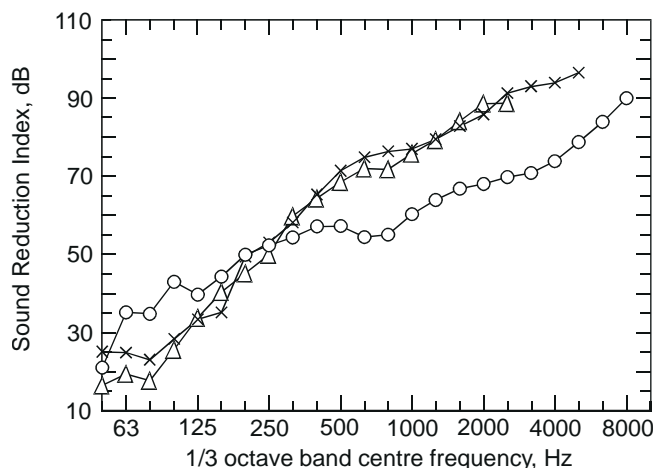
(c) (61) metal-framed double Camden with mineral wool (67 kg/sq. m, 295mm)

(Rw values are shown in brackets)

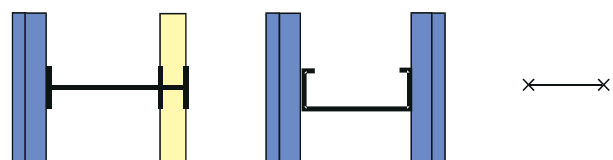
Fig. 5 - The sound insulations of double leaf metal-framed partitions with treated cavities.

of the partition. Fig. 6 shows the measured sound insulation of a double leaf partition with all the boards on the outer faces of the partition. The boards comprised 19 mm thick gypsum plank, fitted horizontally, followed by 12.5 mm plasterboard fitted vertically. The boards were fitted to 100 mm thick structural steel studs which are capable of supporting structural loads, even in the absence of cladding boards. The cavity width between the studs was 50 mm, although this could be reduced without seriously compromising the measured sound insulations.

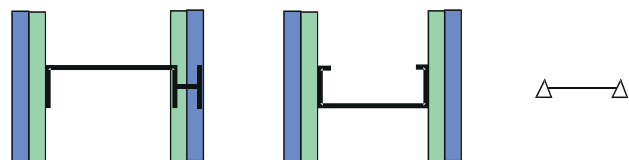
Above 250 Hz, the sound insulations of the single-



(a) (60) single sided partition (63 kg/sq. m, 313mm)



(b) (59) all plasterboard partition (88 kg/sq. m, 285mm)



(c) (58) metal-framed double Camden (62 kg/sq. m, 295mm)

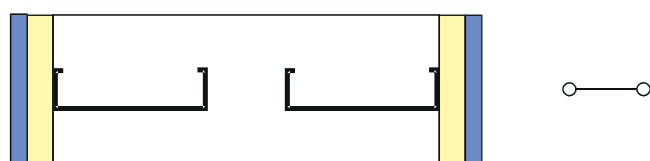
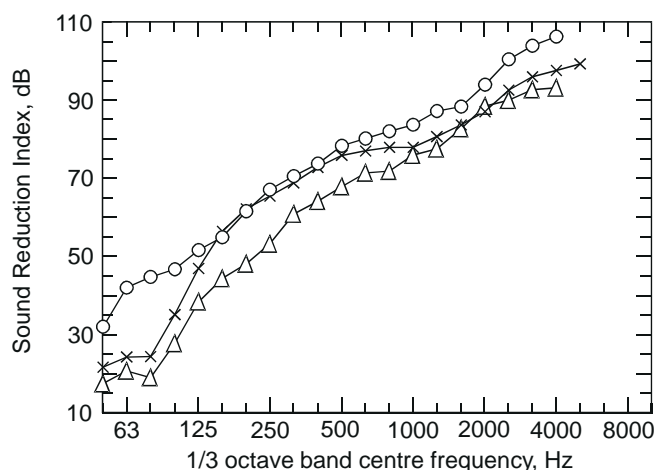
(Rw values are shown in brackets)

Fig. 6 - The sound insulations of double leaf, metal-framed partitions.

