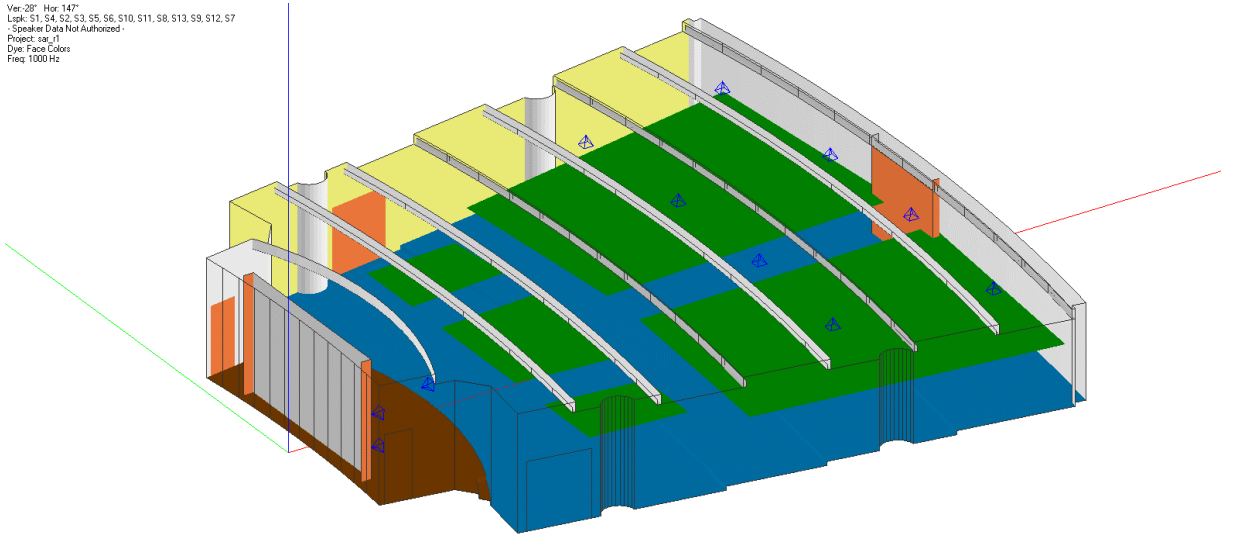# Saudi Arabia Railway
Multi-Purpose Hall

Ver:-28°   Hor: 147°
Lspk: S1, S4, S2, S3, S5, S6, S10, S11, S8, S13, S9, S12, S7
- Speaker Data Not Authorized -
Project: sar_r1
Dye: Face Colors
Freq: 1000 Hz

(c) EASE 4.4 / SketchUp sar_r1   / 5/14/2016 4:36:19 PM / Saudi Media Systems Dan Dexter

ACOUSTIC STUDY

Submitted By:

Saudi Media Systems

P.O Box 8464

Riyadh 11482

Saudi Arabia Railway
Multi-Purpose Hall

INTRODUCTION:

The purpose of this study is to carry out a complete and detailed Acoustical Analysis for the Sound Distribution System of Saudi Arabia Railway Multi-purpose hall.

The study was done through an Internationally Recognized Software of reliable results and output and the data were treated and processed by a highly skilled Engineer specialized in the application working in a reputable company of considerable experience in the field.

INPUT DATA / PARAMETERS / CONSIDERATIONS AND BASIS OF THE STUDY:

The study was done based on following Information:

1. Dimensions and shape of the Hall.

2. Heights of ceiling (the ceiling is not of the same inverted level at the different ambient locations).

3. Levels of seats (steps). Varies from 0.00M to 0.36M/step at Ground Floor

4. Standard height that to be considered for optimum audible level.

5. Design and Distribution of sound system and speakers.

6. Power/Audio output of speakers.

7. Materials proposed for finishing.

8. External Noise caused by the Air Handling units of HVAC system. Said Noise was considered of minimal levels (possible in such application) as High Quality Sound insulations are proposed for attenuation of equipment Noise.

   Selection of HVAC diffusers and Design acoustical levels of sound Transmitted to the Lecture Hall from the Mechanical Equipment are based on NC25.

9. Internal A/C diffusers are of reasonable and acceptable noise Level (i.e. not considered of zero noise).

Saudi Arabia Railway
Multi-Purpose Hall

MILESTONES OF FEEDBACK OF REQUIRED AS RESULTS OF THE ANALYSIS:

i) Check performance of Sound distribution system at all points of the two levels of the Hall.

ii) Verify adequacy of Design of audio system.

iii) Check and verify adequacy of all Materials proposed for finishing.

iv) Specify recommended angles of installation of ceiling panels.

v) Issue any recommendation that may held in achieving better sound performance

MEASURES OF ANALYSIS :

RT : Reverberating Time

SPL : Sound Pressure Level

STI : Speech Transmission Index.

ALCONS : Articulation Loss of Consonants

ATTACHMENTS :

a) Results obtained in each field, Direct SPL, total SPL, ALCONS and STI.

b) Line Graph showing: Reverberation Time Result vs. Sound Frequency, Ideal (reference) Reverberation Time and Limits of Tolerance.

c) Details of wall panels that do enhance the acoustic Materials and performance.

Saudi Arabia Railway
Multi-Purpose Hall

RESULTS :

I.   First operation of Data processing was based on proposing wooden panels as cladding of walls.

Results were not satisfactory.

II.   Based on the proposal of :

-       Using multiplex panel/wood veneer for implementation of interior finishes of the wall panels.

-       Using Rock wool in internal acoustical material for implementation of said wall panels.

-       Carry out access/points of analysis in the vibrating wall panels.

The sound investigation has indicated that using the proposed materials (including above wall panels) and the Audio System (as per proposed design) shall produce distinguished Sound Performance and Reverberation Time.

Charts and Graphs enclosed herewith and related Food Notes do confirm the high Quality and Efficient Sound Performance of the Multi-purpose hall.

