Multimedia Room Acoustical Design

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Abstract – *The room acoustics for multimedia room is complex problem which has to be take in consideration while designing the one. It consists of several parts, like analysing and calculating of acoustical parameters, measuring the real condition, simulating on computer, finding the caouse and giving the solution for possible problems. Calculating and measurnig methods, as well as their results, are analised and shown in this paper. At the end some proposals to obtain better conditions are given. Finaly, the simulation with proposed actions was made, to find out if those proposals solved the problem found out in the real room*

Key words – *Multimedia Room, Acoustical Design, Reverberation Time*

1. INTRODUCTION

Room acoustics is a characteristic of a room where within that space sound is well transferred and well received (heard) according to the type of sound (speech or music) and purpose (listening or recording). The development of acoustics (acoustics science), and especially its subdisciplines, architectural acoustics, is base of defining objective parameters of acoustic quality of a room and in finding methods for their measurement and establishment of their interdependency with subjective parameters of room acoustic quality which were obtained through subjective testing.

The traditional task of room acoustics was to ensure and form conditions which will enable better acoustic transfer from the sound source to the listener. Objective parameters of room acoustics quality are determined by the possibility of finding objective methods of measurements. The parameters that determine the acoustic quality of a room are: reverberation time, time of early decay of sound energy, room constant, room radius, clarity, mean time, definition, relationship between the reflected and direct energy, support, relative level or power index, occasional diffusion, the assessed signal/noise ration, loss of consonant articulation, speech transfer index, the ratio of useful and harmful sound, fraction of lateral energy, interaural coefficient of cross correlation, direction index and the time of initial delay [2].

All measurable parameters of room acoustic quality which are interrelated in some way due to the fact that they have basic characteristics of sound waves are mentioned here. It is not necessary to measure and use all parameters, but it must be known that they have the influence.

Those which can be measured and those that give us reliable information even with subjective parameters on the acoustics of the room being tested should be selected. The obtained results will help to take appropriate actions which will improve the acoustic quality of a particular area.

Subjective parameters for acoustic room quality depend on whether we are referring to speech or music. When determining the acoustic quality of a room with respect to speech the subjective parameters is intelligibility. Subjective parameters for acoustic quality of a room are: loudness, definition or clarity, reproduction of high frequencies or brilliance, reproduction of low frequencies or fullness, sparkle, the sound source localization, intimacy or closeness, echo, noise level, reverberation, tone reproduction, intelligibility of speech, spectral equality, dynamics, area of soundness and transient response, deformities, equal distribution of sound pressure, reproduction of ambiance, impression of space, diffusion, resonance audibility and entire acoustic impression.

As we said, the room acoustic quality is determined with more objective and subjective parameters. The purpose of a room/hall is also very important. Very often there is the case when architectural specificity have bad influence on its acoustical properties. Therefore, design of the room/hall with good acoustical properties is many times the art to find the compromise between acoustical and architectural requirements.

Very similar situation is with multimedia rooms and classrooms, where the same room is used for several different purposes.

2. CALCULATION, MEASURING AND SIMULATION

In this paper we took in consideration and all tests, calculations and measurements were taken in the real multimedia room placed on the Faculty of Electrical Engineering and Computing, Department. of Electroacoustics. Since this is multimedial room, both requirements for good acoustic quality for speech and music have to be satisfied.

2.1. Room acoustic parameters calculation

First of all, reverberation time was calculated in two ways, according to Sabine [1]:

$$T = \frac{0{,}161V}{A}, \quad A = \alpha_1 S_1 + \alpha_2 S_2 + \ldots + \alpha_n S_n \qquad (1)$$

where the volume is calculated from measured room dimension: 6,68x7,23x3,2m (length, width, hight), giving 154,55 m3. This volume is decreased for the volume of bookcases and other furniture in the room, the adjusted volume is given as 151,42 m3. This is the value which is used in all calculations.

Table 1. Reverberation time according to Sabine for empty room

f	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
T [s]	1,06	1,42	1,16	1,14	1,01	1,05

If we take in the account the apsorbtion of listeners (people), instead of empty chairs, for the full room the following results are acquired.

Table 2. Reverberation time according to Sabine for full room

f	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
T [s]	0,96	1,24	1,01	1	0,89	0,92

The relationship between empty and full room, and the optimum (wanted) results are shown on the Fig. 2.