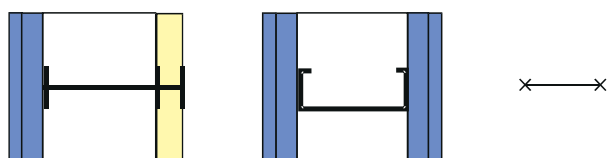
sided partition were considerably lower than those of the other two partitions. This is because the single-sided partition had fewer cavities and the acoustic sealing at the perimeter of the partition was of paramount importance. It is easier to provide a reliable acoustic seal throughout the whole of the partition when more layers of boards are used.

Between 63 Hz and 160 Hz, the sound insulations of the single-sided partition were considerably higher than those of the other two partitions because the positioning of all the boards on the outside of the partition lowers the fundamental resonant frequency of

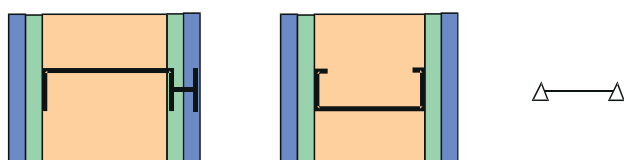




(a) (75)single sided partition with glass wool  
(71 kg/sq. m, 313mm)



(b) (72)all plasterboard partition with glass wool  
(93 kg/sq. m, 285mm)



(c) (61)metal-framed double Camden with mineral wool  
(67 kg/sq. m, 295mm)

(Rw values are shown in brackets)

Fig. 7 - The sound insulations of double leaf metal-framed partitions with treated cavities.

the partition. The overall performance of the single-sided partition is marginally higher than that of the other two partitions shown. Its weight is similar to that of the conventional metal-framed double Camden. If this type of partition were used for studio construction, great care would have to be taken to ensure that there were no weaknesses in either leaf of the partition because this would seriously degrade the performance.

Fig. 7(a) shows the sound insulation of a single-sided partition filled with glass wool. The sound insulations at higher frequencies are much greater than for the

single-sided partition without glass wool (Fig. 6(a)). This is because the glass wool effectively absorbs the sound that has leaked into the cavity, which compensates for any weaknesses at the perimeter of the partition. The sound insulations below 160 Hz are appreciably higher than those of the other two partitions shown in Fig. 7. The overall performance of the treated single-sided partition is appreciably higher than the other two partitions shown. The single-sided partition is only marginally heavier than the conventional metal-framed double Camden.

### 3.3. Simplified partitions

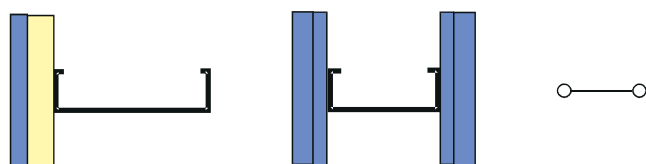
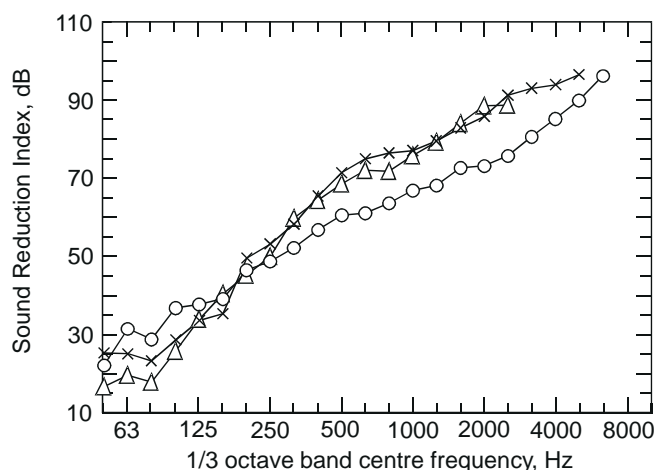
Because the single-sided partition was potentially weakened by only having two layers of boards, an intermediate partition construction was measured where only one of the leaves had a single-sided construction. The results are shown in Fig. 8(a) (*overleaf*). The first leaf was made from conventional 70 mm studs fitted with a layer of 15 mm plasterboard and a layer of 9.5 mm plasterboard each side. The single-sided leaf was constructed from 100 mm thick structural steel studs, with a layer of 19 mm plank fitted horizontally, followed by a layer of 12.5 mm plasterboard fitted vertically.