Saudi Arabia Railway
Multi-Purpose Hall
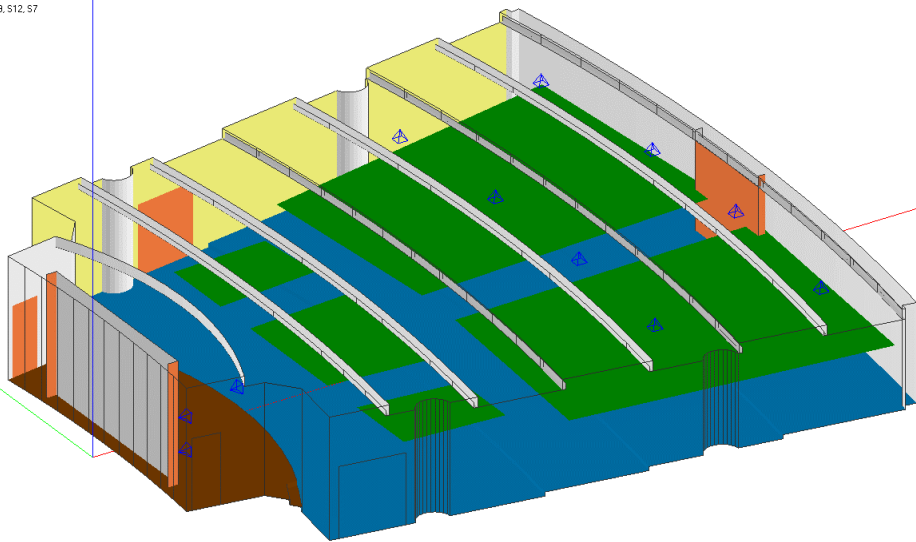
PERSPECTIVE VIEW

Room materials used in analysis:

Floor Area	-	Commercial Grade Carpet
Ceiling	-	Straight Suspended Panels (Gypsum)
Walls	-	Gypsum/1" Thick Acoustic panel covered with fabric

Loudspeakers used in analysis:

Main Front Speaker	- 2 x 300W (Right wing)
Main Front Speaker	- 2 x 300W (Left wing)
Subwoofer Speaker	- 1 x 500W (Center front)
Ceiling Speakers	- 8 x 10W @ 70V Line Distribution.

Saudi Arabia Railway
Multi-Purpose Hall

(c) EASE 4.4 / SketchUp sar_r1

3D Perspective
/ 5/15/2016 10:
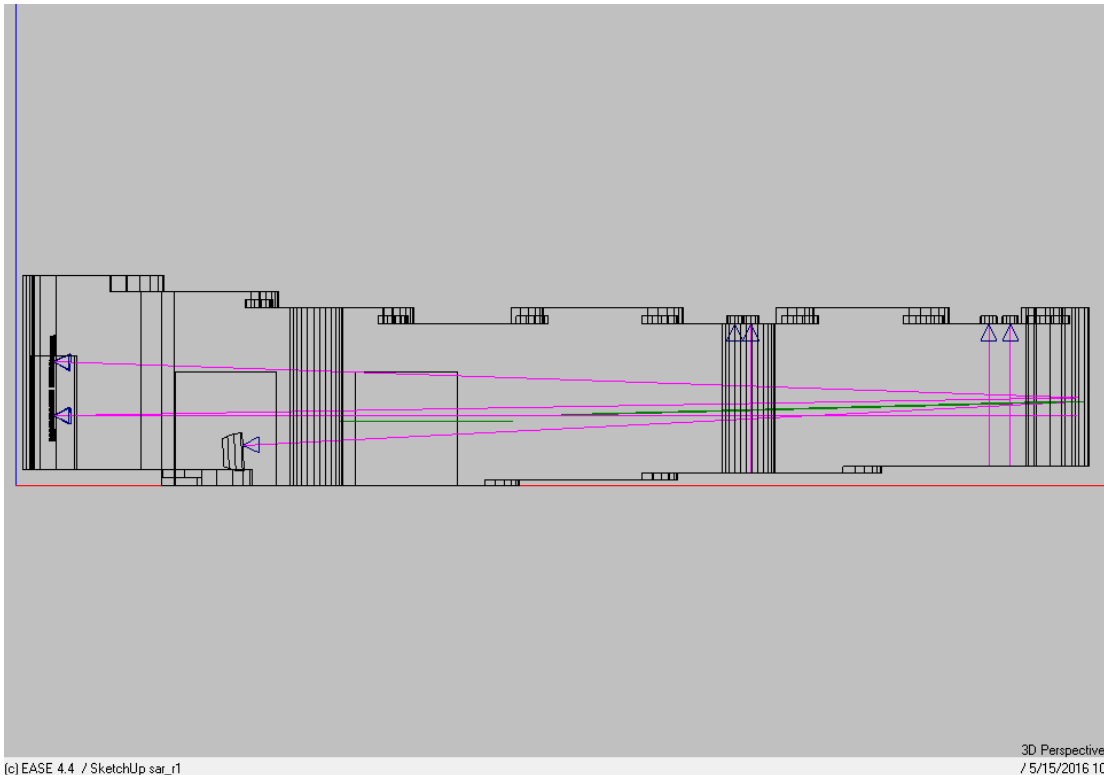
SIDE VIEW

Above shows the side view of the Multi-purpose hall to be analyzed.

The colored Green area is the audience listening area, which is ascending from 0.00m to 0.36m/step above finish floor level. This are the areas being reflected in the drawing and where acoustical calculations are being made.

