Methodology to evaluate acoustic performance in educational spaces by Different Methods

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Abstract: Different methodologies used to evaluate acoustic performancein in educational lecture hall. Theses technical methods have been used in order to define the acoustic problems in lecture hall and suggest acoustic and architecture treatments to solve these acoustic problems. The methods that used for acoustic analysis were Sabin, Eyring, Arau-puchades and ODEON. This paper is foucing on acoustic performance in lecture hall 2 in Tanta Engineering. Acoustic study has been done for lecture hall as follows: Evaluation the acoustic performance by field measurements for reverberation time**,** manual calculation and acoustic simulation; ODEON software. Different acoustic performance analysis was performed. Different acoustic and architecture treatments were suggested based on the analysis. The final results of room acoustics of different cases carried on the hall were compered to the international requirements for educational spaces. The main problems based on the acoustic analysis are the increase of hall height, architecture design of ceiling and hard covering of the internal surfaces

Keywords: ODEON, Acoustic Performance, Reverberation Time, Acoustic Treatments, Acoustic simulation, ODEON, field measurments.

1. INTRODUCTION

Acoustic measuring and simulation are very important to determine acoustic performance and acoustic comfort in spaces.Computer simulations to predict acoustical parameters have been attracting renewed interest in recent years. New technologies for acoustic simulations and measurements have been developed, and it is now possible to predict and measure the acoustics of a room with good accuracy[i].

There are many acoustic software programs in room we will use ODEON because, it cares acoustic side only in first step. It gives complete impression of acoustic performance in space, and results are given out in both graphical representations and tables. It gives most important criteria in space acoustics are usually reverberation time (RT) by (Sabin, Eyring and Arau-puchades) and speech transmission index (STI), early reflection in room (C50), sound pressure level (SPL), sound transmission class (STC) in this study we will foucse on RT[ii].

Acoustic measurements are the obvious prerequisite of acoustic investigations; they are an important tool for the analysis of acoustical problems. Acoustics of educational spaces (classrooms, lecture halls or speech rooms and auditoria) engross the attention of the researchers in this field in the past years. Thus, researches in this field has been going n over the years with the aim of enhancement acoustic performance in educational spaces in universities through studying the most important factors affecting the acoustics performance in educational spaces is relation between RT and space hall. We will calculate RT for one of education spaces by manual equation, field measurement, and simulation by software, and compare final results of reverberation time (RT) with RT require for educational spaces[iii].

We scope this study on main lecture hall 2 in engineering faculty, Tanta University, it located in ground floor of college building (Workshop building), Engineering faculty, Sebrbay colleges' campus, next to Workshop spaces and main quad it`s known Eadady Modarg figure (1).

1. Preparatory Building, Department of Electrical powers And Administration
2. Architecture Department and Administration
3. Library , Mechanical Power Department, Math And Physics Department
4. Building and Construction Building
5. Civil Department
6. Workshops
7. Lecture hall 1&2 (Case study)
8. Main arene.
9. Green Area.

