Comparison of the Predicted Absorption of Different Sized and Shaped Materials Using Traditional “Absorption Coefficients” vs. a Proposed “Absorption Constant”

Introduction

- **In 2009 papers were presented at INCE and ASA showing the considerable effects of the "Edge Effect". A proposed Absorption Constant was described and a formula was proposed using it based on experimental data.**

Absorption Coefficient

$$\alpha = (A_2 - A_1) / S + \alpha_1$$

Where:

α = absorption coefficient of the test specimen, dimensionless, Sabins / ft².

S = area of the test specimen, m² or ft², and

α_1 = absorption coefficient of the surface covered by the specimen

How is Absorption Coefficient used?

$$RT_{60} = k\left(\frac{V}{S_a}\right)$$

where:

RT60 = time needed for the reverberation energy in the room to decay in level 60dB

k = the speed of sound that equals 0.161 when units of measurement are expressed in meters and 0.049 when units are expressed in feet.

V = the volume of the room

S_α = the total surface absorption of the room expressed in m^2 or Sabins

Total Surface Absorption of a room

$$S_\alpha = a_1 S_1 + a_2 S_2 + ...$$

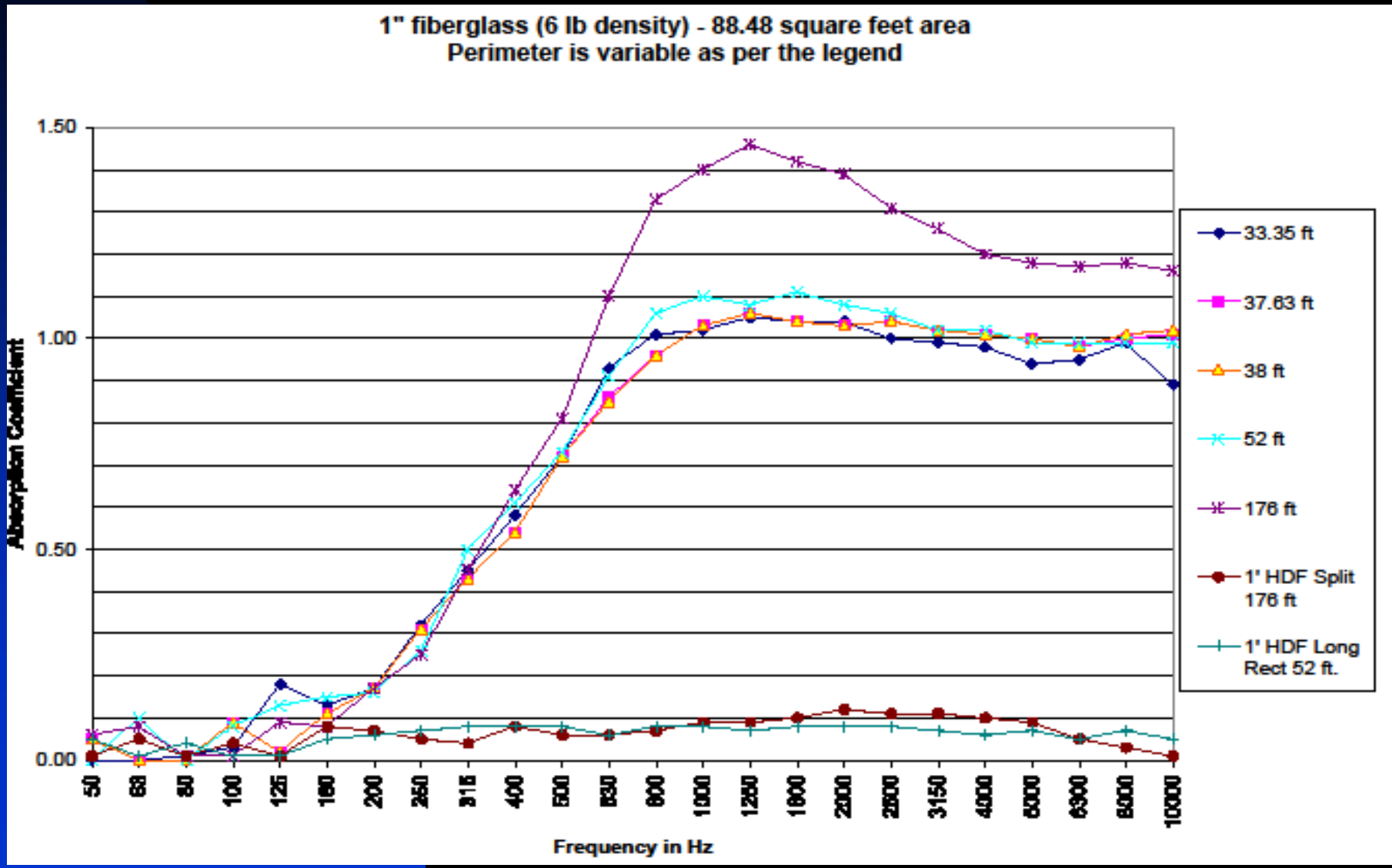
where:

S_a = the total surface absorption of the room expressed in m^2 or Sabins.

