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LABORATORY MEASUREMENTS OF THE SOUND INSULATION OF BUILDING ELEMENTS INCLUDING FLANKING

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1. INTRODUCTION

The Building Regulations of many countries require either explicitly or implicitly that the sound insulation between attached dwellings meet certain minimum standards. In the United Kingdom compliance with these standards can be indicated either by building certain 'deemed to satisfy' constructions or by means of a sound insulation test. This, of course, implies that any novel method of construction must be tested to show compliance. During the development of any new construction method the sound insulation of individual building elements intended to separate dwellings can be tested with a high degree of repeatability in a standard transmission suite. However, it is well known that in actual buildings sound transmission between dwellings takes place not only directly through the separating elements but also through the surrounding construction; so called flanking transmission. Unfortunately, the effect which this flanking transmission will have on the sound insulation of a particular type of construction is difficult to predict and it is, of course, not possible to test in the standard transmission suite. One alternative would be to build a complete dwelling but this has two disadvantages,

(a) Cost

(b) The difficulty of obtaining Building Regulation approval before construction of an untried design. It is no means certain that approval will be granted and even if it is some sort of agreement will have to be entered into to carry out remedial works should the design turn out to be a failure. Such remedial works can be expensive and inconvenient.

Therefore, there would appear to be benefits in some sort of acoustic test chamber which could include flanking transmission. Wimpey Laboratories realised the need for such a chamber over 11 years ago and it is the design and use of these chambers, the Mark III version of which is now in use, that this paper is concerned with.

2. DESCRIPTION

The design of the chamber will be described first and the reasons behind the design discussed later.

The acoustic test chamber consists of a three-sided concrete shell, two storeys in height constructed from 400 mm thick reinforced cast insitu concrete. The construction to be tested is built into this shell, the walls forming a T section with the external wall forming the fourth side of the chamber and the party wall dividing the chamber internally into two. The floors can then be built into the two enclosures so formed to provide four rooms altogether. A flat roof for weather protection sits on top of the entire construction. The chamber design is shown schematically in Figure 1. Acoustic doors rated at 30 dB SRI are provided to allow access to the four chambers. In its current design the upper two rooms are provided to allow party floors to be tested. Party walls can be tested between the lower two rooms only since no attempt is made to reduce sound transmission over the top of the party wall underneath the weatherproof roof. Consideration is being given to changing the design of the chamber slightly to allow a pitched roof to be simulated allowing two separate tests on any party wall to be carried out. The internal dimensions of the chamber are 10 m wide x 5 m deep x 5 m high giving rooms of approximate dimensions of 5 m x 5 m x 2.5 m.

The reasons for the choice of the design were as follows.

The chamber was built to give rooms slightly larger than are encountered in typical attached dwellings to allow more modes in the lower third octave bands and therefore, an improvement in the accuracy. In particular the width of the room away from the party wall is wider than encountered in many dwellings. The effect of shape on sound insulation results will be discussed later in this paper. The width was chosen so that an internal partition could be built parallel to the party wall to give a more typical room width since it was not known what effect this partition might have on sound insulation. In the event, as will be seen later, the agreement between test results and field results was considered close enough without the use of this extra partition. The permanent concrete shell was required to have very low flanking transmission and so 400 mm dense reinforced cast in situ concrete was chosen. This, of course, will have a small but significant flanking contribution, however, the chamber was not designed for the testing of separating elements where the contribution of such flanking became important. The original Mark I and Mark II chambers were designed one and a half storeys in height for the testing of party walls only. When the Mark III chamber was constructed it was decided to go to full two storey height to allow party floors to be tested also. Because of the chamber design two party floors can be constructed simultaneously which gives more flexibility in the use of the chamber as a test tool.

