(A)STC TESTING WITH MLS: OLD DOG, NEW TRICKS

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1 Introduction/background

The original inspiration for this work comes from the Author's work in New Orleans as part of a team of engineers performing a leak detection survey on the 100 year old underground water infrastructure. The work was carried out using a device known as a "correlator" which detected water main leaks. The correlation of leak noise was made possible because the noise (or more accurately the vibration) a leak made on a pipe was completely random and unique, with no repeating pattern. The accuracy of the technology was quite impressive and still managed to work reasonably well on different types of pipe materials, through different fixtures, valves, and even around bends. The technology could even be used to help determine the health of the pipe being tested. Based on observations made of the capabilities of the leak correlator the Author wanted to know could it be applied to Building Acoustics in some way to get more information from standard acoustic field measurements?

The type of signal processing these leak "correlators" were using is similar to other devices that use a Maximum Length Sequence (MLS) pseudo-random noise signal to measure speakers or other room acoustics properties[1]. One common use of MLS systems is the computation of the reverberation time (RT60). The MLS is ideal for this because, like the leak noise on water pipes, it is unique and does not repeat, but it also happens to contain equal amounts of energy in all frequency bands. The method for measuring the RT60 using MLS is done by playing an MLS signal through a loudspeaker in a listening room (preferably in a corner), and then recording the reverberant sound field at another location. The measured result is then correlated against the excitation signal, which gives back the room's impulse response. From the impulse response one can use the Schroeder method [2] in order to calculate the RT60 in the space.

Another possible, but not very common, use for MLS is the (Apparent) Sound Transmission Class test, or (A)STC test, performed as per ASTM E336 [3]. Because of the author's experience with correlation in other fields and the fact that the requirement of the signal for the (A)STC test be a "random noise containing an approximately continuous distribution of frequencies over each test band" the author has begun performing (A)STC tests using MLS. The measurements are then used to correlate the results in the source and receiving rooms in order to explore if the signal can be correlated and what that correlated signal can tell us about the spaces being tested. An initial focus is on correlating the signal in the receiving room in order to obtain a suitable impulse response to determine the RT60 in that space.

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2 Method

In general the testing is performed as per ASTM E336. Briefly the method involves playing a noise signal (MLS in this case) in one room, (the source room), that is adjacent to a second room (the receiver room), and measuring the reverberant sound field in both spaces. The difference in levels between the two spaces gives the amount of sound isolation the separating partition is providing. The results are corrected for the absorption in the spaces by measuring the background sound level and the RT60 in the receiver room.

Typically the RT60 would be determined through an impulsive balloon pop or other interrupted noise method. Since the MLS is to be used and recorded during the reverberant energy measurements it was determined that it is important to use a fixed point measurement method. Also in order to ensure the buildup of the reverberant energy the MLS should be set to repeat itself. In each case the measurement was performed for 30 seconds with a 5 second long MLS signal. This should result in multiple correlation peaks that are well separated from each other.

Once the data has been collected it can then be processed in MATLAB in order to correlate the data and obtain an impulse response. The impulse responses can then be further post processed in MATLAB or analyzed in another software package that follows the ISO 3382 [4] standard, in order to obtain the RT60.

3 Results

While multiple spaces had been tested with MLS the ASTM E336 test used a spatially averaged method in most cases, to measure the reverberant sound field in the source and receiver rooms. It was found that a fixed microphone method yielded the best results and the analysis has focused on tests performed between two offices of the same size (3.7 x 4.3 x 2.6 metres) at the Pinchin head office. The room was originally being tested as a result of complaints that sound isolation was poor between the two spaces. It was found that the partition had an (A)STC of 31 and was likely the result of the separating partition not extending up to the underside of the steel deck above.

3.1 Correlating an impulse response

In addition to recording the MLS in the receiver room it was of interest to record and compare to the MLS that would be recorded in the source room as well. The results of the measured signal correlated with the input MLS to the speaker are presented in Figure 1.