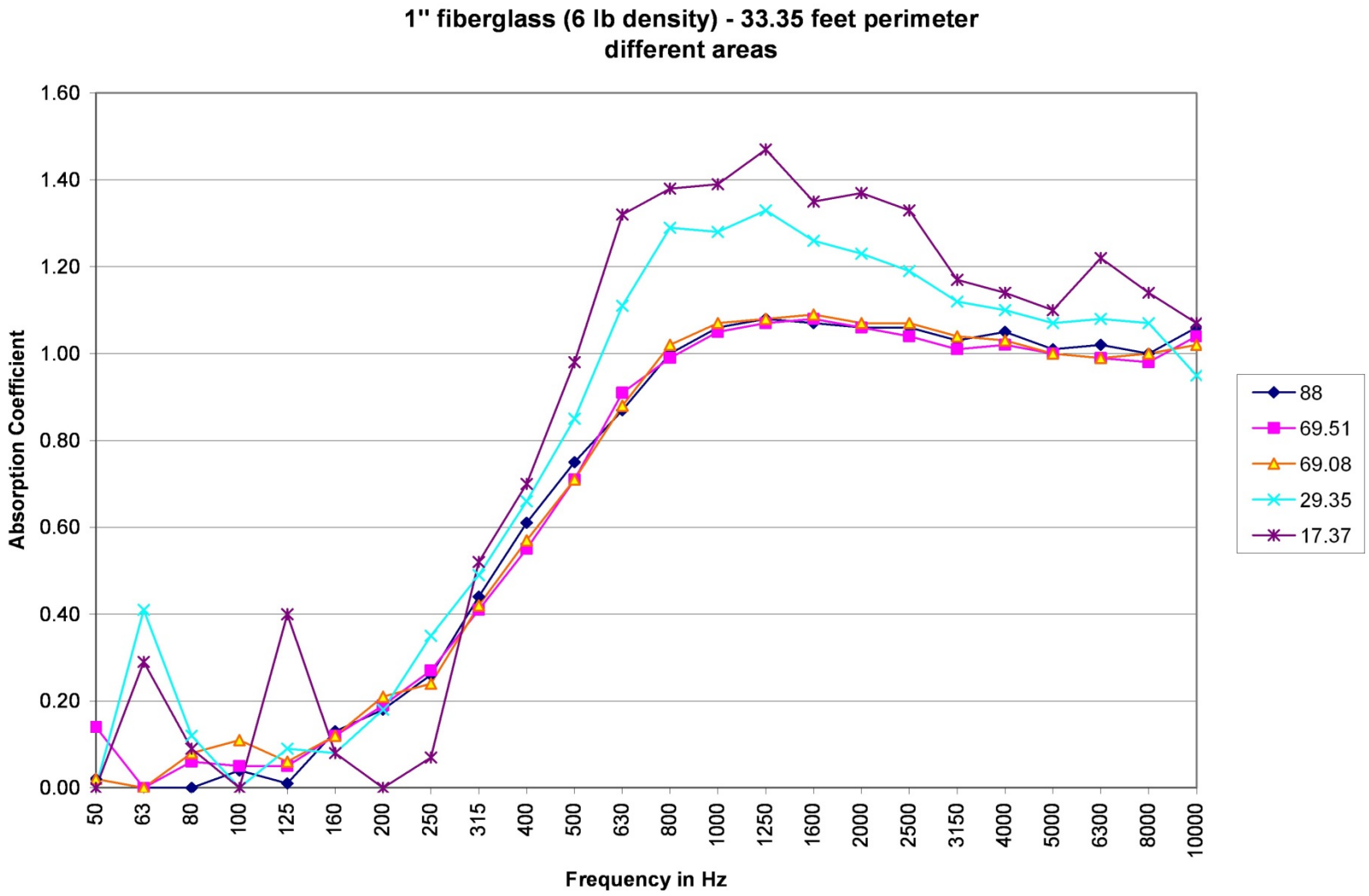
a_1 = the absorption coefficient associated with a given area S