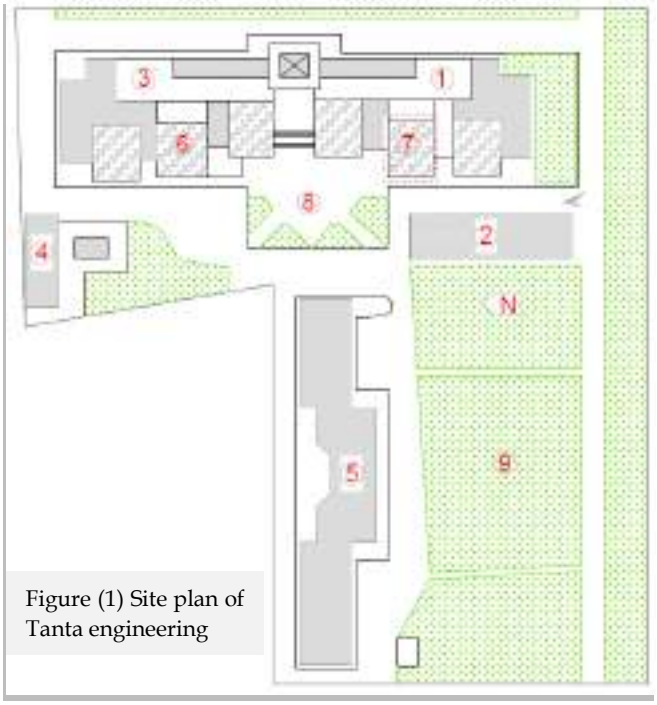


Figure (1) Site plan of Tanta engineering

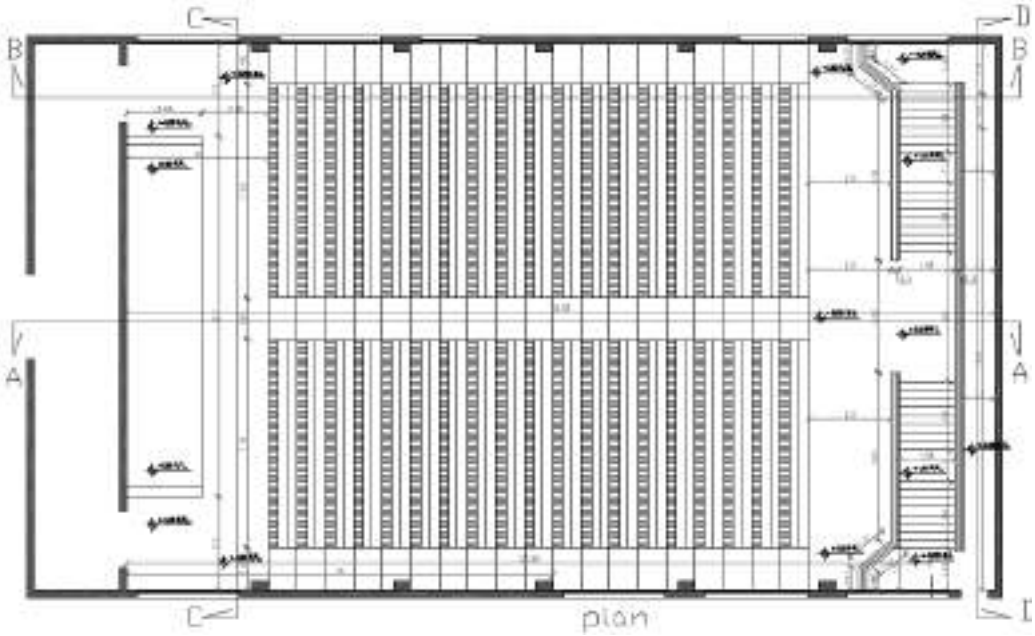
Table (1) Description of Lecture hall 2

Dimensions

L	W	H	Area m^2	Volume m^3
29.7 **m**	19.3 m	10.6 **m**	573.2	6076

Statistical Data

Desks 19 wooden row, with 1m (W), 1m (H), 10 cm the row higher from row previous.
Stage, concrete, 2.65m (W), 13.10 (L), The distance to first row 2.35 m **.**
Hall is divided into 6 modules, width of each about 5m.
Interior surface are covered up with hard finishing, ceiling has skylight in each hall.
Sound system, amplifier, microphone and 8 loudspeakers, 4 at each side



