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# SOUND PARTITION RATING USING SOUND REDUCTION INDEX R AND LEVEL DIFFERENCE D

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## 1. INTRODUCTION

This study considers the rating of the airborne sound insulation of floors which separate dwellings in terms of sound reduction index R and level difference D.

Field measurements have been investigated with regard to the following:-

(i) The error in an individual sound insulation rating.
(ii) Ratings as the weighted standardised level difference $D_{nT,w}$ and as the apparent sound reduction index $R'_w$.
(iii) Floors of similar construction within the same building.
(iv) Reverberation times within the receiving room.

The results indicate that the error in the rating of the sound insulation as the weighted standardised level difference $D_{nT,w}$ from the variation in the measurements taken at a number of random positions is large. The differences between the weighted standardised level difference $D_{nT,w}$ and the apparent sound reduction index $R'_w$ for individual floors are not large. The differences in the ratings of floors of similar construction within the same building are large. The average reverberation times in the receiving rooms have been found to be substantially less than the normalised time of 0.5 seconds.

## 2. THE EFFECT OF POOR SOUND INSULATION

If the sound insulating properties of building elements which separate dwellings is poor then occupiers are liable to suffer disturbance from excessive noise. It has been shown that having better walls between dwellings will improve the level of sound insulation. The lack of sufficient sound insulation in flat conversions has caused numerous problems[1]. This has been addressed in the current Building Regulations (1991) which require sound insulation to be provided in flat conversions.

This study compares two different methods of rating the airborne sound insulation of separating floors. It also examines comparisons between two floors within the same building. These floors of similar construction would be expected to have similar sound insulating properties and they are therefore anticipated to have similar ratings.

## 3. THE RATING OF SOUND INSULATION

British Standards detail the methods of taking measurements[2] for the rating the sound insulation[3] of building elements. This study analyses field measurements taken to rate the airborne sound insulation of floors which separate dwellings. Each individual floor is rated by two methods. In addition two floors which are considered to be of similar construction are rated at each premises. The differences in the ratings of the two floors by the two methods are also examined. This study also looks at the reverberation in the receiving room and considers the effect this has upon the rating of the sound insulation.

In Building Regulations Approved Document E and when ratings are quoted for building elements, they are normally given in terms of the weighted standardised level difference $D_{nT,w}$ as defined in BS 5821. This study also rates in terms of the apparent sound reduction index $R'_w$ which is also defined in BS 5821. It examines the difference in these ratings.

The rating of sound insulation requires the averaging of the sound pressure level measurements in the source room and the receiving room taken at a number of positions. The reverberation times in the receiving rooms are also averaged. The variations in these measurements have been used to calculate errors in individual $D_{nT,w}$ ratings. The field measurements were taken at domestic premises and usually followed the receipt of complaints of poor sound insulation. The measurements for two floors at each of 17 premises are examined.

## 4. ERRORS IN THE WEIGHTED STANDARDISED LEVEL DIFFERENCE

The sound levels in the source room and the receiving room are determined at each frequency by taking the average of measurements at a number of positions. These average sound levels are taken to represent diffuse fields. The sound fields are not actually diffuse and there is variation in the measurements of sound levels in the source room and the receiving room. The variations are larger at low frequency. There is also variation in the measurements of the reverberation times. These reverberation times are also averaged at each third octave band. The variations in these 3 sets of values have been used to determine the error within 95% limit that is present in an individual measurement of a weighted standardised level difference $D_{nT,w}$ rating. In this study a sample of the sound insulation ratings have been examined in this way to determine the errors associated with the individual $D_{nT,w}$s within a 95% limit. The ranges within 95% limits of this sample are contained in TABLE 1.

None of the above errors in individual ratings of $D_{nT,w}$ are less than +/- 3 dB. These errors are large. Errors of this size have been found in other studies[4-6]. The errors maybe reduced by increasing the number of positions at which readings are taken. In this study the number of positions used was as suggested in the British Standard. The errors must be borne in mind if the results of a single floor or a small sample are to compared to standards to check compliance. This need is demonstrated by the standard in Approved Document E which applies to new constructions and gives an average which must be achieved by either 4 or 8 floors. The standard for converted dwellings however can be met by just 2 floors.

