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Absorption coefficients-part 1: is square area enough?

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ABSTRACT

Attempting to correlate the measurements of "Absorption Coefficients" in ASTM-C423[1], ISO-354[2] and ISO-17497-1[3] it was observed that the results were varying to a large degree. An experiment was set up with 1 inch (2.54cm), 6 lb (2.72kg) density fiberglass panels having different shapes, sizes and parameters. The shapes, sizes and parameters of the panels are described in this paper. The types of experiments also are described along with the process that was used based on input from many of the members of the industry. The end results and conclusions are described in a paper titled" Absorption Coefficients Part 2: Is "Edge Effect" More Important Than Expected?"

1. INTRODUCTION

During the qualification of NWAA Labs to do ISO-17497-1 full scale scattering coefficient tests it was noticed that the absorption coefficients of a common material that was measured were significantly different when using the ISO17497-1, ISO 354 and ASTM C-423 tests. When people in the industry were asked about this they indicated that it must be because of "edge effect"[4]. This was also the reason given when "Absorption Coefficients" were being measured that were above 1.00[1]. When asked what "edge effect" was an answer was never received that made sense or was consistent from one person to another. Some questions could be formed because of this lack of satisfactory answers. Why did a difference appear and what causes it? If there appeared to be a real difference, could we quantify it and use it to improve any calculations using these "Absorption Coefficients"? These questions were looked at by Northwood[5, 6] and

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Bartel[7]. Nelson[8] did some additional research on these effects but most of the research was oriented to uniting the impedance tube method with the reverberation room method.

2. COMMON QUESTIONS

A. What is Sound Absorption?

It is the conversion of acoustic energy to thermal energy.

B. What is the "Absorption Coefficient"?

It is a number that results from the division of the number of Sabins of absorption of the acoustic sample by the sample area.

3. SPECIFIC QUESTIONS

A. What is the sample shape and size required by each standard? (ASTM-C423)

ASTM-C423 requires a rectangular sample with a size of 72 ft^2 (6.69m^2). The dimensions shall be a length of 9 ft (2.74m) and a width of 8ft (2.44m). The standard will accept, as an option, a sample size of 64 ft^2 (5.95m^2) with a length and width of 8ft (2.44m).

B. What is the sample shape and size required by each standard? (ISO-354)

ISO-354 requires a rectangular sample with a size of 10m^2 to 12m^2. The dimensions of the sample shall have a width to length ratio of 0.7 and 1.0.

C. What is the sample shape and size required by each standard? (ISO-17497-1)

ISO-17497-1 requires a circular sample with a minimum area of 7.068 meters. The dimensions of the sample shall have a minimum diameter of 3 meters.

4. SIMILARITIES AND DIFFERENCES

A. What are the similarities with the testing methods?)

a. ASTM-C423 and ISO-354 require test samples of similar shape and configuration
b. The calculation of the "Coefficient of Absorption" is done the same way in all of the standards.

B. What are the differences between the standards?

a. ASTM-C423 and ISO-354 require similar sample shapes and sizes but ISO-17497-1 requires a circular sample.
b. ASTM-c423, ISO-354 and ISO17497-1 can use different methods to measure the RT of the reverberation room.
c. All standards have different sample area requirements.
d. All standards have different perimeter requirements.
e. All standards give different "Coefficients of Absorption".

This list makes it very clear that Standards exist, but to what purpose? Getting common answers should be one of those purposes; otherwise Standards are not very "standard".

5. TEST MODELS

To test the differences a testing regime must include a series of tests that vary a single parameter at a time. This allows a comparison of the results so that it can be observed what parameters affect the resultant "Absorption Coefficient". The test method chosen is the ASTM-C423 method using interrupted noise. A series of shapes and sized samples of 1.0 inch (2.54cm), 6 lb (2.72kg), Fiberglass were constructed. Some samples had a common area of 88.48 ft^2 (8.22 m^2) with variable perimeters and some had a common perimeter of 33.35 ft (10.17 m) and a variable area.

Another sample to be tested was a material that was not “Sound Absorptive”. HDF wood panels with the same area and thickness as the main test materials were chosen for this purpose. This material was then surface sealed with a marine varnish.

The last sample set was to be a different thickness of the same material with a common area.

A. Samples with a common area and changing perimeter.

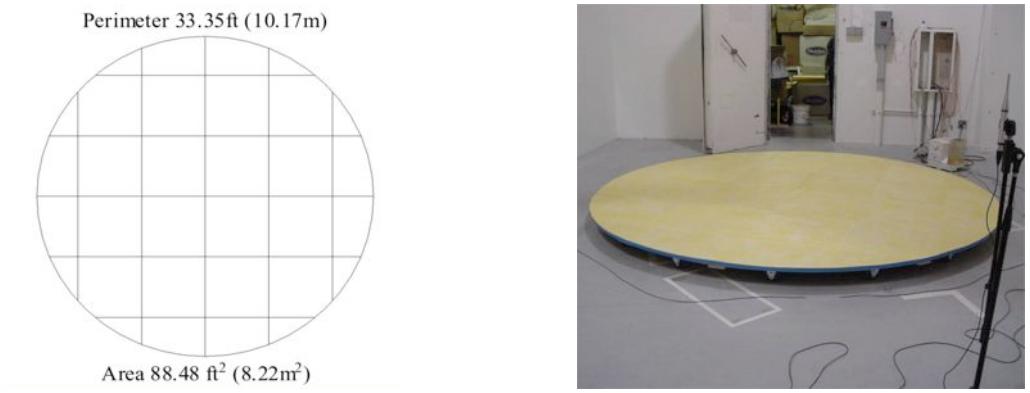


Figure 1: Circular sample 5.31 ft (1.62m) dia.