Saudi Arabia Railway
Multi-Purpose Hall
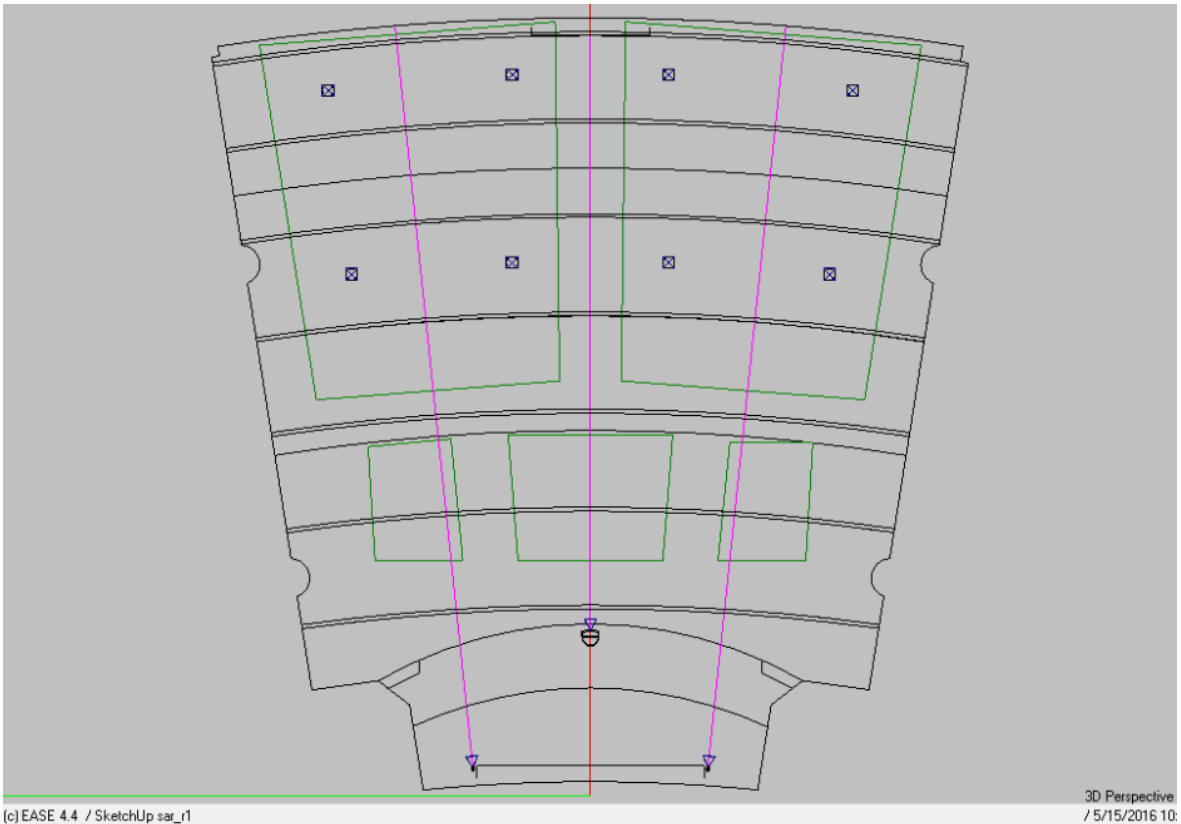

(c) EASE 4.4 / SketchUp sar_r1

3D Perspective
/ 5/15/2016 10:

TOP VIEW

Above shows the Top View of the Multi-purpose hall to be analyzed

The colored Green area is the audience listening area. This is the area being reflected in the drawing and from where acoustical calculations are being made.

Saudi Arabia Railway
Multi-Purpose Hall
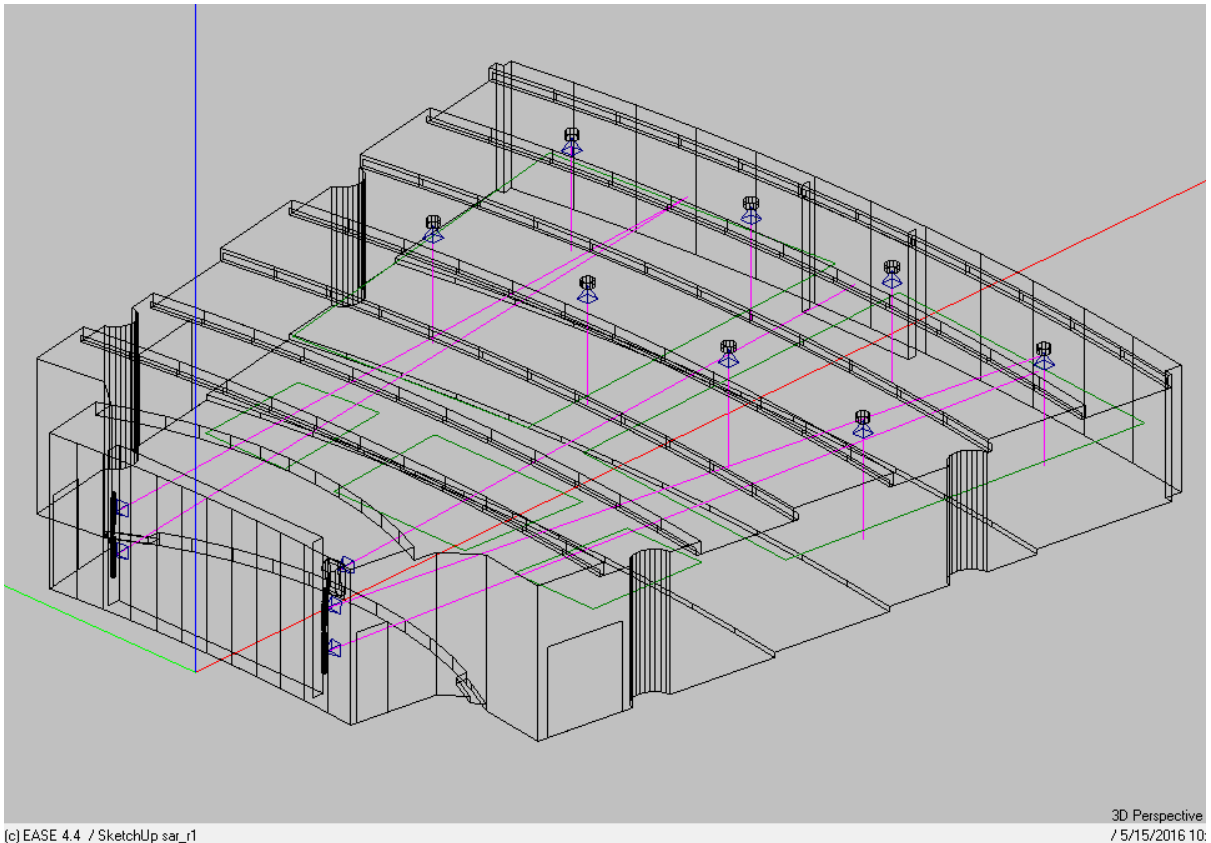
(c) EASE 4.4 / SketchUp sar_r1

3D Perspective
/ 5/15/2016 10:

STRUCTURE

Above drawing shows the structure of Multi-purpose hall showing the stage area, and the listening/seating area. Also shown is the speaker positioning for the whole Multi-purpose hall.

The colored Green area is the audience listening area at 1.2m from the finish floor level which is ascending from 0.00m to 0.36m/step. The colored violet is the dB Cone aiming of the speakers while the black colored are the faces and structure of the Multi-purpose hall.

