Measurement of Absorption Coefficients to ISO354 using Tall Sources and Microphones

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ABSTRACT

ISO 354:2003 specifies a method of measuring the sound absorption coefficient of material samples used as wall or ceiling treatments, or the equivalent sound absorption area of objects, such as furniture, persons or space absorbers, in a reverberation room. The standard specifies the dimensions of the room and the room volume, with a desired volume of approximately 200m^3. To achieve this volume more proportional dimensions than found in normal rooms are necessary. This means ceiling heights of reverberation rooms are higher than typically found in buildings. However, the same sound source and microphone heights are specified as used in room acoustics standards such as ISO 3382 that of 1.2-1.5m. Material samples are typically laid on the floor of a reverberation room and hence the direct distance to the sample is short. This paper reports on measuring the same samples using standard source and receiver heights as well as doubling those heights. This additional height should allow more time for sound mixing which is needed to achieve a diffuse sound field.

1. INTRODUCTION

The sound absorption of materials and surfaces is normally measured in accordance to ISO 354:2003 [1]. It has been found that reproducibility is low using the current standard to determine random incidence absorption [2]. Significant research has been undertaken to increase the diffusivity of the sound field in reverberation chambers [2-5]. This research was necessary to ensure the assumptions in the Sabine equation are as valid as possible. However, the homogeneous and isotropic sound field assumed is fundamentally not possible whilst the material sample is being tested in the chamber, i.e. the sample itself affects the measurement. The proposed solution in the new working draft of the ISO 354 standard includes the use of a reference sample so that a correction factor can be applied to the sample being tested [6]. In this paper, another complementary solution is proposed based on simply using taller sound sources and microphones so

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that the sample is further from the transducers. The hypothesis being this would allow more time for a homogeneous and isotopic sound field to develop in the reverberation chamber.

2. MEASUREMENT METHODOGOLY

The room acoustic measurement standards ISO 3382 [7-9] specifies that an omni-directional sound source should be used and be set at a height of 1.5-1.6m. These standards also states that the microphone should be omni-directional in nature and set to a height of 1.2-1.5m. It should be noted many other guidance and standards specific similar measurement heights. The reason is that measurements should be representative of the use of the room whether its purpose is performance, recording, domestic, or work environment such as a plan office. However, in the case of the reverberation chamber the room should be proportionate to increase diffusivity and hence would have a much greater ceiling height than for a typical room to meet volume recommendation of 200m^3.

Hence, this paper describes an alternative measurement methodology using much taller transducers. The idea for the methodology came from a taught module assignment call Cheap Acoustics [10], part of our Masters in Environmental and Architectural Acoustics programme [11]. The methodology is demonstrated in the reverberation chamber of London South Bank University using the standard and taller sound source and microphone heights. The chamber is 7.6m by 6.35m by 4.2m, volume of 202.7m^3. The standard compliant heights selected were dodecahedron 1.5m and microphone 1.2m, see Figure 1. For the taller heights the source was set at 2.5m and microphone 3.3m, see Figure 2.

Figure 1. ISO 354 standard transducer heights in the empty LSBU Reverberation Chamber

Figure 2. Alternative transducer heights in the empty LSBU Reverberation Chamber

The 12 microphone locations were selected in accordance with ISO 354 and 36 reverberation time measurements. The measurements were taken using winMLS2004 generated eSweep signal. The signal was produced by a Digigram VX pocket sound card linked to a Rion dodec omni-directional sound source, and picked up by an Earthwork M30BX Class 1 omni-directional measurement microphone. Measurements covered a range of 40-10000 Hz and were analysed in 1/3 octave bands. The measurements were repeated twice with the addition of a 10m^2 sample of a Class A porous absorber, see Figure 3 for the taller configuration.

Figure 3. Alternative transducer heights in the LSBU Reverberation Chamber with sample

3. MEASUREMENT RESULTS

The reverberation times, T_{20}, were calculated from the average of three measurements undertaken for four configurations combining transducer heights and with and without the material sample. The sample was 10m^2 of acoustic foam (75mm deep) arranged at an off-set angle to the walls of the chamber. Figure 4 shows the measured T_{20} in the reverberation chamber with and without 10m^2 of porous absorption at different measurement heights.