Above 200 Hz, the sound insulations of the simplified partition were lower than those of the other two partitions shown in Fig. 8. This is probably because the joint at the perimeter of the single-sided leaf is difficult to seal reliably and the sealing is critical to the performance of the partition. Also, the simplified partition has fewer cavities than the other two partitions.

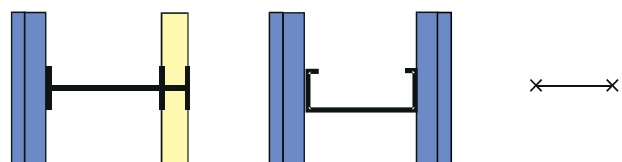
Between 63 Hz and 125 Hz, the simplified double leaf partition has appreciably higher sound insulations than the other two partitions, because the fundamental resonant frequency has decreased. The overall performance of the simplified partition is comparable to those of the other two partitions shown.

Above 400 Hz, the simplified double leaf partition (Fig. 8(a)) has lower sound insulations than the single-sided double leaf partition (Fig. 6(a)). This is due to the single-sided partition having fewer cavities and the sealing at the perimeter of the partition is critical. Below 400 Hz, the converse is true, as moving all the boards to the outer faces of the partition reduces the fundamental resonant frequency. The overall performances of the two partitions are comparable.

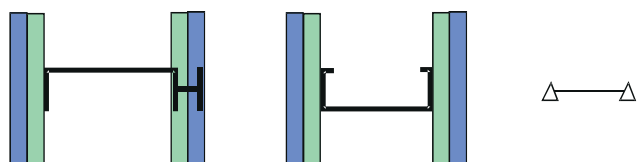
Fig. 9(a) (*overleaf*) shows the effects of the installation of glass wool in the cavity of the single-sided leaf of the simplified partition. The addition of the glass wool significantly increased the sound insulations at all frequencies (compare Fig. 8(a) and Fig. 9(a)). The



(a) (59)simplified double leaf partition  
(77 kg/sq. m, 302mm)



(b) (59)all plasterboard partition  
(88 kg/sq. m, 285mm)



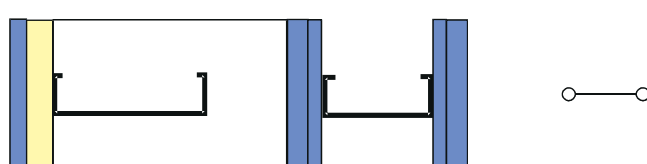
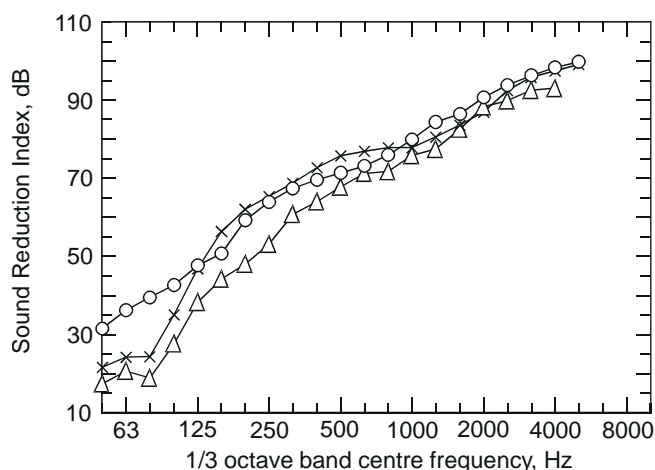
(c) (58)metal-framed double Camden  
(62 kg/sq. m, 295mm)