Figure 2: Square sample 9.406 ft (2.87m) L X 9.406 ft (2.87m) W

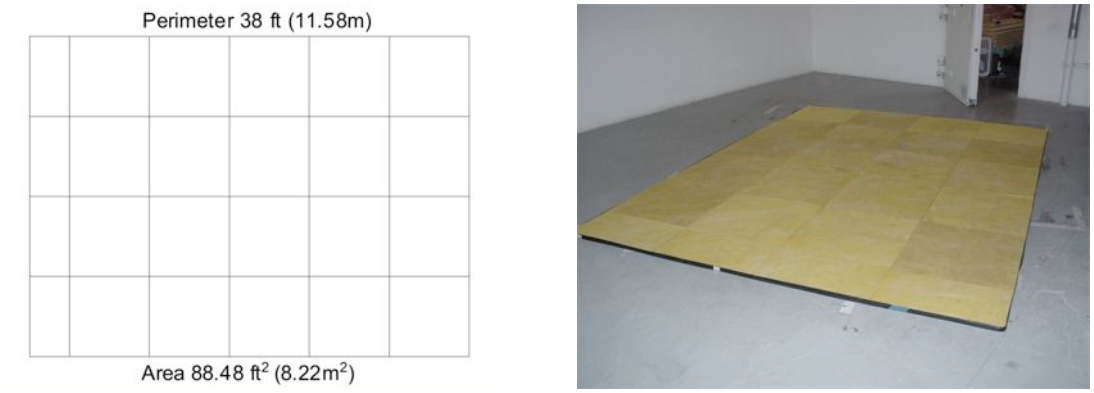


Figure 3: Standard Rectangle sample 11 ft (2.87m) L X 8 ft (2.87m) W

A. Samples with a common area and changing perimeter. (Cont)

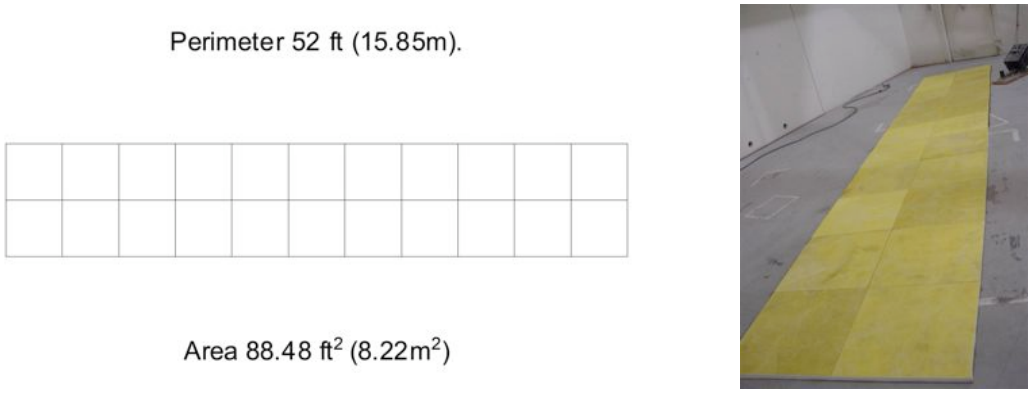


Figure 4: Rectangular Long sample 22 ft (6.71m) L x 4 ft (1.22m) W

Figure 5: Scattered pieces sample 22 pieces 2 ft (0.61m) X 2 ft (0.61m)

B. Samples with a common perimeter and changing area.

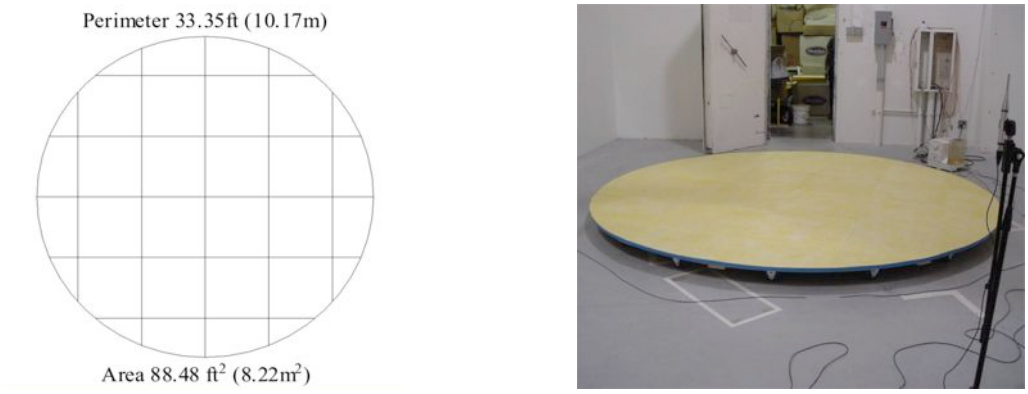


Figure 6: Circular sample 5.31 ft (1.62m) dia.