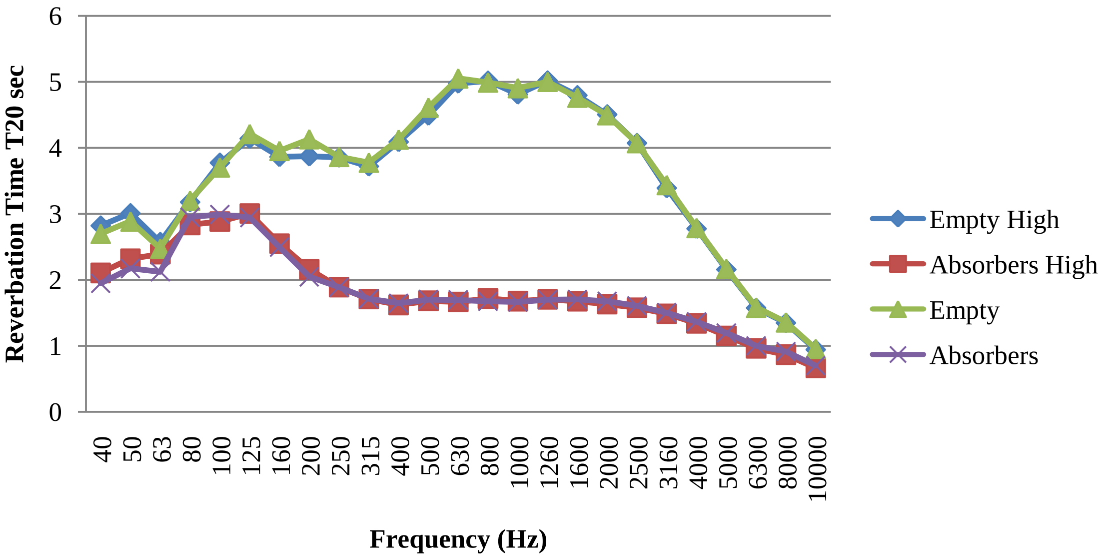

Figure 1: Averaged Reverberation Time (T_{20}) using different transducer heights

Figure 4 showed that on average there was only a marginally difference between the standard and high transducer configuration in terms of absolute reverberation time measurements for empty or with sample arrangement. However, on closer inspection both the empty and absorber configuration the averaged reverberation time measured was higher for the taller transducer configuration at low frequencies. It should be stated that normally <100 Hz data is not presented for reverberation chamber measurements due to the modality in the room.

4. MEASUREMENT ANALYSIS

By studying the standard deviation of the multiple measurements it might be possible to determine the most consistent configuration. Figure 5 shows the standard deviation of the empty chamber which according to theory be more diffuse and hence provide a more consistent uniformity in the sound field than the with sample configuration.

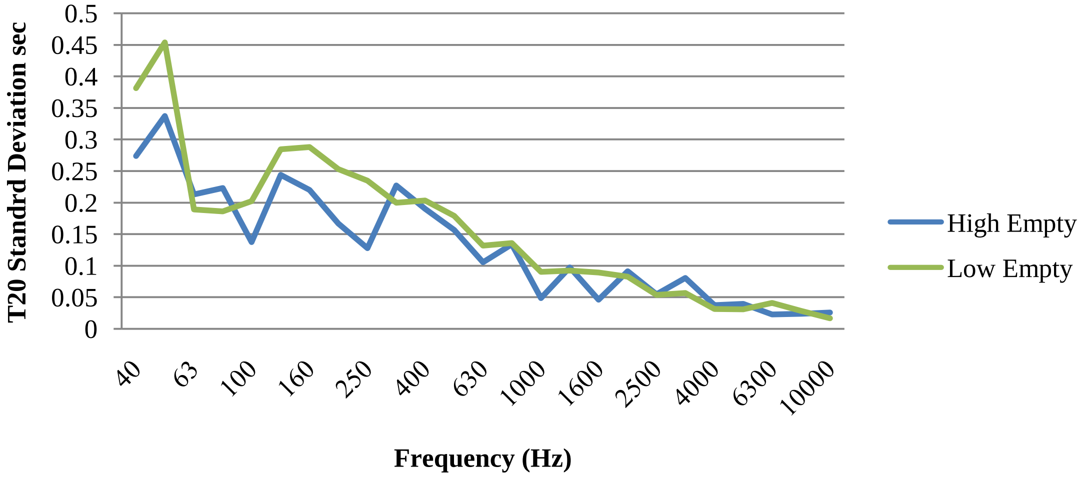

Figure 5. Standard deviation of the measured T_{20}: empty chamber for two transducer heights.