(Rw values are shown in brackets)

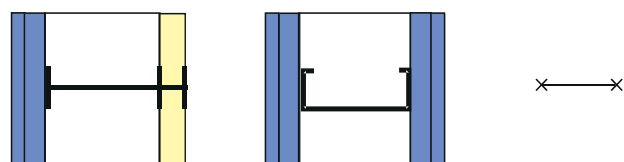
Fig. 8 - The sound insulations of double leaf, metal-framed partitions.

sound insulation of the treated simplified partition (Fig. 9(a)) was significantly higher than the treated metal-framed double Camden (Fig. 9(c)) at all frequencies. Above 100 Hz, the performance of the treated simplified partition was comparable to that of the treated all-plasterboard alternative to the metal-framed double Camden. However, below 125 Hz, the sound insulations of the new simplified partition were significantly higher, because the new partition has a lower fundamental resonant frequency.

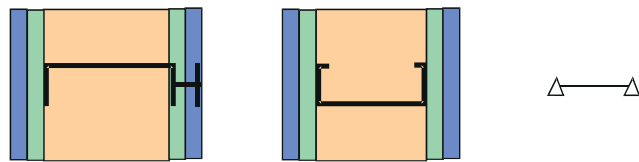
The treated simplified partition (Fig. 9(a)) has lower sound insulations than the treated single-sided partition (Fig. 7(a)), particularly at lower and higher fre-



(a) (71)simplified double leaf partition with glass wool  
(82 kg/sq. m, 302mm)



(b) (72)all plasterboard partition with glass wool  
(93 kg/sq. m, 285mm)



(c) (61)metal-framed double Camden with mineral wool  
(67 kg/sq. m, 295mm)

(Rw values are shown in brackets)

Fig. 9 - The sound insulations of double leaf metal-framed partitions with treated cavities.

quencies. At lower frequencies, the treated single-sided partition had higher sound insulations because positioning all the boards on the outer surfaces of the partition lowers the fundamental resonant frequency. At higher frequencies, the treated single-sided partition had higher sound insulations because the partition contained more glass wool.

#### 4. ALTERNATIVES TO THE TRIPLE CAMDEN

The sound insulations of a number of partitions having similar overall thicknesses to that of the triple Camden

were measured in the BBC Transmission Suite. For tests on double leaf partitions, one leaf was constructed in the opening in the receive room walls and the other leaf was constructed in the opening in the source room walls. This ensured that the two leaves were structurally independent. For the triple leaf partitions, one leaf was constructed in the opening in the source room walls and the other two leaves were constructed in the opening in the receive room walls. The reveal in the receive room walls was lined with a layer of carpet underfelt to act as a vibration break between the two leaves constructed in the reveal. The outer layers of boards on the two leaves constructed in the receive room walls had to overlap the edges of the reveal because the overall thickness of the two leaves was greater than the thickness of the receive room walls.

Fig. 10(a) shows the sound insulation of a single-sided partition. The partition was constructed from 100 mm wide structural steel studs. Each stud was clad with a

layer of 19 mm plank, fitted horizontally, followed by a layer of 9.5 mm plasterboard, then a layer of 15 mm plasterboard. The overall thickness of the partition was identical to the thickness of the triple Camden. Fig. 10(b) shows the sound insulation of a simplified triple leaf partition. This is effectively the partition of Fig. 8(a) with another single-sided leaf alongside. Fig. 10(c) shows the sound insulation of a metal-framed triple Camden.

Above 125 Hz, the sound insulation of the single-sided partition is significantly lower than the other two partitions shown. This is because of the difficulty in reliably sealing at the perimeter of partition and because the partition contained only one cavity. Below 100 Hz, the single-sided partition had the highest sound insulations because it had the lowest fundamental resonant frequency.