S = the surface area of a single surface expressed in ft^2 or m^2

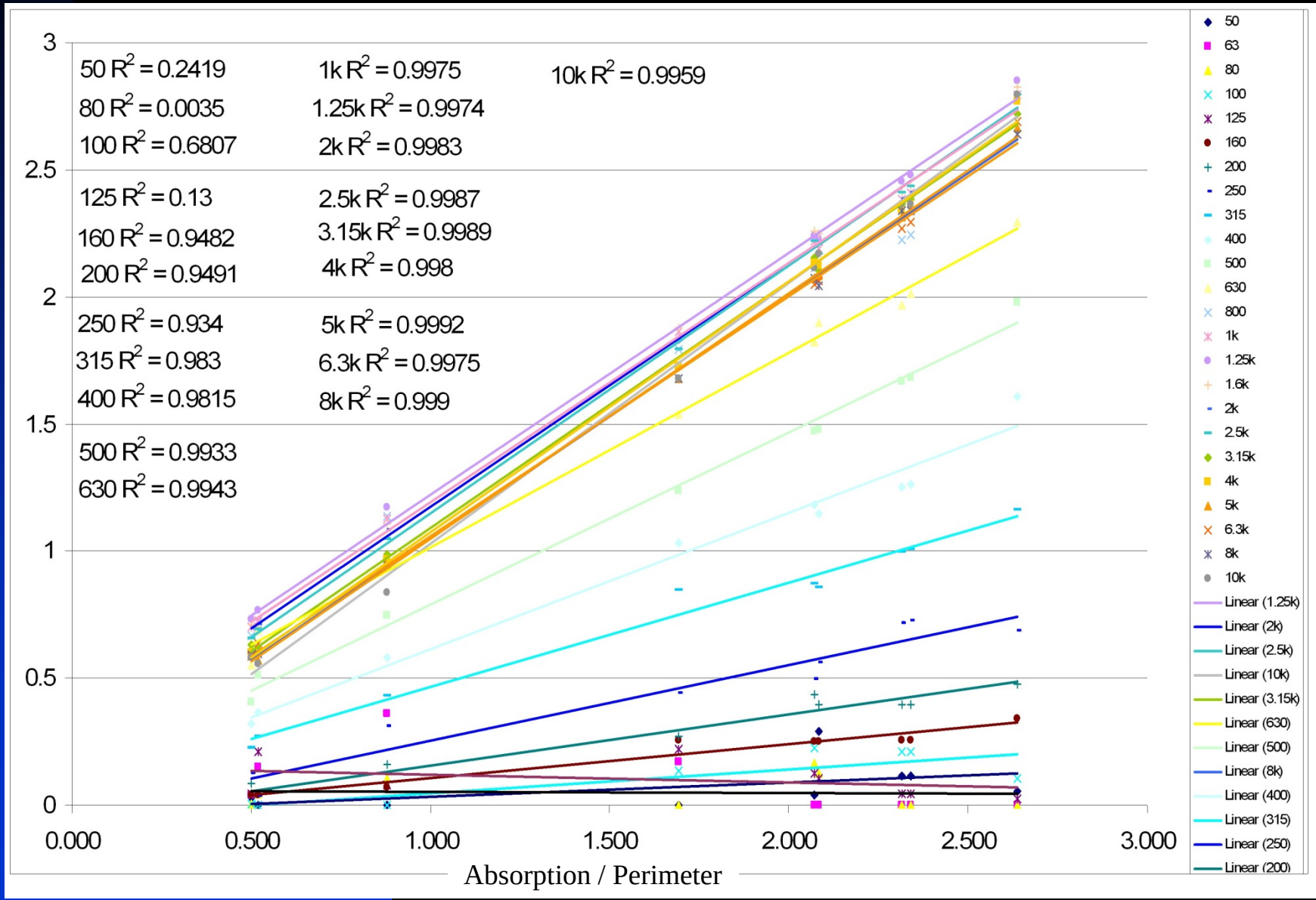
Constant Area Comparisons



Constant Perimeter Comparisons



Data Correlations



Recommendations

A New Formula for Calculation of Absorption in Rooms.

It is thought that a new formula should include the perimeter. This should ideally be used based on the charts previously presented.

The absorption should not be a coefficient since it is variable but should be expressed and used in m^2 or Sabins.