Saudi Arabia Railway
Multi-Purpose Hall

Project		
Hall :	SketchUp sar_r1	Town :
Version :		RT desired : 0 s

Geometry		Absorption		Mean Free Path	
Room Surface :	1011.58 m²	Avg. Abs. Area :	212.85 m²	Length :	3.69 m
Volume :	933.98 m³	Avg. Abs. Coeff. :	0.21	Time :	0.01 s

Eyring Reverberation (Standard Tolerance)

TOLERANCE
IDEAL REVERBERATION TIME
TOLERANCE
RESULT

Band	RTime [s]
100 Hz	0.64
125 Hz	0.64
160 Hz	0.71
200 Hz	0.8
250 Hz	0.91
315 Hz	0.91
400 Hz	0.92
500 Hz	0.92
630 Hz	0.8
800 Hz	0.71
1000 Hz	0.63
1250 Hz	0.58
1600 Hz	0.53
2000 Hz	0.49
2500 Hz	0.46
3150 Hz	0.43
4000 Hz	0.4
5000 Hz	0.37
6300 Hz	0.33
8000 Hz	0.3
10000 Hz	0.28

LINE GRAPH

Reverberation Time (RT) is the time it takes for decaying sound to drop 60dB below its initial level or it's the rate of decay of sound. To calculate the Reverberation time based on Sabine's Formula its stated as

$$RT = \frac{0.16 \times \text{Volume of Room}}{\text{Absorption area in } m^2}$$

Shown above is the line graph representation between the ideal reverberation time (Red Color) with its tolerance (Black Color) and the resulting RT (Blue Color) of the acoustical study of the multi-purpose hall. Acoustical study land up with the long reverb time of 0.91sec at 315Hz to 0.91 sec @ 250Hz and short reverberation time of 0.41s at 10kHz. This shows that frequencies 315Hz, 250Hz, 200 has failed the ideal reverberation time to produce very bright and live sound. Frequencies from 100Hz,125Hz,160Hz,400Hz to 10 kHz are within and it is beyond the ideal reverberation time.

To conclude, The result of the investigation on Reverberation Time of the Auditorium based on the materials in used is acceptable. The materials used as per investigation is suitable for room acoustics (See attached for the details of the materials)

Saudi Arabia Railway
Multi-Purpose Hall

Ver:-90°   Hor: 90°
Lspk: S1, S4, S2, S3, S5, S6, S10, S11, S8, S13, S9, S12, S7
- Speaker Data Not Authorized -
Project: sar_r1
Map: Direct SPL (Z)
Freq: 1000 Hz
(1/3 Octave Average)
Shadow Cast: No
Resolution = 1.00 m

Direct SPL [dB]
Max: 94.24
95
94
93
92
91
90
89
88
87
86
85
84
83
82
81
80
79
78
77
76
Min: 84.01
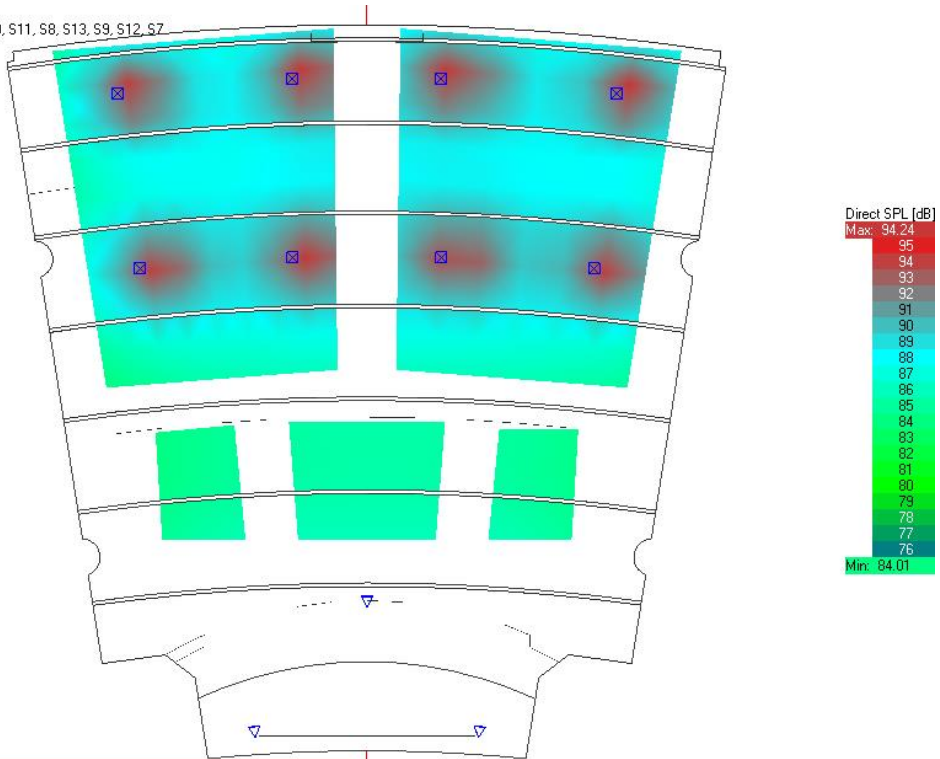
(c) EASE 4.4 / SketchUp sar_r1   / 5/15/2
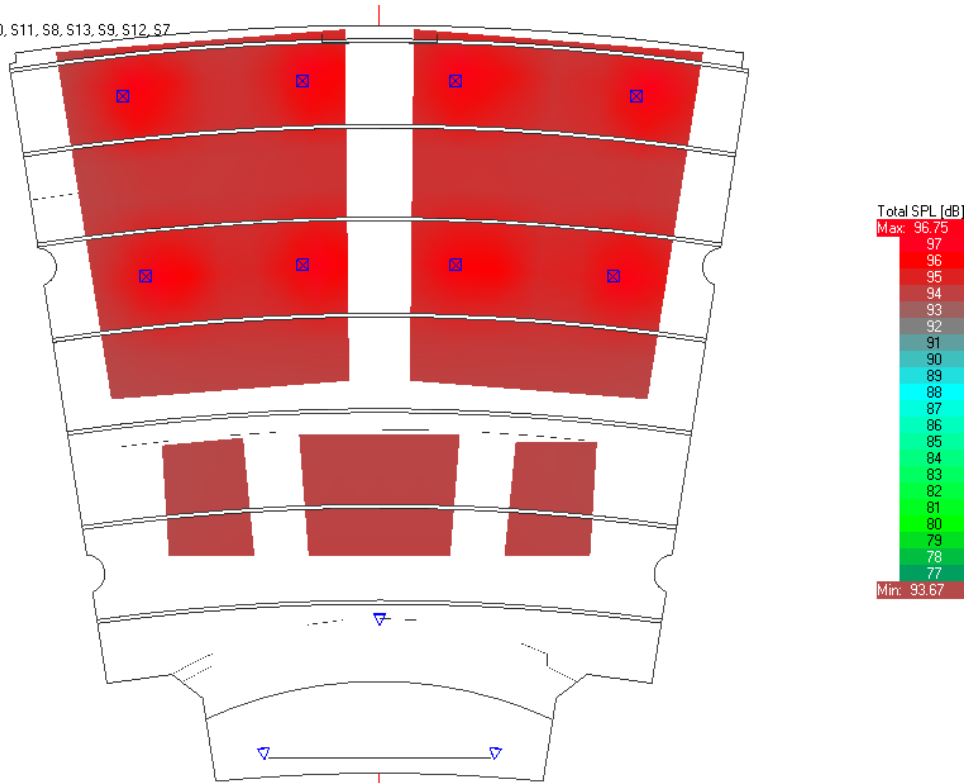
DIRECT SPL