**TABLE 1: Range of 95% limits of sample of $D_{nT,w}$s for 8 floors.**

| DnT,w dB | 95% Limit Range dB |
|---|---|
| 39 | 35-43 |
| 38 | 34-41 |
| 44 | 40-47 |
| 49 | 46-52 |
| 48 | 45-52 |
| 49 | 45-52 |
| 40 | 37-43 |
| 44 | 41-48 |

## 5. COMPARISON OF $D_{nT,w}$ AND $R'_w$

The differences between the two rating methods $D_{nT,w} - R'_w$ are given in TABLE 2

**TABLE 2: Differences between the weighted standardised level difference $D_{nT,w}$ and the weighted apparent sound reduction index $R'_w$.**

| $D_{nT,w} - R'_w$ | Number Of Floors Occurred For |
|---|---|
| 2 | 1 (3%) |
| 1 | 5 (15%) |
| 0 | 18 (53%) |
| -1 | 8 (24%) |
| -2 | 2 (6%) |

Using the level differences in terms of intensity (W $m^{-2}$) units the average difference is calculated to be

-0.70 dB +/- 1.2 dB (within 95% limit)

A comparison of $D_{nT,w}$ and $R'_w$ has been made using a student t test[7]. At the 95% confidence limit there is no significant difference between the two sets of values of $D_{nT,w}$ and $R'_w$. This analysis is subject to the proviso that $D_{nT,w}$ and $R'_w$ are assumed to be independent although this is not actually true. For each determination of $D_{nT,w}$ and $R'_w$ the sound levels in the source room and the receiving room are identical. The reverberation time T and the absorption area A are also dependant. It is likely that the large errors in individual measurements of $D_{nT,w}$ and $R'_w$ is the reason for there being no significant difference between them.

## 6. COMPARISON OF FLOORS IN THE SAME BUILDING

The differences between the two $D_{nT,w}$ ratings of the two floors within the same premises which are of similar construction are given in TABLE 3.

The differences in $D_{nT,w}1$ and $D_{nT,w}2$ have been analysed using a student t test. At the 95% confidence limit there is a significant difference between the two sets of values of $D_{nT,w}1$ and $D_{nT,w}2$. Using the level differences in terms of intensity (W $m^{-2}$) units the average difference $D_{nT,w}1 - D_{nT,w}2$ is calculated to be

5.8 dB +/- 3.0 dB (within 95% limit)

**TABLE 3: Magnitude of the differences between the weighted standardised level differences $D_{nT,w}$ for floors within the same dwelling.**

| $D_{nT,w}1 - D_{nT,w}2$ | Number Of Occurrences |
|---|---|
| 12 | 1 |
| 11 | 1 |
| 8 | 1 |
| 5 | 3 |
| 4 | 2 |
| 3 | 5 |
| 1 | 4 |

The differences between the two $R'_w$ ratings of the two floors within the same premises which are of similar construction are given in TABLE 4.

The differences in $R'_w1$ and $R'_w2$ have also been analysed using a student t test. At the 95% confidence limit there is a significant difference between the two sets of values of $R'_w1$ and $R'_w2$.

Using the level differences in terms of intensity (W $m^{-2}$) units the average difference $R'_w1 - R'_w2$ is calculated to be

5.7 dB +/- 2.5 dB (within 95% limit)

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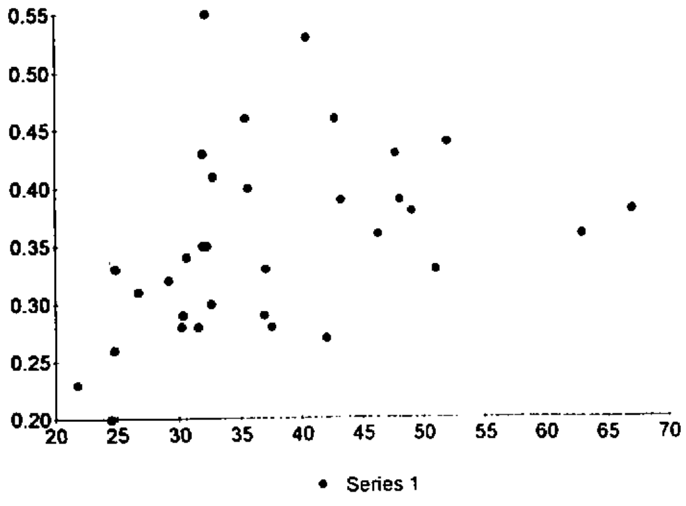
**TABLE 4: Magnitude of the differences between the weighted apparent sound reduction indices $R'_W$ for floors within the same dwelling.**

| $R'_W1 - R'_W2$ | Number Of Occurrences |
|---|---|
| 11 | 2 |
| 8 | 1 |
| 7 | 1 |
| 6 | 1 |
| 5 | 2 |
| 3 | 3 |
| 2 | 5 |
| 0 | 2 |

## 7. REVERBERATION IN THE RECEIVING ROOM

The is no correlation between the volume of the receiving room and the average of the reverberation times at the 16 third octave bands is illustrated in FIGURE 1

**FIGURE 1: Correlation between the average at all frequencies of the reverberation times and the volume of the receiving room.**



It can be seen from the chart there is no correlation between the average reverberation time and the volume of the receiving room. This finding agrees with another study[8] that the reverberation time in residential living rooms and bedrooms is independent of the size of the room. A normalised reverberation time can therefore be used for rooms which is not related to the size of the room. It may also be noted that the findings in this project do not agree[8-9] that the reverberation time is normally 0.5 s.