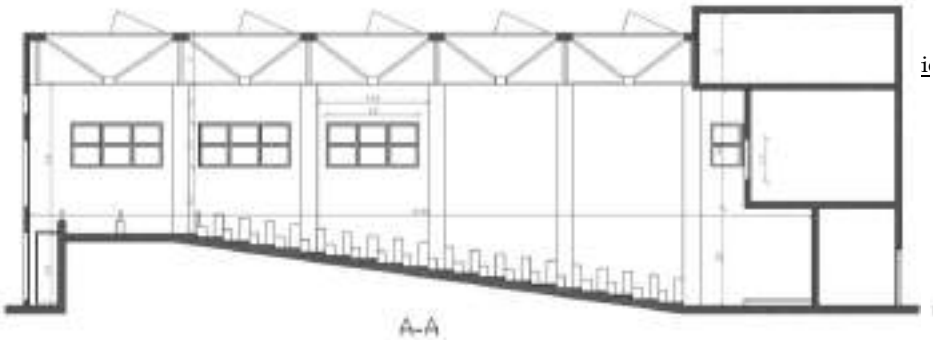


Fig (4) Elevation of side wall

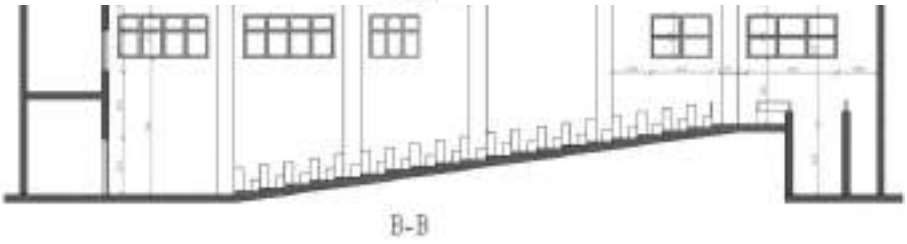


Fig (5) Elevation of side wall

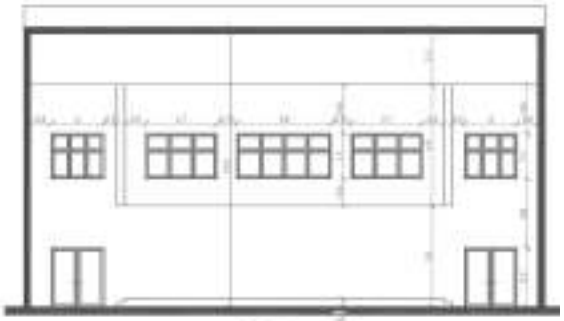


Fig (6) Elevation of front wall

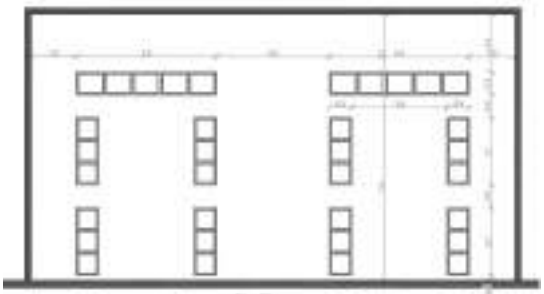


Fig (7) Elevation of rear wall

2- Methodology

a- Selection case study.
b- Architecture describe for case study.
c- Calculate requirement RT for case study by equation.
d- Done field measurement by devices in case study.
e- Evaluation basic case from field measurement results.
f- Entering architecture data for case study in acoustic software simulation.
g- Done acoustic simulation for case study model.
h- Evaluation basic case from acoustic software simulation results.
i- Calabrat acoustic software program and compare RT results by manual equation, field measurement, and acoustic program simulation.
j- Determin acoustic problems in case study.
k- Suggestion acoustic and architecture treatments