SPL (Sound Pressure Level) – is 10 times the logarithm of the ratio of the time-mean square pressure to the square of the reference pressure. The basis of measurements of many acoustic parameters , including measurements of. Sound intensity, Sound Absorption, Sound Power Level, Sound Transmission Loss. The measurement of Sound pressure is based on the use of a microphone that is used as a transducer to create voltage signal that is proportional to the root mean square pressure at the point in space where the microphone is located. A logarithmetric detector approximates the response of the human ear to such pressure variations, and the results in a measurement range that is reduced from a factor of a milling to 0dB to 95dB.

Test Result:

The portion that is in Red color has an SPL of 94.24dB. The rest of the areas has lower than 92dB. It is obviously notice that this portions has the direct firing from the speaker. This means that this areas had a large range of magnitude of these pressure variations that human can sense.

Saudi Arabia Railway
Multi-Purpose Hall

Ver:-90° Hor: 90°
Lspk: S1, S4, S2, S3, S5, S6, S10, S11, S8, S13, S9, S12, S7
- Speaker Data Not Authorized -
Project: sar_r1
Map: Total SPL (Z)
Freq: 1000 Hz
(1/3 Octave Average)
Shadow Cast: No
Resolution = 1.00 m

Total SPL [dB]
Max: 96.75
97
96
95
94
93
92
91
90
89
88
87
86
85
84
83
82
81
80
79
78
77
Min: 93.67

(c) EASE 4.4 / SketchUp sar_r1   / 5/15/2
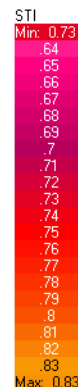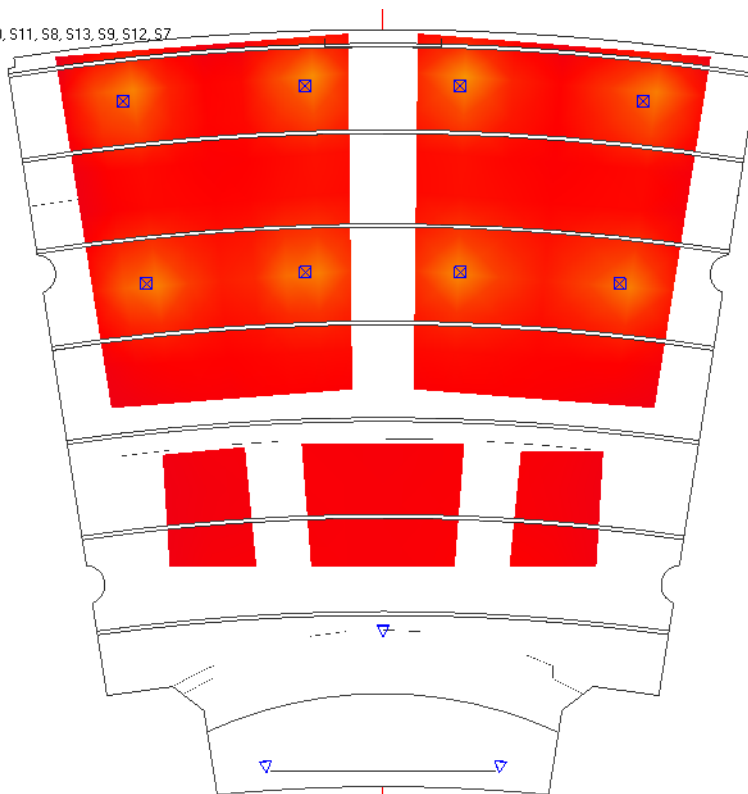
TOTAL SPL

SPL (Sound Pressure Level) – is 10 times the logarithm of the ratio of the time-mean square pressure to the square of the reference pressure. The basis of measurements of many acoustic parameters , including measurements of. Sound intensity, Sound Absorption, Sound Power Level, Sound Transmission Loss. The measurement of Sound pressure is based on the use of a microphone that is used as a transducer to create voltage signal that is proportional to the root mean square pressure at the point in space where the microphone is located. A logarithmetric detector approximates the response of the human ear to such pressure variations, and the results in a measurement range that is reduced from a factor of a milling to 0dB to 95.6dB.

Test Result:

    At rear areas and center areas has resulted SPL of 96.75dB. The rest of the areas has lower than 94dB. It is obviously notice that this portions has the direct firing from the speaker. This means that this areas had a large range of magnitude of these pressure variations that humans can sense.

Saudi Arabia Railway
Multi-Purpose Hall

Ver:-90° Hor: 90°
Lspk: S1, S4, S2, S3, S5, S6, S10, S11, S8, S13, S9, S12, S7
- Speaker Data Not Authorized -
Project: sar_r1
Map: STI (M)
Shadow Cast: No
Resolution = 1.00 m

STI
Min: 0.73
.64
.65
.66
.67
.68
.69
.7
.71
.72
.73
.74
.75
.76
.77
.78
.79
.8
.81
.82
.83
Max: 0.83

(c) EASE 4.4 / SketchUp sar_r1   / 5/15/2

STI

Speech Transmission Index (STI) – is calculated from a set of other numbers called MTF Modulation Transfer Function. It takes into account how the transmission from source to receiver is affected at different frequency bands and how much these bands contribute to speech intelligibility.