It can be seen from Figure 5 that the standard deviation was consistently lower for the taller transducer measurements than the standard (low) transducer configuration. Taking the standard deviation of the standard deviations, low σ=0.115 and high transducers σ=0.09. The consistency of the high transducer measurement was significantly improved for frequencies below 315 Hz. This frequency is approximately the Schroeder cut-off above which the sound field is considered diffuse.

Turning to the with sample configuration measurements, it could be assumed that adding material with significantly different properties to the chamber would create a less diffuse sound field. Figure 6 shows the standard deviation of the measurements in the chamber with the sample absorber for the two transducer configurations.

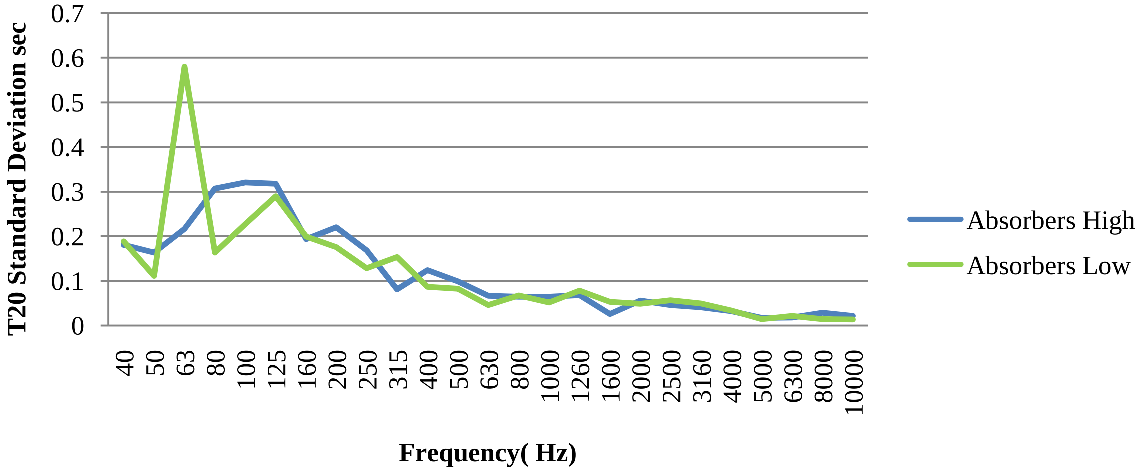

Figure 6: Standard deviation of the measured T_{20}: chamber with absorbers for two transducer heights.

It can be seen from Figure 6 that the high transducer configuration was significantly more consistent than the low transducer configuration, particularly below 125 Hz. Taking the standard deviation of the standard deviations, low $\sigma=0.12$ and high transducers $\sigma=0.10$. When comparing Figure 5 and Figure 6 it can be seen that, as predicted, the measured reverberation times were more consistent in the empty chamber than in the chamber with absorbers. This was apparent from the standard deviation of the standard deviations, empty $\sigma=0.115$ and $\sigma=0.09$, compared to with sample $\sigma=0.12$ and $\sigma=0.10$, for the standard and taller transducer configurations.

5. CONCLUSIONS

Much work is currently being undertaken to update ISO 354 in an effort to provide more consistency between testing laboratories across the world. Many suggestions have been explored such as test samples for calibration and more diffusers added to the chamber. This paper studied a much cheaper solution that of simply using taller transducer configurations. This increased cost of taller tripods and microphone stands was less than $10.

Preliminary results were found to show that greater consistency was achieved using higher transducer configurations than for those stated in ISO 354. It was also shown, as expected, that adding porous absorbers to a reverberation chamber increased the inconsistency or non-uniformity of the sound field compared to the empty reverberation chamber.

6. ACKNOWLEDGEMENTS

We gratefully acknowledge the financial assistance of the UK Acoustics Network (UKAN).

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