3. COMPARISON OF TEST CHAMBER RESULTS WITH FIELD RESULTS

The results from the test chamber would, of course, only be useful if they bore some relationship to results obtained in practice. Results obtained in the field are affected not only by the basic acoustic properties of the materials involved but also such things as room layout, position of internal partitions and windows, workmanship standards during construction etc. Therefore, any individual result might be expected to differ from results obtained in the chamber. However, it was hoped that since the chamber was testing the archetypal party wall/flank wall situation that chamber results would give a good indication of mean performance on site. In a way, tests done in the chamber were the physical equivalent of the 'deemed to satisfy' constructions in the then current Building Regulations which merely specified the mass and construction of the party wall and external wall element.

Most of the chamber results available refer to walls since the Mark III chamber has only recently been brought into use. Two examples of comparisons for walls are shown in Figures 2 and 3. The first relates to tests on solid brickwork where the results of the test in the chamber are compared with results reported by BRE. Figure 3 shows the results of a chamber test on a no fines construction compared with average results of 25 field tests by various workers. In addition to the average field results the 95% confidence limits assuming the normal distribution are also shown. It can clearly be seen from these graphs that the chamber result is obviously part of the same population as the field results and also at many frequencies is very close to the mean.

3.1 Effect of room shape

Recently, interest has been expressed by several bodies on the use of a test chamber facility such as that described in this paper as a method of showing that particular construction designs can be deemed to satisfy the sound insulation requirements of the Building Regulations. Obviously, this will require some sort of agreed method for the use of the chamber and the interpretation of the results. One aspect which has been the subject of informal discussions is the effect of room shape on the results. Tests done in the chamber are normalized only to the extent that the receiving room levels are corrected to the levels which would obtain if the receiving room reverberation time was 0.5 seconds at all frequencies. No attempt is made to normalize for the areas of the various building elements involved. As mentioned earlier, the width of the chamber perpendicular to the party wall is greater with respect to the length than occurs in many field measurements. If it is assumed that most of the sound travelling between the rooms passes through the party element, then the level difference will depend on the following:

$$10^{Ld/10} \propto \frac{S}{A}$$

Where Ld = level difference between rooms in dB.
S = shared party wall area in m^2.
A = receiving room absorption in m^2 Sabines.

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Now $A \simeq \frac{.16V}{T}$

Where V = receiving room volume in m^3.
T = reverberation time in s.

Therefore $10^{Ld/10} \propto \frac{ST}{V}$

for a rectangular room $\frac{S}{V} = \frac{1}{D}$

Where D = width of receiving room perpendicular to party wall in m.

Therefore $10^{Ld/10} \propto \frac{T}{D}$

It can therefore be seen that for a complete normalization the receiving room width perpendicular to the party wall should also be included. For results which are available it would appear that in those rooms where field sound insulation tests have been carried out in the past, D has a typical value of 3.8 m. It can therefore be seen that results in the chamber used with its full width of 5 m might be expected to give results for sound insulation approximately 1 dB better than average field results. If the comparisons of chamber tests with field measurements are studied, it can be seen that this hypothosis can neither be supported or disproved. However, it must be pointed out that this correction should only apply where most of the sound energy is passing through the party wall element. Where sound flanking down the external wall or via the intermediate floor is the principal route for sound transmission then clearly the greater the width of the room perpendicular to the party wall, the larger is the area of the intermediate floor and external wall and therefore the lower values of insulation given by the chamber might be expected to be. Therefore, the usefulness of such a correction factor will depend on the degree of flanking transmission.

3.2 Effect of windows in external wall

The Building Regulations used to have a minimum separation of windows in an external wall either side of a party wall with the clear implication that windows with a separation less than this would reduce the sound insulation. Therefore, for the vast majority of the tests carried out in the chamber over the years, windows at this minimum separation have been included in the external wall. There has recently been some evidence to show that the presence of a large opening in the external wall close to the junction with the party wall was reducing the amount of energy transmitted to the rest of the external wall and therefore, reducing the flanking sound. Also, there is a possible flanking path for a cavity external wall through the window reveal linings down the cavity and the influence of this flanking path will depend on whether or not the cavity is closed with block work at the window reveals. Because of this change of thinking on the influence of windows on flanking transmission, they will probably be omitted in any tests carried out to show Building Regulation compliance if such a method is ever approved. However, our experience over the years with the chamber has shown that, particularly at high frequencies, the presence of windows can form a significant flanking route and therefore, it is probably valuable to continue to include them for pure development work.