STI Score Intelligibility

0.75 to 1.0	- Excellent
0.6 to 0.75	- Good
0.45 to 0.6	- Fair
0.3 to 0.45	- Poor
0 to 0.3	- Bad

Test Result:

only the back areas , has a "excellent" rating of STI (colored yellow orange). The front and the side area of the multi-purposed hall has an "good" rating which range from 0.73 – 0.75 (colored red).

Saudi Arabia Railway
Multi-Purpose Hall

Ver:-90°   Hor: 90°
Lspk: S1, S4, S2, S3, S5, S6, S10, S11, S8, S13, S9, S12, S7
- Speaker Data Not Authorized -
Project: sar_r1
Map: Articulation Loss (M)
Shadow Cast: No
Resolution = 1.00 m

ALCons [%]
Max: 3.22

| 20 |
| 19 |
| 18 |
| 17 |
| 16 |
| 15 |
| 14 |
| 13 |
| 12 |
| 11 |
| 10 |
| 9 |
| 8 |
| 7 |
| 6 |
| 5 |
| 4 |
| 3 |
| 2 |
| 1 |

Min: 1.92
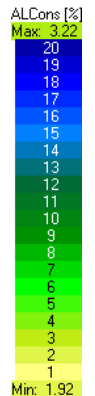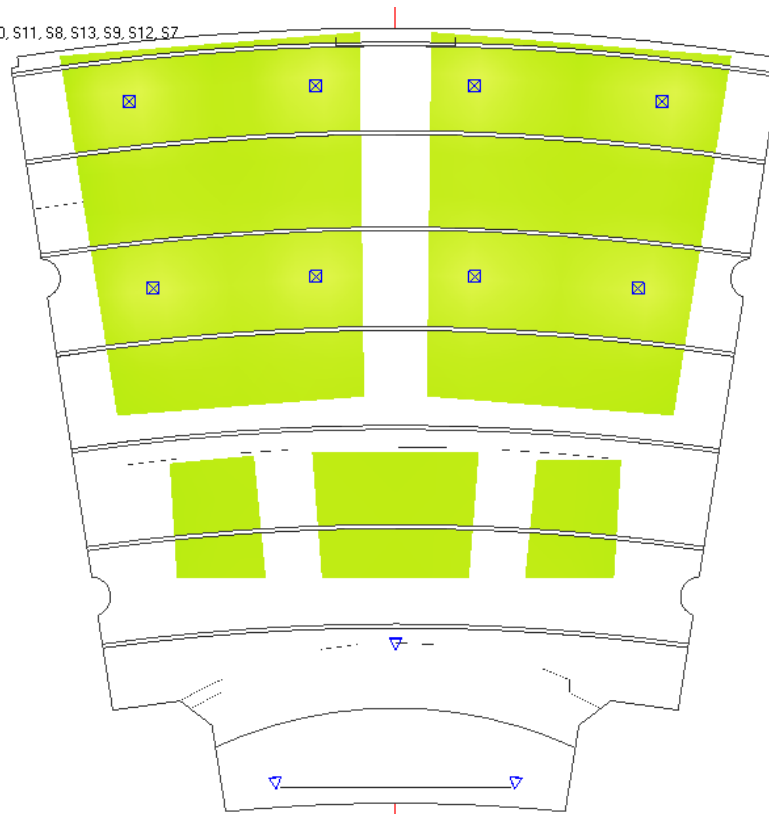
(c) EASE 4.4 / SketchUp sar_r1   / 5/15/:

ALCONS

Articulation Loss of Consonants – is another means of measuring intelligibility. It is computed from the measurements of the Direct-to-Reverberant Ratio and the early decay Time using a set of correlations define by Sabine formula and is specified in percent.

Alcons Score Intelligibility

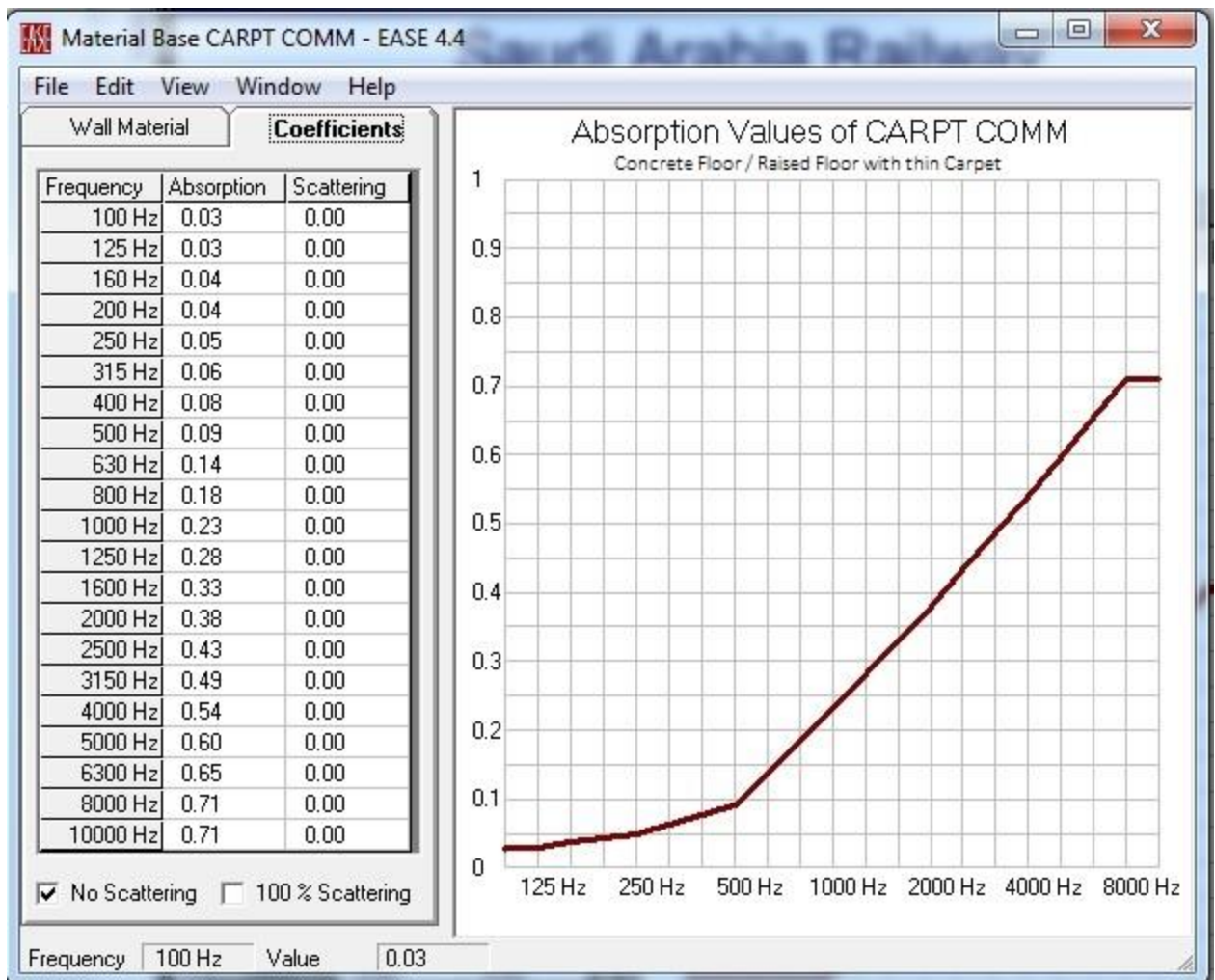|	
< 3 %	- Excellent
3 to 7 %	- Good
7 to 15 %	- Fair
15 to 35 %	- Poor
>35 %	- Bad