The average reverberation times for all of the measurements at each of the 16 third octave bands at which it is measured is significantly less than the normalised reverberation time of 0.5 seconds (see TABLE 5).

The average of all the reverberation times is:
0.36 +/- 0.05 seconds (within 95% limit).

There is only a small error in the reverberation time. The large errors that are present in the individual $D_{nT,w}$ rating of a floor are largely due to the errors in the measuring of the sound levels in the source room and the receiving room.

**TABLE 5: Average reverberation times across all rooms in each third octave band.**

| 1/3 Octave Band T Hz | Reverberation Time seconds |
|---|---|
| 100 | 0.38 |
| 125 | 0.35 |
| 160 | 0.34 |
| 200 | 0.35 |
| 250 | 0.38 |
| 315 | 0.38 |
| 400 | 0.38 |
| 500 | 0.38 |
| 630 | 0.38 |
| 800 | 0.37 |
| 1000 | 0.36 |
| 1250 | 0.35 |
| 1600 | 0.34 |
| 2000 | 0.34 |
| 2500 | 0.31 |
| 3150 | 0.32 |

## 8. CONCLUSIONS

The errors in individual measurements of the weighted standardised level difference $D_{nT,w}$ are large. With these errors it is necessary to rate a number of similar floors when checking compliance to any particular standard. In Approved Document E the standard requires the testing of 4 or 8 floors for new build but only 2 for floors in converted buildings. The larger the sample that is tested then the greater reliability that the standard has been met. It is recommended that the number of examples tested of floor types in converted buildings should be at least equal the number that needs to tested for new build. The desire to test even more samples to further enhance the reliability must be balanced against the cost of testing.

In this study 34 floors have been rated as the weighted standardised level difference $D_{nT,w}$ and the apparent sound reduction index $R'_w$. Taking the differences in the two rating methods in terms of intensity and within a confidence limit of 95% the error of 1.2 dB is greater than the average difference of -0.7 dB. It is concluded that the difference in the two rating methods for individual floors is small compared to the error of +/- 3 dB for single measurements and not important.

From a student t test which compared the independent variables S (S = area of separating floor) to 0.326 V (V = volume of receiving room) it was shown that the significant difference at the 95% confidence limit between $D_{nT,w}$ and $R'_w$ = 0.24 dB. This fraction of a dB is small and substantially smaller than the error of +/- 3 dB in a single measurement rating. Ideally the analysis of ratings of a larger sample would show if a similar significant difference is maintained.

When a pair of rooms has the same floor area then $D_{nT} = R'$ when the ceiling height in the receiving room = 3.1 m. This criteria is close to being met in domestic rooms and illustrates why the difference between the two rating methods is small.

The differences in the rating levels of pairs of floors of similar construction within the same building are large by both rating methods. In this study two floors within 17 properties are compared. The average difference in the weighted standardised level differences $D_{nT,w}$ is 5.8 +/- 3.0 dB and the average difference in the weighted apparent sound reduction index $R'_w$ is 5.7 +/- 2.5 dB. From the sample size of this project it is not concluded that either method is more appropriate for rating the sound insulation of construction types. The differences between the ratings of pairs of floors by both methods which is due to the standard of construction and flanking transmission are much larger than the difference between the rating methods of 0.24 dB.

When rating sound insulation to support action for noise nuisance the rating from only one floor may not be reliable. It is concluded that ratings from at least two floors be taken. If the difference in these two ratings is large (5 dB or greater) and the standard which is being applied is neither clearly passed or failed the rating of further floors should be considered.

An alteration in the normalised reverberation from 0.5 seconds to the average of the measurements found in this project would have an effect upon the $D_{nT,w}$ rating levels. A normalised reverberation time of 0.36 seconds would increase the rating by 1.4 dB. This increase in the rating of 1.4 dB would mean that some methods of upgrading sound insulation may pass the standard in approved document E when they would fail with a normalised reverberation time of 0.5 s. There would be a lowering of the sound insulation for residential occupiers if the standard was not also adjusted in line.

The sample size in this study upon which these conclusions are made is quite small. Further studies of larger samples of current sound insulation tests between domestic rooms would demonstrate if a change in the normalised reverberation time is required.

## REFERENCES

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