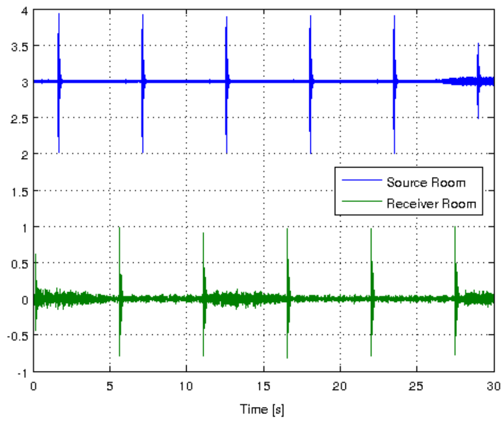

Figure 1: Correlation results for source and receiver rooms.

From Figure 1 we can see that the results from the correlation gave multiple impulse responses that are similarly spaced with, at first glance, a similar shape. It is clear upon closer inspection that the lower curve that represents the receiver room shows more random variation between peaks as compared to the upper curve that represents the source room. This result is not surprising since the signal has to travel through the partition into the receiver room.

3.2 RT60 determination

Based on the results shown in Figure 1 we have suitable data to be able to compute our RT60 via the Schroeder method. As an additional check traditional balloon pop impulse tests were conducted in the source and receiver rooms in order to verify the results from the MLS measurements. The results are averaged over multiple samples and summarized in Tables 1 and Table 2. In addition to the average result the Standard Deviation (STD) has been included to give an impression of how consistent the results are over multiple samples.

Table 1: RT60 results in source room.

	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
Avg.MLS	0.291s	0.310s	0.300s	0.331s	0.320s	0.272s
Avg.IMP	0.380s	0.386s	0.338s	0.331s	0.322s	0.288s
STD.MLS	0.001	0.001	0.001	0.003	0.003	0.003
STD.IMP	0.022	0.019	0.014	0.020	0.017	0.012

Table 2: RT60 results in receiver room.

	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
Avg.MLS	0.328s	0.470s	0.447s	0.407s	0.374s	0.388s
Avg.IMP	0.388s	0.372s	0.295s	0.304s	0.305s	0.288s
STD.MLS	0.047	0.052	0.046	0.029	0.006	0.012
STD.IMP	0.057	0.051	0.029	0.012	0.016	0.028

As can be seen from comparing the results in Tables 1 and 2 that the MLS RT60s are close to the impulsive balloon pop measurements in the source room but are consistently higher in the receiver room. We can also see that based on STDs of both methods in either room, the results are consistent over multiple samples, with the MLS tests in the source room being an order of magnitude more consistent compared to the impulsive balloon pops.

4 Discussion

Based on the results we can see that in the source room that the traditional impulsive balloon pops give results that are close to the results from the RT60 calculated from the MLS measurements, which is to be expected. While it was clear that an impulse response could be determined from the recordings of the MLS in the receiver room the RT60 results from those measurements are consistently high in the mid to high frequency bands. This result can be potentially explained by the fact that the partition separating the two spaces did not extend from slab to slab. It is theorized that the presence of a strong flanking path will couple the spaces together such that the system response of both spaces will behave in a similar way to two capacitors that are coupled together by a resistor would, thus extending the RT60. If this is the case then by following this method and comparing the difference between the RT60 determined by correlating a signal through the structure to an RT60 determined in the space itself may result in a quantitative test for the presence and the magnitude of flanking paths between two spaces.

5 Conclusion

Based on the results we can conclude that it is possible to transmit an MLS signal through a partition (or structure in general) and then correlate the signal to obtain an impulse response. Based on the limited amount of data the results would suggest that meaningful information can be determined from performing (A)STC testing in this manner. It is expected that if the two spaces had not been coupled together by a flanking path through the ceiling plenum then the RT60 results in the receiver room would have been much closer to the RT60 calculated by the more traditional method. However, even though the RT60's were different the STD showed a consistent result and the difference between the RT60 results could indicate the presence and magnitude of the flanking path between the two spaces.

The amount of data that was available for this work was limited since only recently it was discovered that fixed mic measurements were needed in order to obtain reasonably good results. Thus more testing is required before anything can be said conclusively.

References

[1] J. Vanderkooy, “Aspects of MLS Measuring Systems”. J. Audio End. Soc., Vol. 42, No. 4, 1994 April

[2] M. R. Schroeder. “New method for measuring reverberation time”. J. Acoust. Soc. Am., vol. 37, pp. 409-412, 1965

[3] ASTM E336: Standard Test Method for Measurement of Airborne Sound Attenuation between Rooms in Buildings

[4] ISO 3382: Measurement of room acoustic parameters.