Test Result:

almost 20 % areas of the Multi-purpose hall , has an "Good" rating of ALCONS at 3.22% (colored dark yellow green). The front and the side area of the Multi-purpose hall has an "Excellent" rating which range from 1.92 – 3 (colored light yellow green).

Saudi Arabia Railway
Multi-Purpose Hall

Material Base CARPT COMM - EASE 4.4

File   Edit   View   Window   Help

| Wall Material | **Coefficients** |

Frequency	Absorption	Scattering
100 Hz	0.03	0.00
125 Hz	0.03	0.00
160 Hz	0.04	0.00
200 Hz	0.04	0.00
250 Hz	0.05	0.00
315 Hz	0.06	0.00
400 Hz	0.08	0.00
500 Hz	0.09	0.00
630 Hz	0.14	0.00
800 Hz	0.18	0.00
1000 Hz	0.23	0.00
1250 Hz	0.28	0.00
1600 Hz	0.33	0.00
2000 Hz	0.38	0.00
2500 Hz	0.43	0.00
3150 Hz	0.49	0.00
4000 Hz	0.54	0.00
5000 Hz	0.60	0.00
6300 Hz	0.65	0.00
8000 Hz	0.71	0.00
10000 Hz	0.71	0.00

☑ No Scattering   ☐ 100 % Scattering

Frequency   100 Hz   Value   0.03

Absorption Values of CARPT COMM
Concrete Floor / Raised Floor with thin Carpet

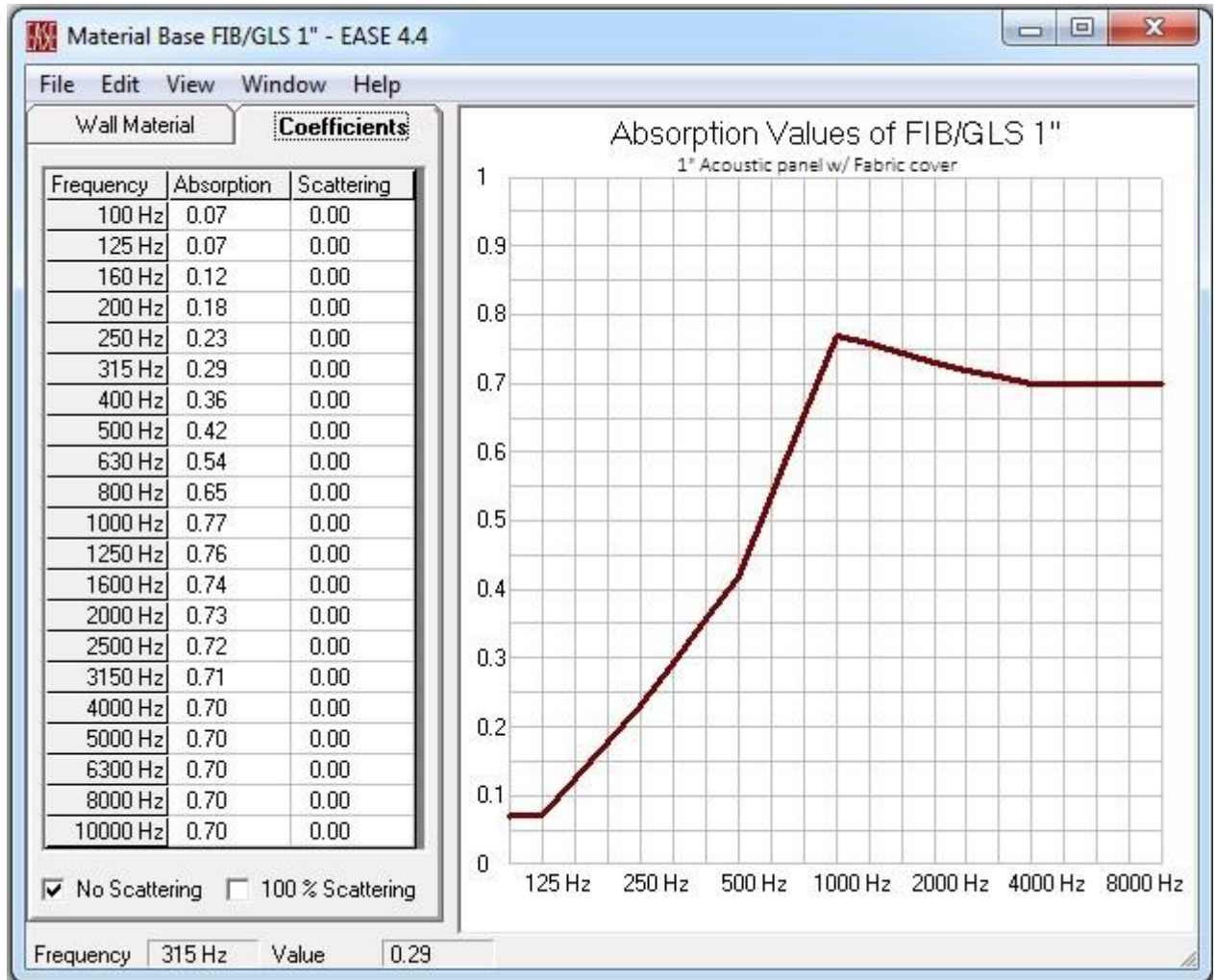Absorption Coefficient for Commercial Carpet

Note :
1. The absorption coefficient of the above material is shown for reference and matching purposes for the absorption coefficients of the actual materials to be used.
2. Absorption coefficient of the actual material to be used should not be less than the absorption coefficient used in this test.