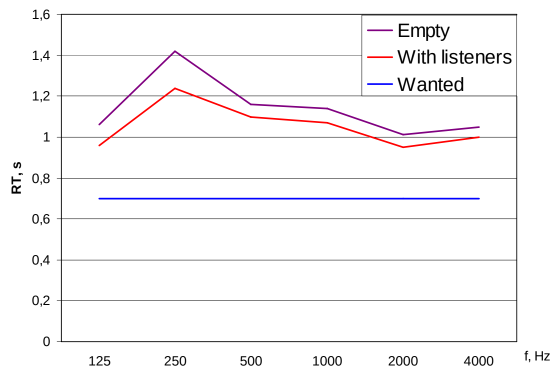

Fig. 1. Reverberation time according to Sabine

When Eyring formula is used, the following results are obtained:

Table 3. Reverberation time according to Eyring for empty room

f	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
T [s]	0,96	1,56	1,1	1,07	0,95	1

Table 4. Reverberation time according to Eyring for full room

f	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
T [s]	0,83	1,21	1,06	0,95	0,82	0,94

Resonant frequencies of the room were calculated according to equation [1]:

$$f = \frac{c}{2} \cdot \sqrt{\frac{p^2}{A^2} + \frac{q^2}{B^2} + \frac{r^2}{C^2}} \qquad (2)$$

When we take values for p, q, r as 0,1 and 2, the obtained frequencies are shown in the Table 5.

Table 5. Resonant frequencies

pqr	010	100	110	020	200	001
Mod [Hz]	23,6	25,4	34,6	47,2	50,7	53

pqr	120	210	011	101	111	220
Mod [Hz]	53,6	56	58,1	58,9	63,4	69,3

pqr	021	201	002	012	102
Mod [Hz]	71	73,5	106,3	108,8	109,2

2.2 Room acoustic parameters measuring

The reverberation time measuring was made with Brüel&Kjær instrument on 6 positions in the room.

Table 6. Measured reverberation time

Freq. [Hz]	Position				
	1	2	3	4	5
62,5	1.14	1.44	1.24	1.22	1.33
125	1.32	1.50	1.37	1.22	1.54
250	1.67	1.55	1.62	1.59	1.67
500	1.50	1.55	1.48	1.57	1.56
1000	1.40	1.38	1.38	1.35	1.36
2000	0.99	1.18	1.14	1.14	1.17
4000	0.89	0.82	0.85	0.83	0.83
8000	0.67	0.63	0.99	0.64	0.65

Sound pressure level distribution was measured in 30 measuring points with 6x5 matrix

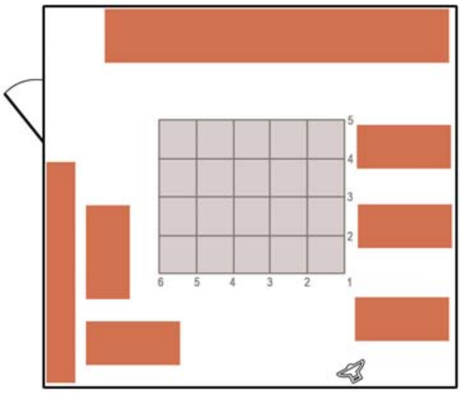

Fig. 2. SPL distribution measuring points

Table 7. SPL distribution

Pos.	31.5 Hz	63 Hz	125 Hz
(1,1)	63.5	80.0	77.5
(1,2)	64.5	82.0	81.0
(1,3)	64.5	82.5	66.0
(1,4)	64.0	80.5	79.0
(1,5)	64.0	78.0	83.0
(2,1)	63.0	71.0	78.0
(2,2)	63.0	74.0	74.0
(2,3)	62.0	78.0	73.0
(2,4)	61.0	79.0	75.0
(2,5)	58.0	77.5	79.0
(3,1)	63.0	79.0	74.5
(3,2)	61.0	74.0	72.0
(3,3)	58.0	65.0	71.0
(3,4)	54.0	74.5	74.0
(3,5)	51.0	76.0	73.0
(4,1)	63.5	83.5	70.5
(4,2)	53.0	78.5	74.5
(4,3)	49.0	74.0	76.0
(4,4)	52.0	75.0	73.0
(4,5)	61.5	76.5	70.0
(5,1)	67.0	84.5	70.0
(5,2)	62.0	79.5	73.0
(5,3)	64.0	75.5	74.0
(5,4)	68.0	77.5	73.0
(5,5)	67.0	77.0	73.0
(6,1)	65.5	80.0	71.0
(6,2)	58.5	79.5	62.0
(6,3)	56.5	77.5	70.0
(6,4)	65.0	79.0	75.5
(6,5)	68.5	83.0	77.0

Further on, the SPL vs. Freq. is measured in one point near the center of the room, and obtained results are shown on the Fig. 4. We can see that those results are coresponding very good to calculated values of resonant frequencies of the room.

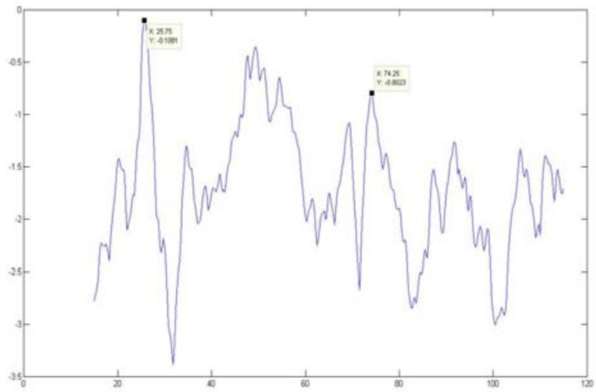

Fig. 3. SPL vs. Frequency distribution

2.3 Room acoustic parameters simulating

First of all, we simulated the present situation in multimedia room with PC program Ease 4.1.