Above 160 Hz, the sound insulation of the single-sided alternative to the triple Camden (Fig. 10(a)) was actually lower than that for the single-sided alternative to the double Camden (Fig. 6(a)). The alternative to the triple Camden had more mass and a wider cavity than the alternative to the double Camden. The perimeter of the alternative to the triple Camden was probably not sealed as well as the perimeter of the alternative to the double Camden. This demonstrates the need for effective perimeter sealing.

Above 125 Hz, the sound insulations of the simplified triple leaf partition (Fig. 10(b)) were lower than those of the triple Camden. Below 160 Hz, the converse was true. These observations are similar to those made for

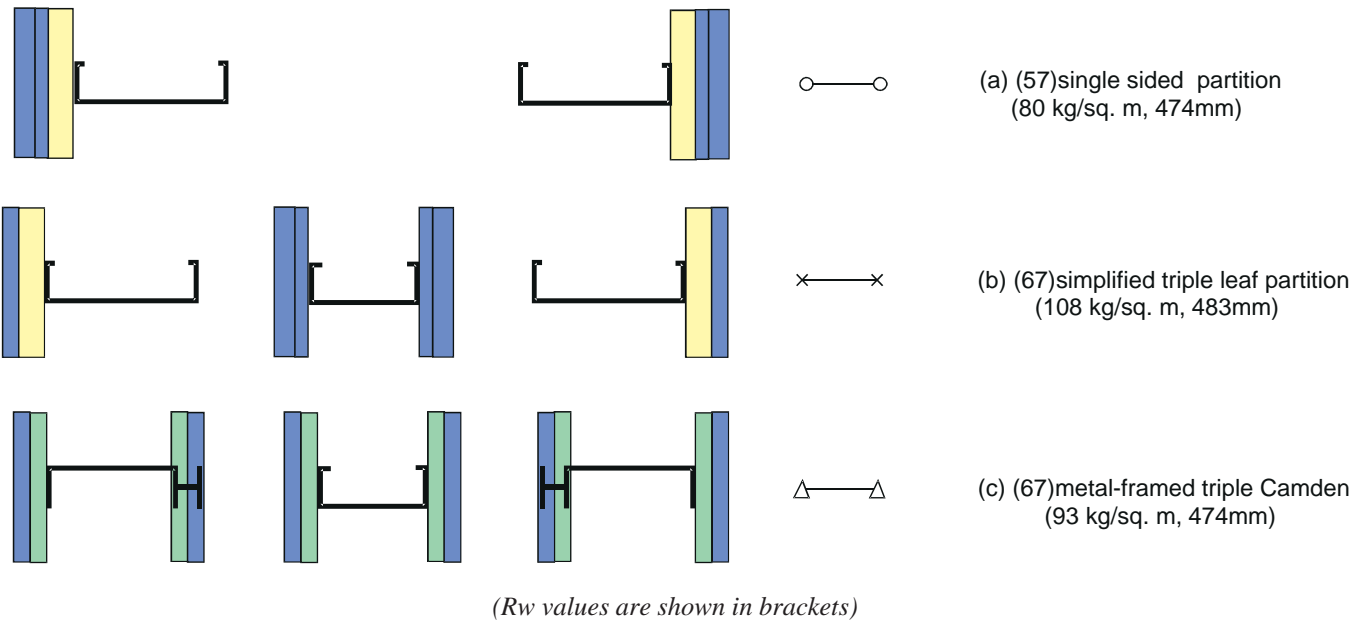
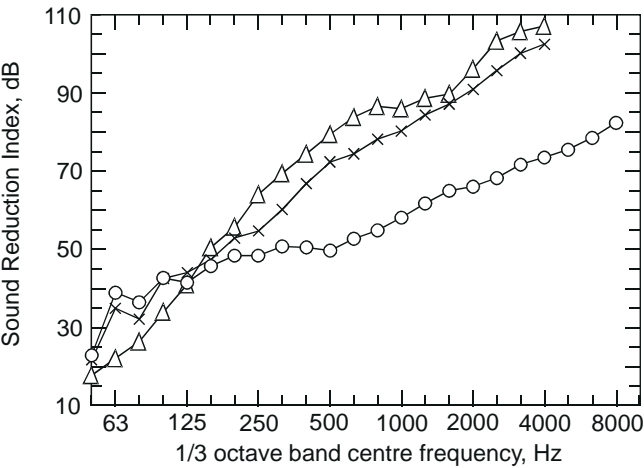