Proposed Formula using the Absorption Constant

$$A_{x(f)} = \left(\frac{\left(\frac{A_{s(f)}}{P_s} - \frac{A_{m(f)}}{P_m} \right)}{\left(\frac{S_s}{P_s} - \frac{S_m}{P_m} \right)} * S_x + \left(\left(\frac{A_{m(f)}}{P_m} \right) - \left(\frac{\left(\frac{A_{s(f)}}{P_s} - \frac{A_{m(f)}}{P_m} \right)}{\left(\frac{S_s}{P_s} - \frac{S_m}{P_m} \right)} * \frac{S_m}{P_m} \right) * P_x \right)$$

where:

A_x = absorption of the surface being predicted, m2 or Sabins.
A_s = absorption of scattered sample, m^2 or Sabins.
A_m = absorption of mono sample, m^2 or Sabins.
S_x = area of surface being predicted, ft^2 or m^2
S_s = area of scattered sample, ft^2 or m^2
S_m = area of mono sample, ft^2 or m^2
P_x = perimeter of surface being predicted, ft or m
P_s = perimeter of scattered sample, ft or m
P_2 = perimeter of mono sample, ft or m
(f) = frequency of interest in prediction

Calculating the Absorption Constant

$$k_{ab(f)} = \frac{\left(\left(\frac{As_{(f)}}{Ps}\right) - \left(\frac{Am_{(f)}}{Pm}\right)\right)}{\left(\left(\frac{Ss}{Ps}\right) - \left(\frac{Sm}{Pm}\right)\right)}$$

where:

k_{ab} = absorption constant

A_s = absorption of scattered sample, m^2 or Sabins.

A_m = absorption of mono sample, m^2 or Sabins.

S_s = area of scattered sample, ft^2 or m^2

S_m = area of mono sample, ft^2 or m^2

P_s = perimeter of scattered sample, ft or m

P_m = perimeter of mono sample, ft or m

(f) = frequency of interest in prediction

Calculating the Absorption Constant

$$k_{ab(f)} = \frac{\left(\left(\frac{As_{(f)}}{Ps}\right) - \left(\frac{Am_{(f)}}{Pm}\right)\right)}{\left(\left(\frac{Ss}{Ps}\right) - \left(\frac{Sm}{Pm}\right)\right)}$$

$$k_{ab(1000)} = \frac{\left(\left(\frac{174.5}{240}\right) - \left(\frac{109.7}{44}\right)\right)}{\left(\left(\frac{120}{240}\right) - \left(\frac{120}{44}\right)\right)}$$

$$k_{ab(1000)} = \frac{(0.73 - 2.49)}{(0.5 - 2.73)}$$

$$k_{ab(1000)} = \frac{-1.76}{-2.23}$$

$$k_{ab(1000)} = .79$$

Proposed Formula using the Absorption Constant

$$A_{x(f)} = k_{ab(f)} * S_x + \left(\left(\frac{A_{m(f)}}{P_m} \right) - k_{ab(f)} * \frac{S_m}{P_m} \right) * P_x$$

where:

K_{ab} = absorption constant

A_x = absorption of the surface being predicted, m2 or Sabins.

A_s = absorption of scattered sample, m^2 or Sabins.

S_x = area of surface being predicted, ft^2 or m^2

S_m = area of mono sample, ft^2 or m^2

P_x = perimeter of surface being predicted, ft or m

P_s = perimeter of scattered sample, ft or m

P_2 = perimeter of mono sample, ft or m

(f) = frequency of interest in prediction

Proposed Formula using the Absorption Constant

$$A_{x_{(f)}} = k_{ab_{(f)}} * S_x + \left(\left(\frac{A_{m_{(f)}}}{P_m} \right) - k_{ab_{(f)}} * \frac{S_m}{P_m} \right) * P_x$$

$$A_{x(1000)} = .79 * 120 + \left(\left(\frac{109.7}{44} \right) - .79 * \frac{120}{44} \right) * 84$$