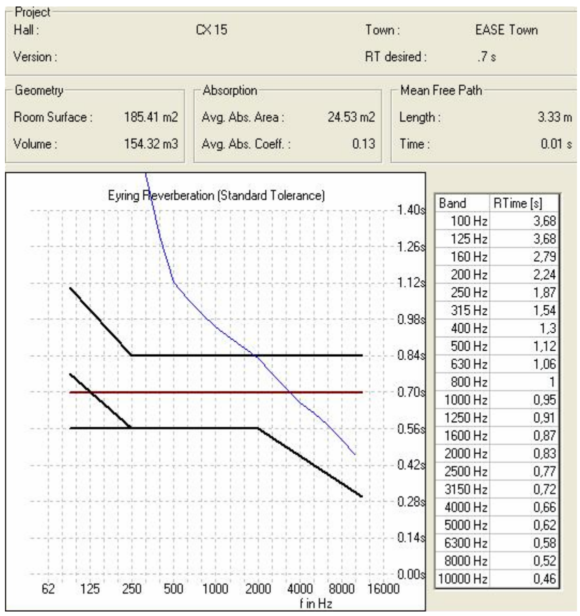

Fig. 4. Simulated acoustics parameters

Obtained results are in some way as expected. According to this simulation, reverberation time is acceptable for the frequency range over 2 kHz, but it is much more then desired 0.7 s in the frequency range below 500 Hz.

3. ACOUSTIC IMPROVEMENT OF MULTIMEDIA ROOM

Since we can see that one of the most important and most used acoustic parameter – reverberation time is not suitable for multimedia room, in this case, calculations were made, and the results was that at least 15 m2 of additional apsorbtion/diffusion material has to be applied in the MM room.

In this case, reverberation time in the room would be as follows:

Table 8. Reverberation time according to Eyring for empty room

f	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
T [s]	1,01	1,34	0,70	0,51	0,41	0,40

Table 9. Reverberation time according to Eyring for empty room

f	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
T [s]	0,87	1,08	0,60	0,43	0,34	0,35

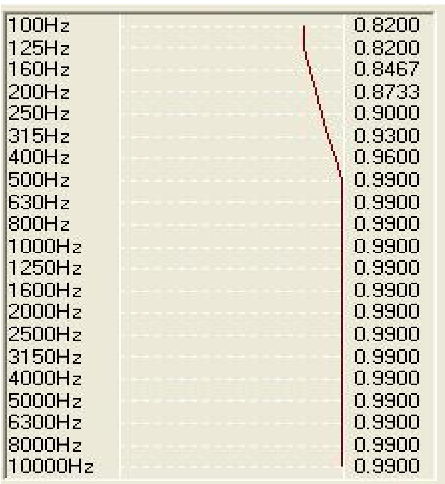

Fig. 5. The characteristics of proposed additional material to be applied in the MM room

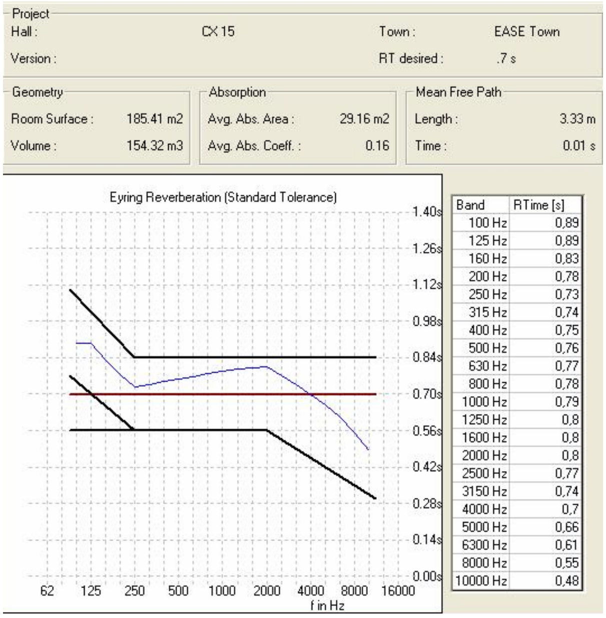

Fig. 6. Simulated acoustics parameters with additional apsorbtion material

4. CONCLUSION

In this article we can see good compliance between theoretical results obtained by calculations and simulation and practically obtained measured results. That confirm that all methods and parameters were set up good, and that only in this case we can be shure that simulated results will be useful in the practice.

Further on, presented procedure of the acoustical design of multimedia room, which includes analysis, calculation, simulation and measurement shows the need of professional approach and supervision of the performance of all multimedia rooms, considering their ever growing usage for many purposes.

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