Fig. 10 - The sound insulations of triple leaf, metal-framed partitions.

the double leaf partitions and similar reasons apply. The simplified triple leaf partition (Fig. 10(b)) and the metal-framed triple Camden have similar overall sound insulations, but the simplified partition had the benefit of improved low frequency sound insulations.

Fig. 11 shows the effects on the sound insulations of the addition of acoustic treatment to the cavities of the partitions intended as alternatives to the triple Camden. The treated single-sided partition (Fig. 11(b)) and treated simplified partition (Fig. 11(d)) have similar performances to each other, the simplified partition having slightly higher sound insulations in the range 80 Hz – 200 Hz. The addition of glass wool to the

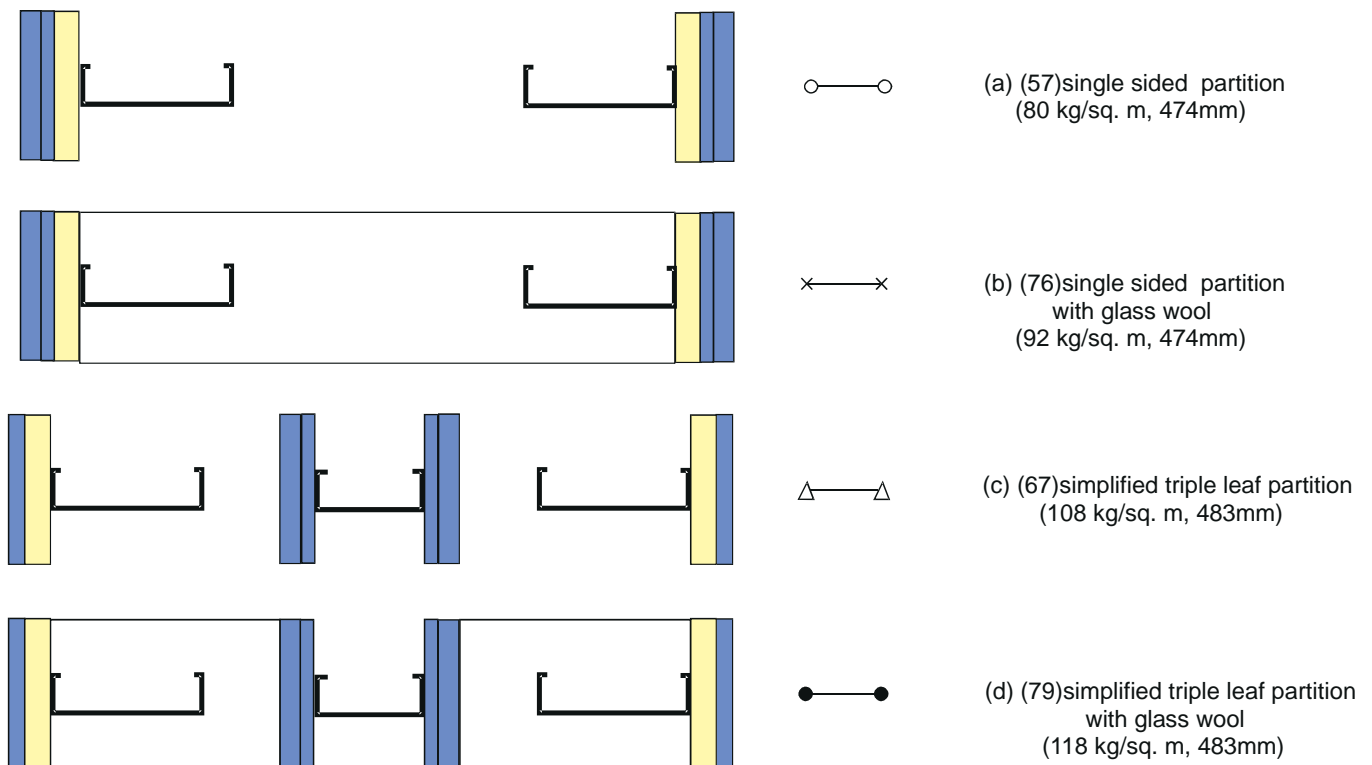
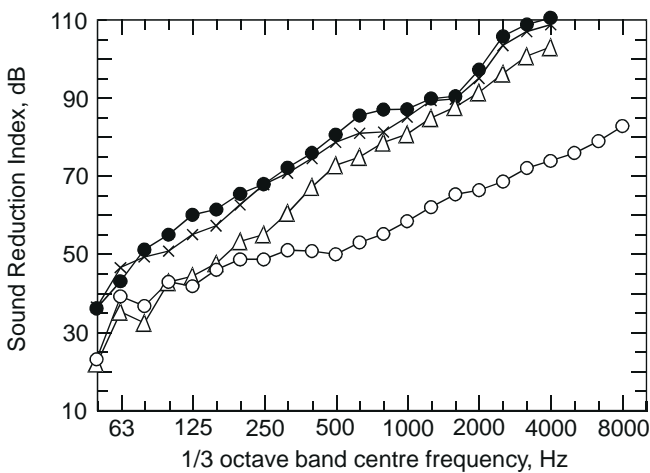
cavities increased the measured sound insulations because the glass wool effectively damps the boards and absorbs sound that has leaked into the cavity. The increase in sound insulation at higher frequencies on the addition of glass wool to the cavity of the single-sided partition was very large because the glass wool effectively absorbs the significant amount of sound that has leaked at the perimeter of the partition.