$$A_{x(1000)} = 94.8 + \left(2.49 - .79 * 2.73 \right) * 84$$

$$A_{x(1000)} = 94.8 + \left(2.49 - 2.16 \right) * 84$$

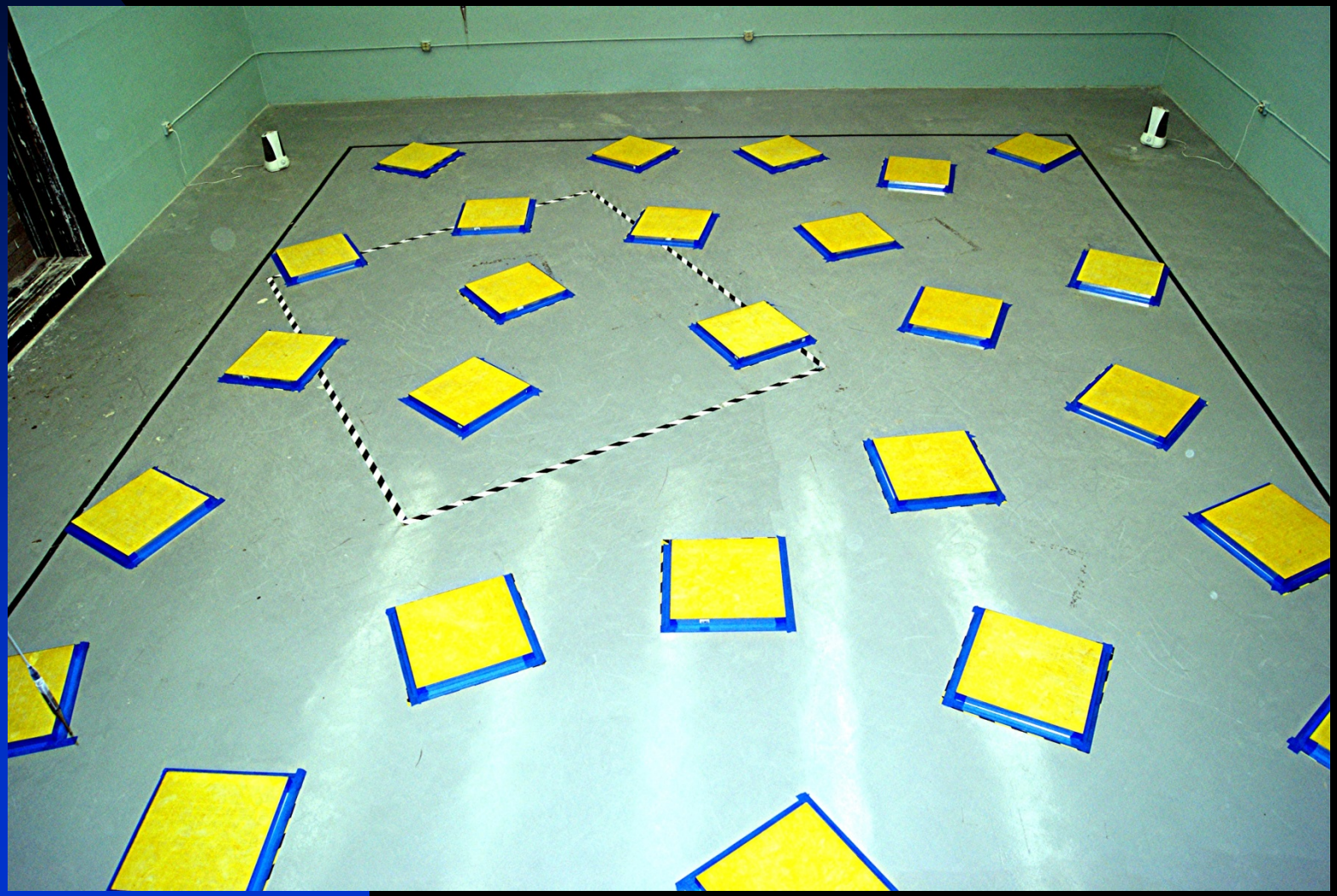
$$A_{x(1000)} = 94.8 + .33 * 84$$