B. Samples with a common perimeter and changing area. (Cont)

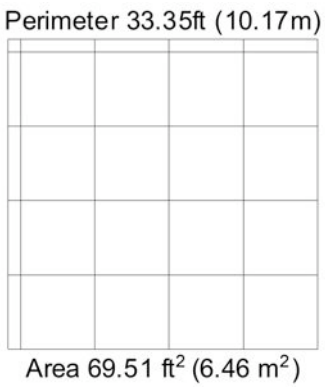
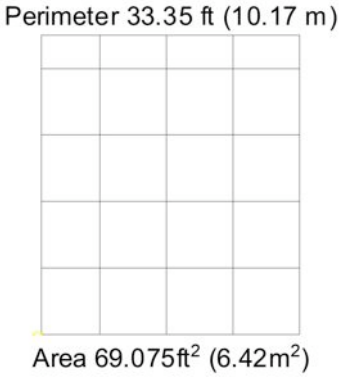


Figure 7: Square sample 8.34 ft (2.54m) L X 8.34 ft (2.54m) W



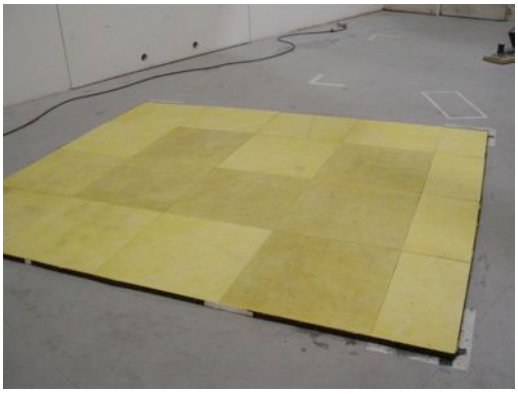


Figure 8: Standard Rectangle sample 9.675 ft (2.95m) L X 7.675 ft (2.34m) W

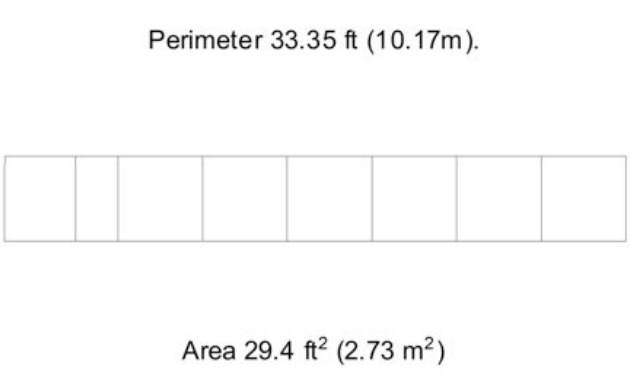


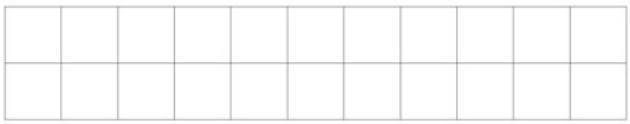
Figure 9: Rectangular Long sample 14.7 ft (4.48m) L x 2 ft (0.61m) W

B. Samples with a common perimeter and changing area. (Cont)

Figure 10: Scattered pieces sample 4 pieces 2 ft (0.61m) X 2 ft (0.61m)
1 piece 0.07 ft (0.02 m) x 0.07 ft (0.02 m)

C. Samples with a common area and non- absorptive material.

Perimeter 52 ft (15.85m).



Area 88.48 ft^2 (8.22m^2)

Figure 11: Rectangular Long sample 22 ft (6.71m) L x 4 ft (1.22m) W
Material is 1 inch (2.54 cm) thick HDF sealed with Marine Varnish

Figure 12: Scattered pieces sample 22 pieces 2 ft (0.61m) X 2 ft (0.61m)
Material is 1 inch (2.54 cm) thick HDF sealed with Marine Varnish

D. Samples with a common area and changing perimeter. (2 inch (5.08cm) thick)

Figure 13: Standard Rectangle sample 12 ft (3.66m) L X 6 ft (1.83m) W

Figure 14: Rectangular Long sample 18 ft (5.49m) L X 4 ft (1.22m) W

Figure 15: Scattered pieces sample 12 pieces 2 ft (0.61m) X 3 ft (0.91m)

1. ACKNOWLEDGMENTS

This paper would not have been possible without the help of Gary Mange, Laboratory Manager of Western Electro Acoustic Laboratory, who did the actual tests for us. He is a member of the ASTM Standards committee for Absorption Measurements. Michael Vargas was of great help creating the mathematical correlations of the measured data.

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