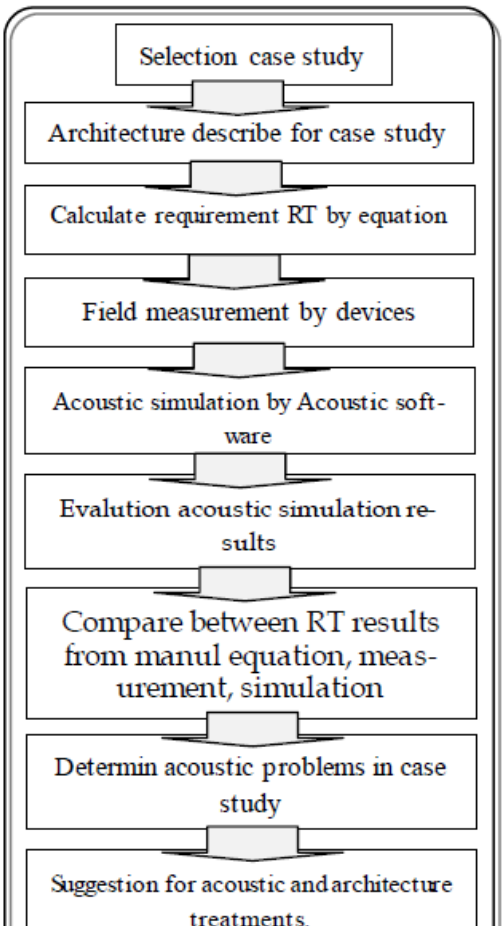


Figure (8) AcousticEvalution Methodology for space

2.1. RT by Manual equation

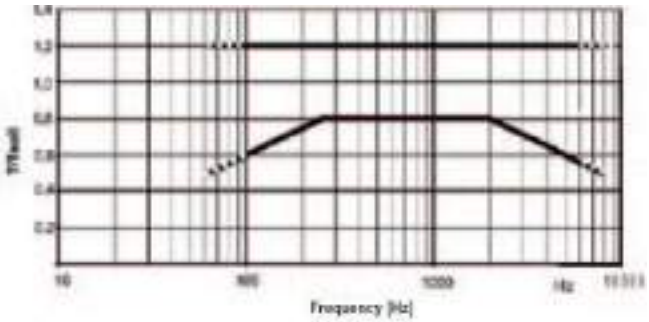
In previous paragraph we selected case study and architecture describe then determine requirement reverberation time for hall from equation

TR= [0.32 * lg (V) – 0.17]s , , (V) space size,

Whereas TR depends on space volume, required reverberation time is based on furnished occupied areas. When unoccupied TR, should no more than 0.2 s over required time. (Vary 20% in frequency range 250 Hz to 2000 Hz).the figure shown chart of Requirement reverberation time range for speech spaces[4].

Table (2) for RT require values at differnat frequency

	125 HZ	250 HZ	500 HZ	1000	2000	4000	8000
RT requirement	1.48	1.05	1	1	1	1	1



The frequency depending RT (Reverberation Time) range for speech.

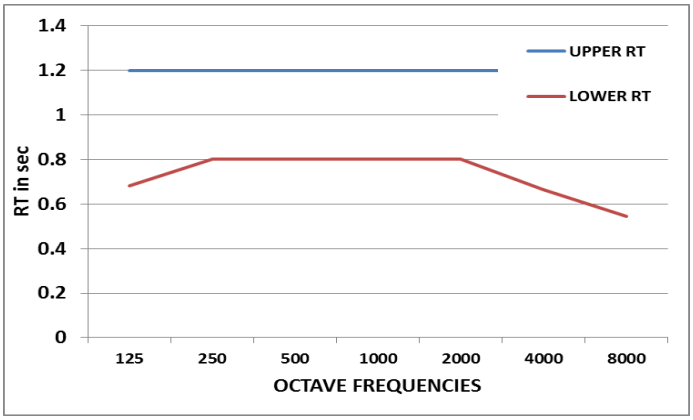


Fig (9) Chart of RT require for hall (case study) Range (0.6-1.2)

2.2. RT by Field measurement for basic case

Acoustic measurements are main prerequisite of acoustic investigations. In this research measurements depend on reverberation time measured, it is done through following**:**

1- **Used Devices:** there are a lot of types of acoustic measuring equipment but in this research we use Hand-held Analyzer Type 2270 (B&K) is use with connection of condenser microphone type 4189 (B&K) and omnidirectional loudspeaker type 4292 (B&K) with power amplifier 2716 (B&K). Using the reverberation time Software BZ-7227.

2- **Work Method:** analyzer generates noise test signal and excites the space of the room through third octave filtered noise signal figure (11). The reverberation time measured in different points through the room at the seating area figure (10). The reverberation time measured using white or pink noise at 1/3 octave band from 125 to 8000 Hz. And calculate the average reverberation time for measurements in space.