$$A_{x(1000)} = 94.8 + 27.72$$

$$A_{x(1000)} = 122.52$$

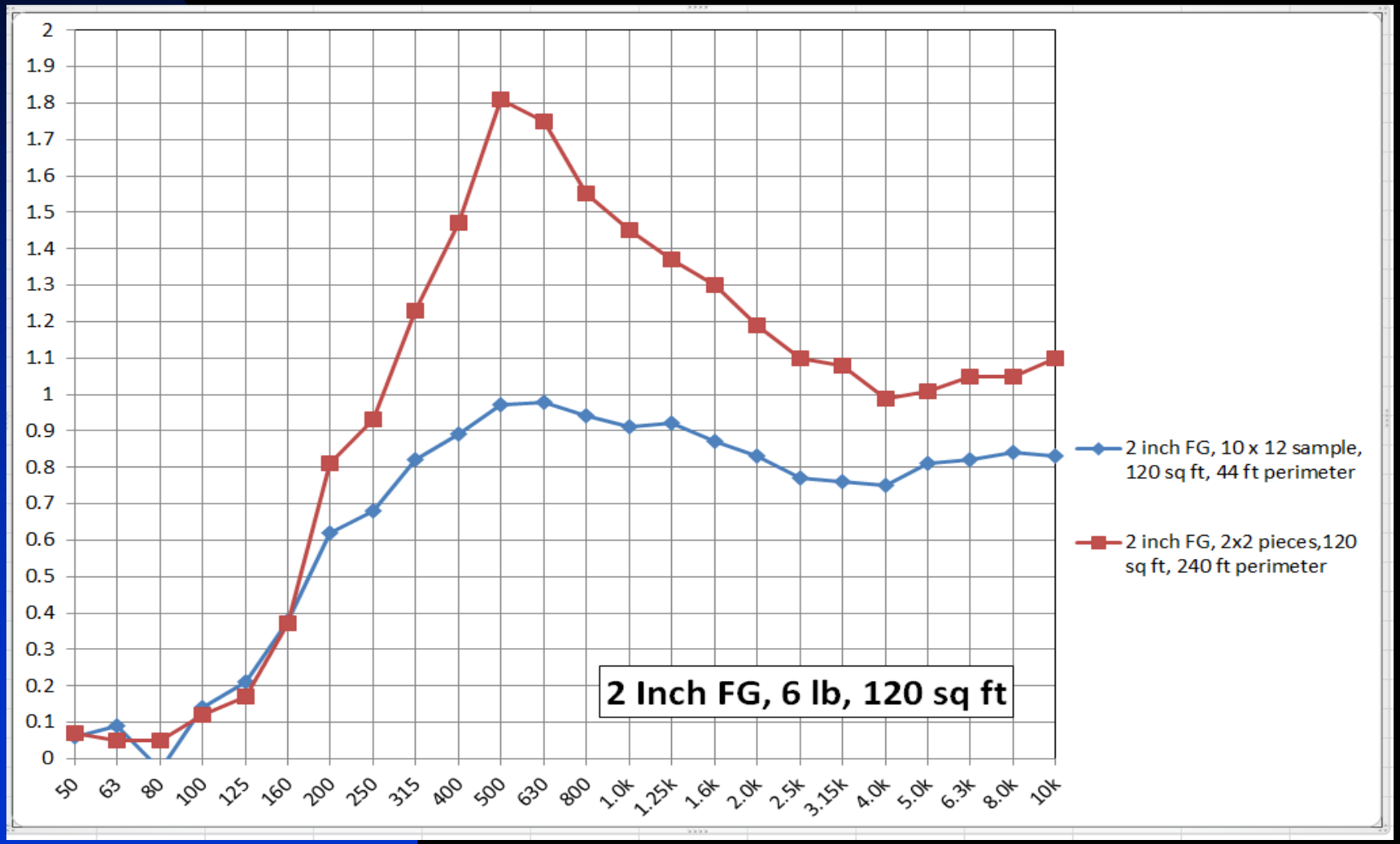
Sample 1
2 Inch FG Measurements (monolithic)

Sample 2
2 Inch FG Measurements (Scattered)