For completeness, Fig. 12 shows a comparison of the sound insulations of metal-framed single, double and triple Camdens. These curves are consistent with those usually achieved in the field for unperforated Camdens. The sound insulations at higher frequencies are affected by the number of boards, cavities and the overall thicknesses of the partitions. Below 100 Hz, the sound insulations are controlled by fundamental resonances in the partitions.

## 5. CONCLUSIONS

The low frequency sound insulations of lightweight partitions can be improved by several methods :-

- by increasing the mass of the partition,
- by altering the board types and spacings to alter the fundamental resonances,



(Rw values are shown in brackets)

Fig. 11 - The sound insulations of triple leaf, metal-framed partitions with treated cavities.

- by altering the coupling through the studs,
- by altering the damping of the boards.

The measured sound insulation of a single leaf partition having staggered studs was higher than that of a comparable single leaf partition using conventional metal 'C' studs. However, the increase in sound insulation was probably too small to justify the use of staggered stud partitions, except in special circumstances.

Coupled-stud partitions intended as alternatives to the double Camden had poor levels of sound insulation. Two other types of partition construction intended as alternatives to the metal-framed double Camden had comparable overall sound insulations to those of the double Camden, but the new partitions had significantly higher low frequency sound insulations. The low frequency sound insulations were improved by repositioning the boards to alter the performance at

the fundamental partition resonant frequency.

Two alternative designs to the triple Camden were also measured. Only one of these was acceptable on sound insulation grounds. The performances of all the partitions were significantly improved by the inclusion of glass wool in the cavities.

## 6. RECOMMENDATIONS

A field trial of the new partitions should be undertaken to ensure that no unforeseen difficulties arise from the use of the partitions. The simplified partitions should be used first, followed by the single-sided partitions if the simplified partitions prove to be acceptable. Particular care must be taken to ensure that all partition boundaries and openings are well sealed. In addition, it is recommended that glass wool should be installed in the cavities of the partitions, if this does not rule them out on grounds of cost.