4. AN EXAMPLE OF A RECENT INVESTIGATION

An example of the way the acoustic test chamber can be used as a tool for assisting in the development of new construction methods is given by a recent project carried out for the Cement and Concrete Association. The results of the first part of this investigation have already been published (1) and therefore, only a brief summary of the investigation will be given here. The investigation was on a proposed building system using a concrete blockwork masonry party wall of low surface mass combined with a plasterboard dry finishing system. Because of the low total mass of the wall and the fact that no wet plastering regime was used to the masonry, meant that the wall would not comply with the then current Building Regulations nor with the recently revised Regulations. The separating wall employed the principle of constructional isolation between the various elements of the wall and comprised a single leaf concrete blockwork masonry core with a plasterboard dry finish system each side. This dry finishing system was independent of the masonry core wall and was supported along the top and bottom horizontal edges by the floors with no intermediate restraint. By design, continuous air spaces were created between the back of the plasterboard finishing system and the face of the concrete masonry core wall. At the junction of the separating wall with the external flanking wall the masonry core wall was bonded with metal ties to the inner leaf of the concrete blockwork of the conventional masonry cavity wall. The concrete masonry inner leaf of the cavity flanking wall was finished internally with plasterboard dry lining applied directly to the masonry using a plaster dab fixing system.
Concrete masonry used in the trial constructions consisted of solid blocks in the nominal dry-density range 475 kg/m^3 to 1200 kg/m^3 and of thickness 125 mm to 140 mm, two different block types comprising lightweight aggregate and autoclaved aerated concrete being used in alternate tests. Concrete blocks were bedded in mortar as for normal building practice, joints being filled and finished struck flush with the face of the masonry walling. The same concrete block types were also used to form the inner leaf masonry of the cavity flanking wall, which was constructed so as to comply fully with other Building Regulations' requirements, such as thermal insulation. Two different independent dry-finishing systems to the direct separating wall were used, the

first consisting of cellular cored plasterboard partition, and the second being a laminated plasterboard wall lining comprising two plasterboard laminates bonded together in position. Several optional variations on the basic construction were also incorporated, such as the inclusion of mineral fibre quilt to one side of the direct separating wall in the air space cavity between masonry core wall and the independent dry-finishing.

The chamber tests have shown that the wall and its associated flanking structure, comprising external masonry cavity walling and an intermediate timber joisted floor construction, is capable of achieving a high level of sound insulation. The typical prototype constructions return sound insulation values which easily met the old Building Regulation party wall grade limit of 23 dB aggregate adverse deviation and the new Building Regulation, Part E requirements which are now given in terms of $D_{nT,W}$. A typical test result is given in figure 4 labelled 'no sealant'. The aggregate adverse deviation was 6 dB and the $D_{nT,W}$ value 56. This is a typical example but, because of the fact that the construction was built into a test chamber the opportunity was taken to vary such factors as the amount of sealing around the edge of the dry lining. Figure 4 shows a comparison of two tests with and without flexible sealant around the edge of the dry lining to the party wall. It can be seen that, in fact, there is very little difference.

5. CONCLUSIONS

The acoustic test chamber facility described is a useful tool for testing the sound insulation of novel building constructions whilst incorporating all major sound flanking transmission paths. Comparison with field results show that tests in the chamber are similar to average results obtained in the field. The chamber has been usefully employed by the Cement and Concrete Association as part of their overall Efficient Masonry House Building Design programme and the development work on the acoustic aspects were carried out far more economically in the chamber than would have been the case if complete houses had to be built.