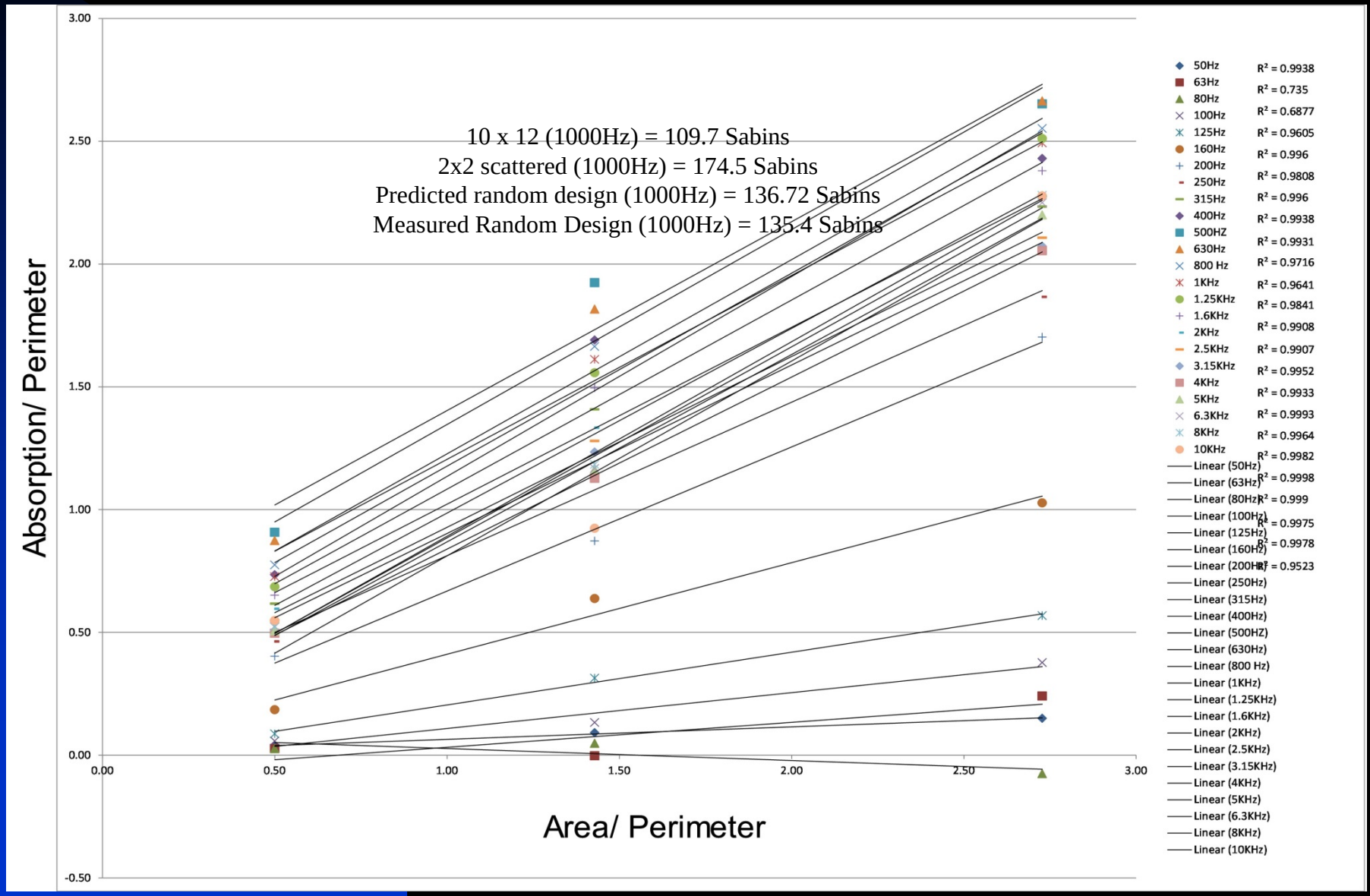


Sample 3
2 Inch FG Prediction & Measurement

Sample 1(blue) and Sample 2(red)
2 Inch FG Measurements (mono & scattered)



2 Inch FG Regressions



Predictions of the absorption of Sample 3

- The absorption of Sample 3 was calculated using the proposed “Absorption Constant”.
- The constant was based on the previous formulas shown. The sample was then measured and results are shown in the next slides.
- The differences between the standard calculations and the proposed calculations were shown in absolute values (sabins) and percentages of errors.

Sample 1(blue), Sample 2(red),Sample 3(violet, green) 2 Inch FG prediction vs measurement graph