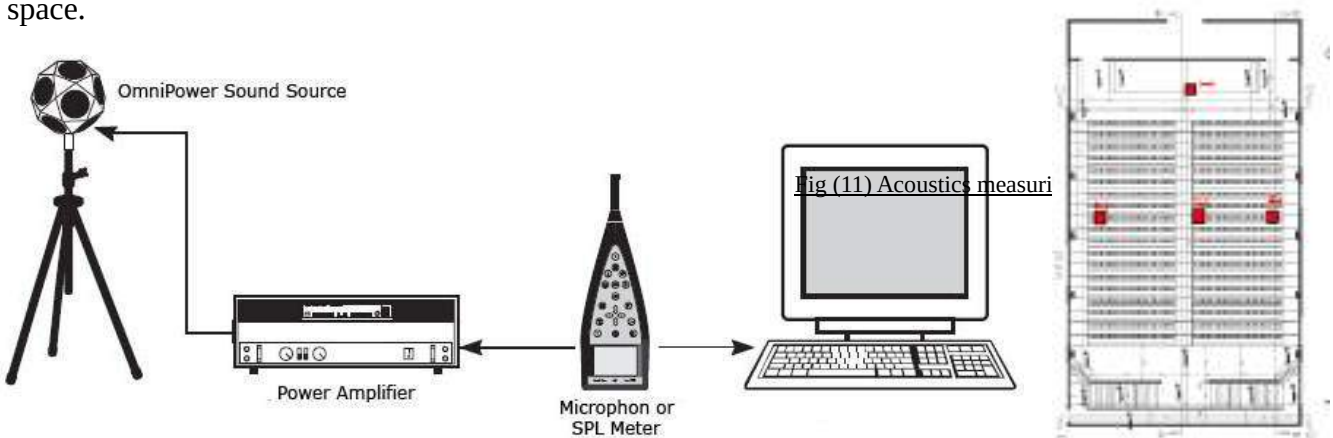


Fig (11) Acoustics measuri

Freq.HZ	point 1	point 2	Point 3	Point 4
125	3.44	3.64	4.75	3.4
250	4.44	3.76	3.66	3.11
500	6.58	4.36	3.98	3.8
1000	7.08	4.31	4.8	4.17
2000	3.8	3.63	3.59	3.26
4000	2.32	2.83	2.34	2.34
8000	1.4	1.33	1.24	1.31

Fig (10) Points for Reverbera-tion Measurements in hall

2.2.1. Results of field measurements

Table (3) Reverberation time measurements at 4 points in hall

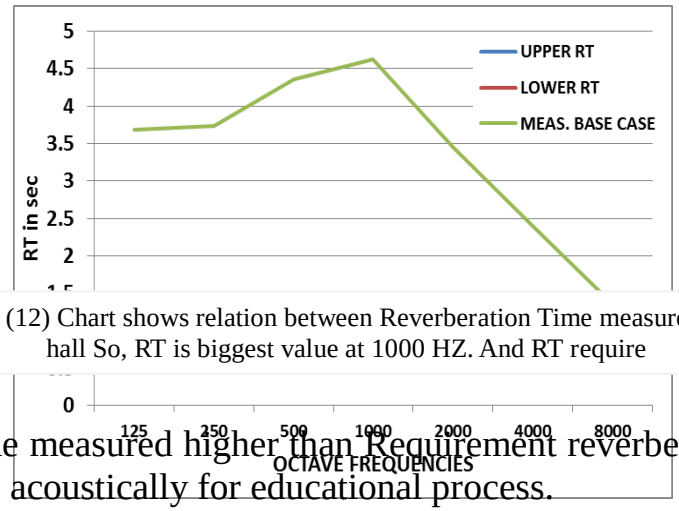


Fig (12) Chart shows relation between Reverberation Time measured in hall So, RT is biggest value at 1000 HZ. And RT require

From chart at figure (12) Reverberation time measured higher than Requirement reverberation time range for hall, thus the hall is unsuitable acoustically for educational process.