Saudi Arabia Railway
Multi-Purpose Hall

Material Base FIB/GLS 1" - EASE 4.4

File   Edit   View   Window   Help

Wall Material | **Coefficients**

Frequency	Absorption	Scattering
100 Hz	0.07	0.00
125 Hz	0.07	0.00
160 Hz	0.12	0.00
200 Hz	0.18	0.00
250 Hz	0.23	0.00
315 Hz	0.29	0.00
400 Hz	0.36	0.00
500 Hz	0.42	0.00
630 Hz	0.54	0.00
800 Hz	0.65	0.00
1000 Hz	0.77	0.00
1250 Hz	0.76	0.00
1600 Hz	0.74	0.00
2000 Hz	0.73	0.00
2500 Hz	0.72	0.00
3150 Hz	0.71	0.00
4000 Hz	0.70	0.00
5000 Hz	0.70	0.00
6300 Hz	0.70	0.00
8000 Hz	0.70	0.00
10000 Hz	0.70	0.00

☑ No Scattering   ☐ 100 % Scattering

Frequency   315 Hz   Value   0.29

Absorption Values of FIB/GLS 1"
1" Acoustic panel w/ Fabric cover

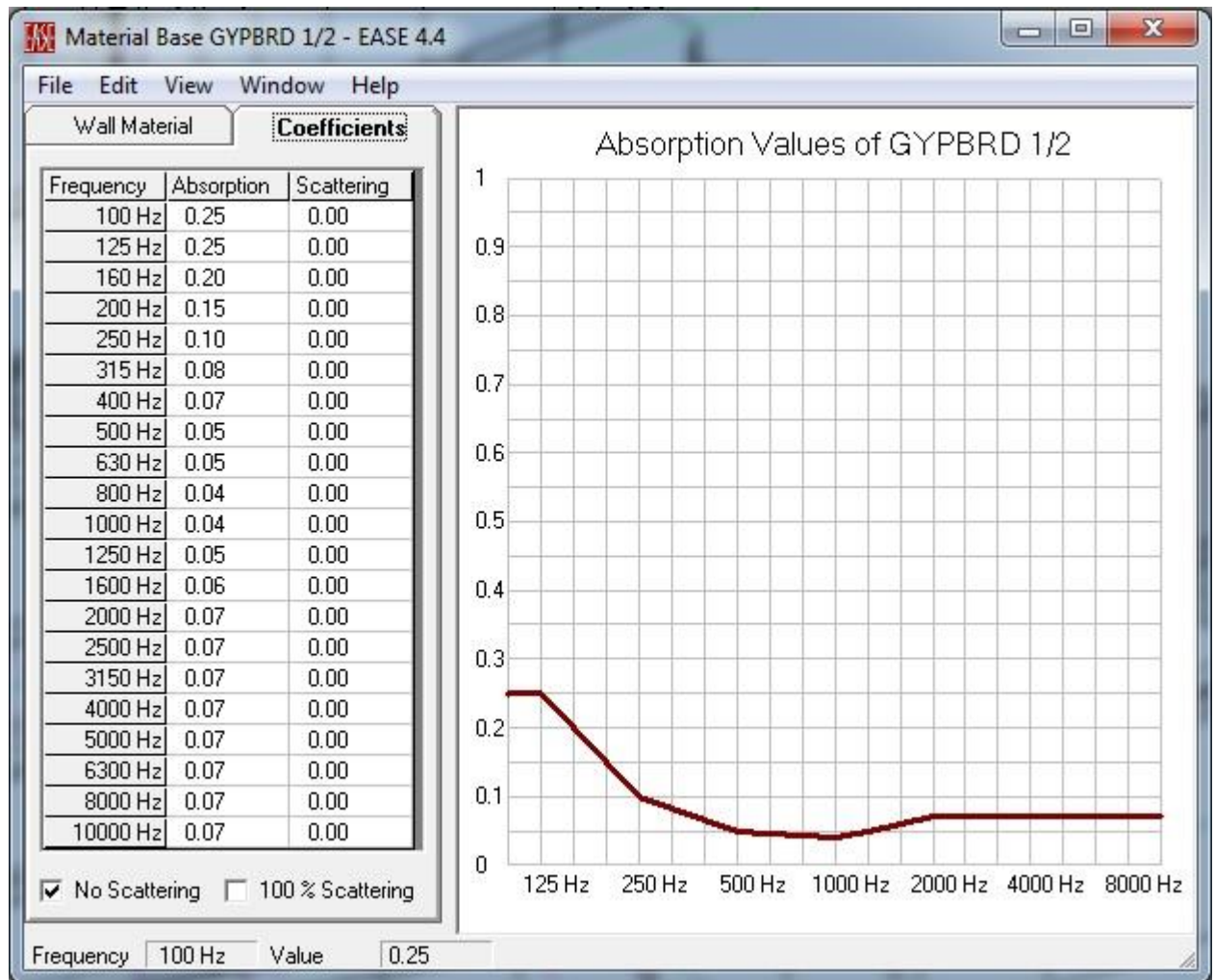Absorption Coefficient for 1" thick Acoustic Panel covered with Fabric

Note :
1. The absorption coefficient of the above material is shown for reference and matching purposes for the absorption coefficients of the actual materials to be used.
2. Absorption coefficient of the actual material to be used should not be less than the absorption coefficient used in this test.

Saudi Arabia Railway
Multi-Purpose Hall

Absorption Coefficient for 1/2" Gypsum Board

Note :
1. The absorption coefficient of the above material is shown for reference and matching purposes for the absorption coefficients of the actual materials to be used.
2. Absorption coefficient of the actual material to be used should not be less than the absorption coefficient used in this test.

rh RENKUS-HEINZ   ADVANCING SOUND.PROVIDING SOLUTIONS.