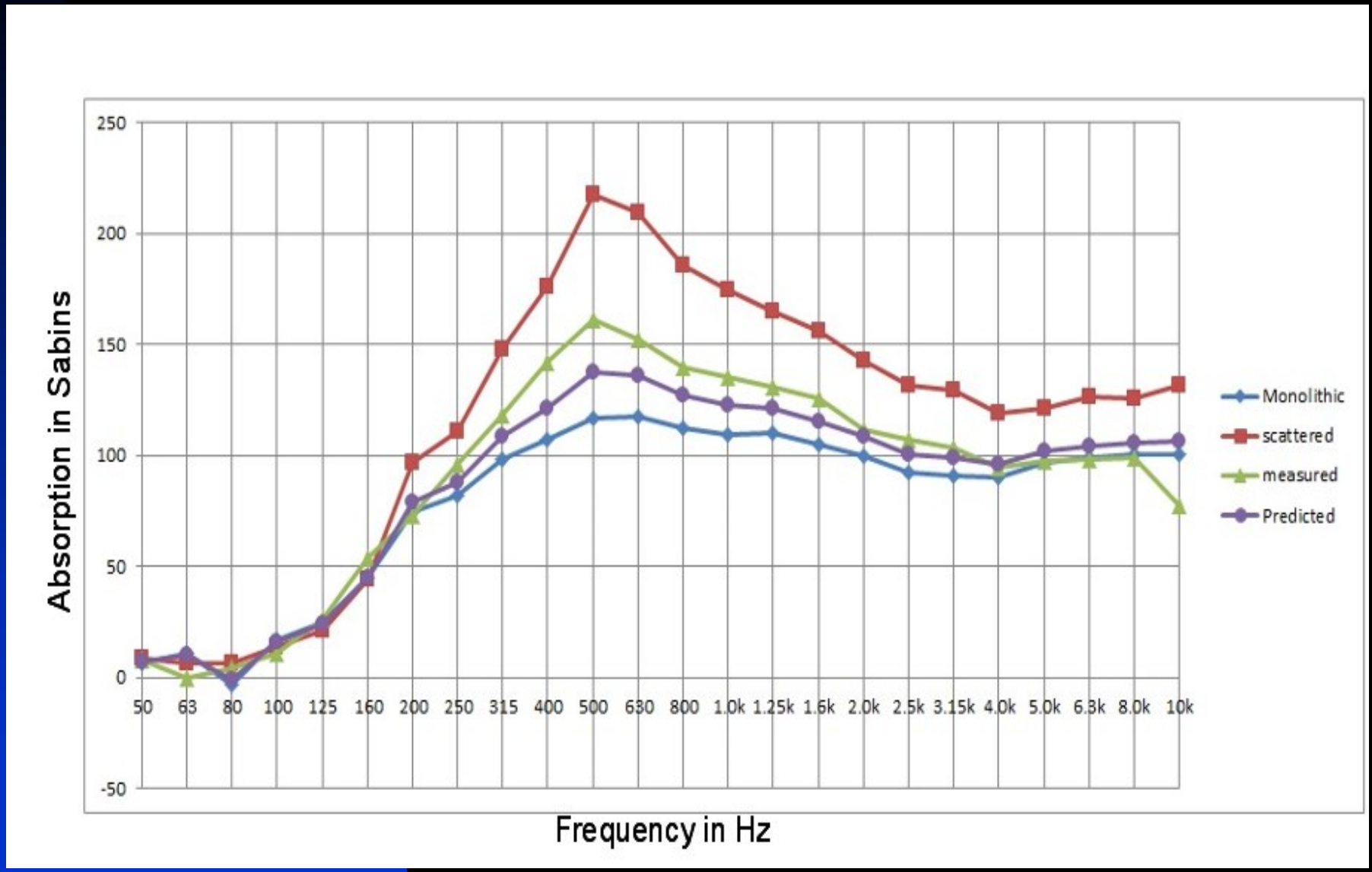


Chart Information (next slide)

All samples are 120 Ft²

Column 1	**Third Octave Bandwidth**
Column 2	**Absorption Coefficient**
Column 3	**Sample 1 Absorption (sabins)**
Column 4	**Sample 2 Absorption (sabins)**
Column 5	**% diff between Col 3 and Col 4**
Column 6	**Sample 3 Absorption (predicted)**
Column 7	**% diff from Col 3 and Col 6**
Column 8	**Sample 3 Absorption (measured)**
Column 9	**% diff from Col 3 and Col 8**
Column10	**% diff from Col 6 and Col 8**

80 Hz data affected by noise event during measurement process

2 Inch FG prediction vs measurement chart

2 inch Fiberglass, 6 lb density									
Hz	A_k	Mono	Scattered	% Diff	Predicted	% Diff	Measured	% Diff	% Diff p-m
50	0.05	6.60	8.80	33	7.05	7	7.70	17	-9
63	0.1	10.60	6.60	-38	9.78	-8	-0.20	-102	102
80	-0.05	-3.30	6.50	-297	-1.30	-61	4.10	-224	415
100	0.14	16.60	13.90	-16	16.05	-3	11.20	-33	30
125	0.22	25.00	20.90	-16	24.16	-3	26.40	6	-9
160	0.38	45.20	44.50	-2	45.06	0	53.60	19	-19
200	0.58	74.90	96.70	29	79.35	6	73.30	-2	8
250	0.63	82.10	111.20	35	88.04	7	96.10	17	-9
315	0.73	98.30	148.10	51	108.46	10	118.30	20	-9
400	0.76	106.90	176.40	65	121.08	13	142.00	33	-17
500	0.78	116.70	217.80	87	137.33	18	161.60	38	-18
630	0.8	117.20	209.80	79	136.10	16	152.60	30	-12
800	0.8	112.30	186.00	66	127.34	13	139.80	24	-10
1.0k	0.79	109.70	174.50	59	122.92	12	135.40	23	-10
1.25k	0.82	110.50	164.70	49	121.56	10	130.80	18	-8
1.6k	0.78	104.70	156.30	49	115.23	10	125.60	20	-9
2.0k	0.75	100.10	143.00	43	108.86	9	112.00	12	-3
2.5k	0.7	92.70	131.70	42	100.66	9	107.50	16	-7
3.15k	0.69	91.20	129.20	42	98.96	9	103.70	14	-5
4.0k	0.7	90.40	119.20	32	96.28	7	94.70	5	2
5.0k	0.76	96.80	121.40	25	101.82	5	97.80	1	4
6.3k	0.77	99.00	126.10	27	104.53	6	98.10	-1	6
8.0k	0.79	100.30	125.60	25	105.46	5	99.40	-1	6
10k	0.78	100.20	131.70	31	106.63	6	77.60	-23	27

Thank You for your attention. If you have additional questions please contact me at:

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