2.2. **RT by Computer software simulation for basic case**

We evaluate basic case acoustically by ODEON software version 9.2, and calibrate program, acoustic simulation at 3 point in different places, this is through several stages:

1- ODEON software
2- Create hall model and entering acoustic data
3- Simulation for hall acoustic performance
4- Results
5- Calibrate

2.3.1. Results of acoustic hall (BASICE CASE) by ODEON At receives 1, 2, 3

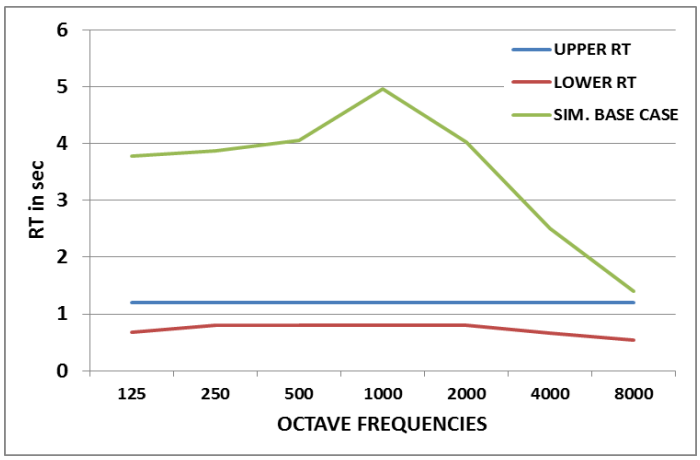
- Table (4) shown results of acoustic parameters RT

T30(s)sim

Rec. no.	63	125	250	Average 500	1000	2000	4000	8000
1	3.33	3.4	3.5	3.77	4.93	3.78	2.56	1.6
2	3.61	3.89	4.13	4.29	5.05	4.35	2.33	1.19
3	4	4.07	3.98	4.13	4.93	3.95	2.62	1.4

T30(s)	**63Hz**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
	3.65	3.78	3.87	4.06	4.97	4.03	2.5	1.4

- Table (5) shown results average of acoustic parameters



From chart figure (13) Reverberation time simulated higher than Requirement reverberation time range for hall, thus the hall is unsuitable acoustically for educational process.

Fig (13) Chart shows relation between Reverberation Time simulted in hall so; RT is biggest value at 1000 HZ. And RT require

2.3. R T by Sabin, Eyring, Arau-puchades

From figure (14) RT is higher than Requirement reverberation time range for hall

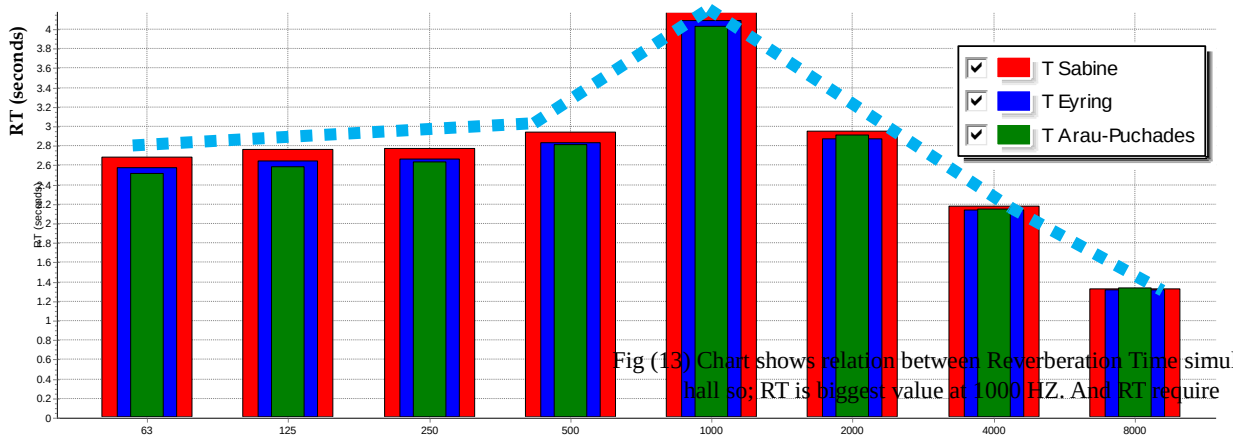


Fig (13) Chart shows relation between Reverberation Time simulted in hall so; RT is biggest value at 1000 HZ. And RT require

Figure (14) shows RT by Sabin, Eyring, Arau-puchades

From chart figure (13) Reverberation time simulated higher than Requirement reverberation time range for hall, thus the hall is unsuitable acoustically for educational process.