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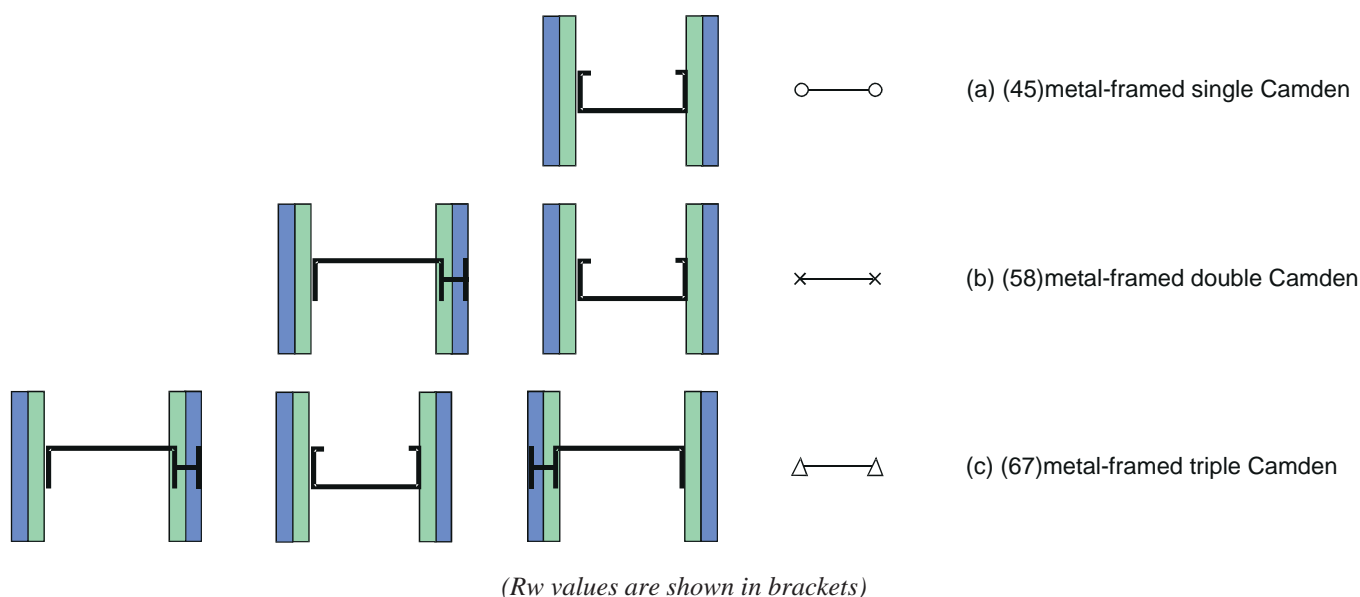
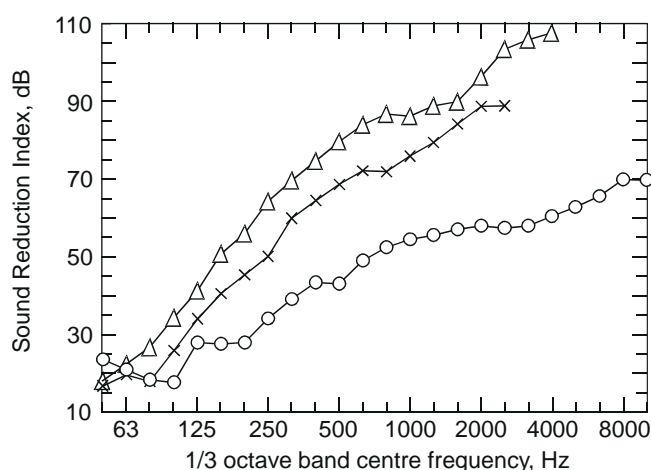


Fig. 12 - The sound insulations of metal-framed Camdens.

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