6. ACKNOWLEDGEMENT AND FURTHER INFORMATION

The author would like to thank the Cement and Concrete Association for permission to present some of their results in this paper. In this pre-print it has only been possible to present a very limited number of results. The conference presentation discusses further results, however, the author will be pleased to give further details of the many tests which have been carried out over the years in the acoustic chamber to any interested parties subject to the usual requirements of commercial confidentiality.

(1) P WATT, 'Sound insulation of dry finish concrete masonry separating walls', Building , 17 May, 90-91 (1985).

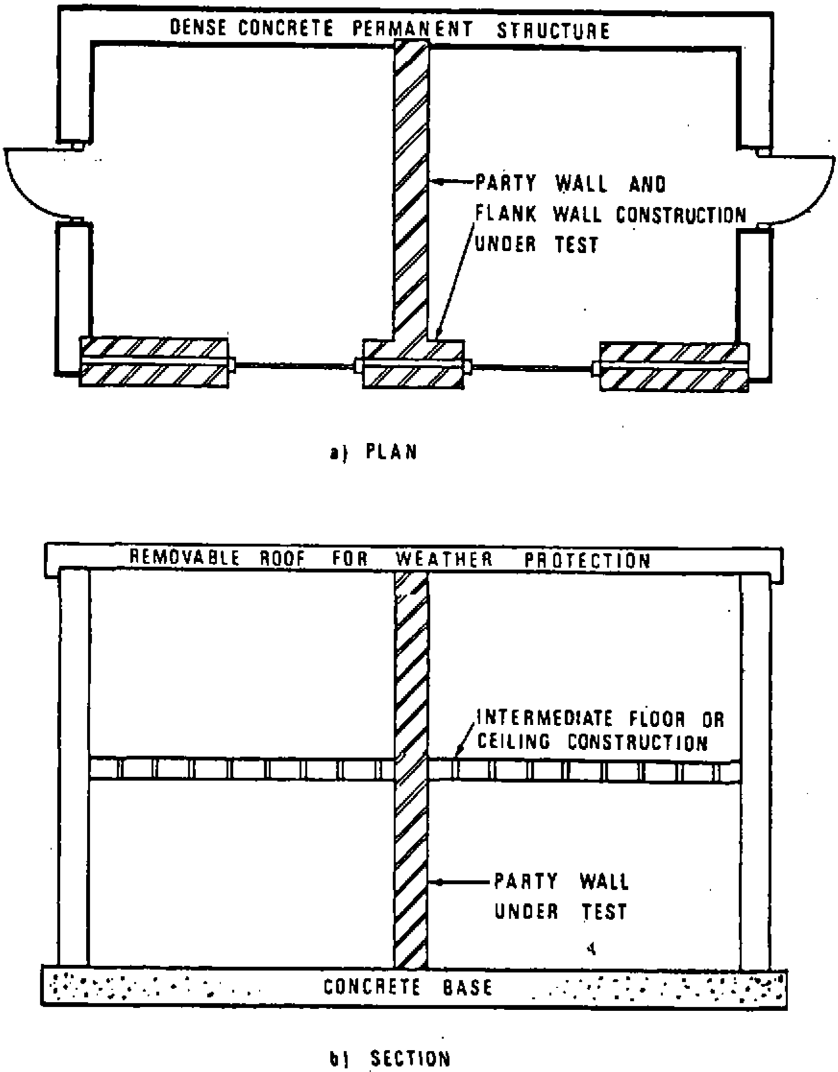


Figure 1: Schematic chamber layout

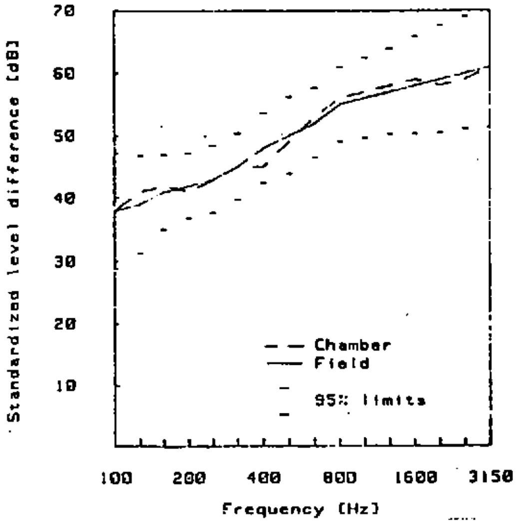


Figure 2: Comparison of chamber and field results for brickwork construction

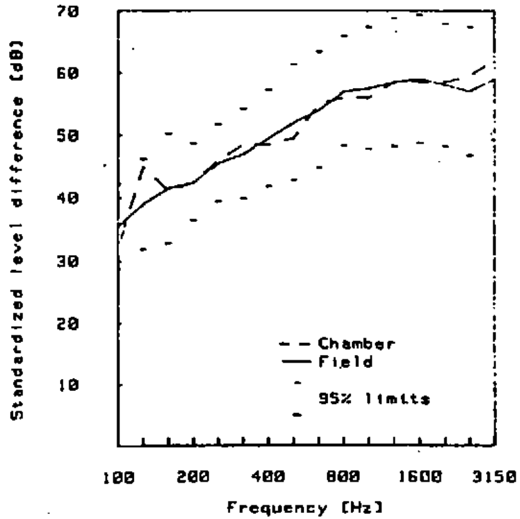


Figure 3: Comparison of chamber and field results for no-fines construction

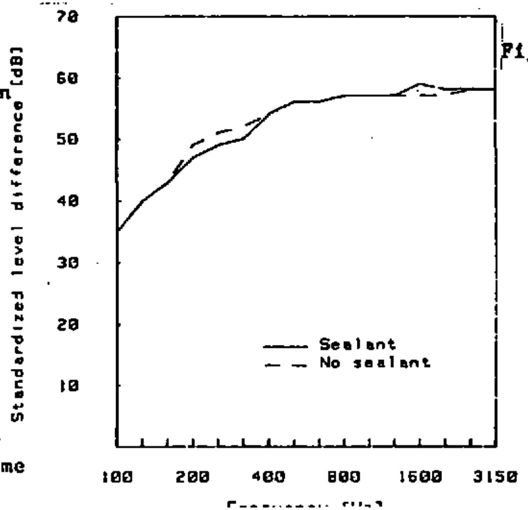
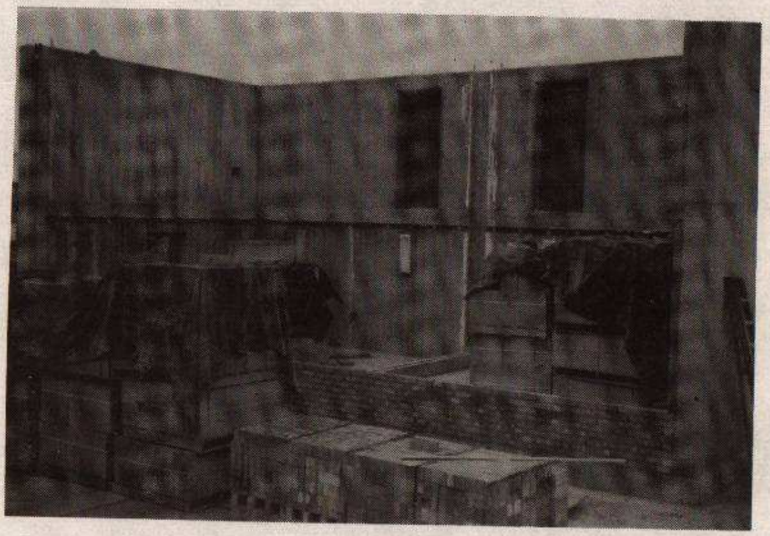


Figure 4: Chamber results for C & CA test programme

Completed construction in chamber



Construction being installed