Final results through compare between RT require & RT measure & RT simulation.

- Table (6) shows RT values (requirement, measurement, simulation)

	125 HZ	250 HZ	500 HZ	1000	2000	4000	8000
RT requirement	1.48	1.05	1	1	1	1	1
RT average (Measuring)	3.68	3.73	4.36	4.62	3.46	2.4	1.36
RT average (Simulation)	3.78	3.87	4.06	4.97	4.03	2.5	1.4

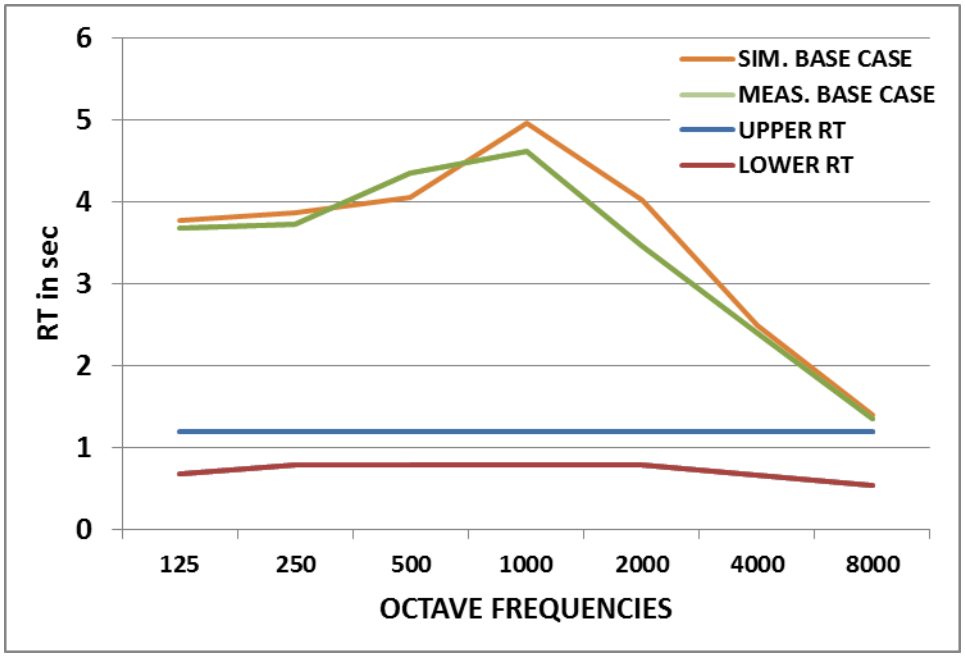


Fig (15) Chart shows relation between RT values for (requirement, measurement, and simulation)

From chart in figure (15)

- There is no high difference between RT mea & RT sim, thus the program was calibrated,
- RTmeasure & RTsimulate are higher than RTrequire.
- The hall is acoustically unsutable and has acoustic problems.
- The hall needs acoustic and architecture treatments to solve acoustic problems and enhancement acoustic performance in it..

3. Conclution

Methodology to evaluate acoustic performance in universities`educational spaces and selecation acoustic problems to suggeste acoustic and architecture treatments to solve this determined problems.

4. Acknowledgement

I`m thankful to alla then my doctors, Pro. Dr. Ahmed Rizk, Pro.Dr. Huda sideak, Dr. Hosny Dewar, Dr. Mahmud Abd-Alrazikfor for supporting and helping me.

5.Referances

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