



THE ACOUSTICS OF A MULTIPURPOSE CULTURAL HALL

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ABSTRACT

The acoustical characteristics of hall depend primarily on this size (volume, capacity, shape of the various surfaces type of upholstery employed gradient of the floor, design of the stage and other materials used. The acoustic of multipurpose cultural spaces require considerable thought in arriving at optimal acoustics. More specifically Reverberation quality of the hall is significantly important. An acoustical study of the hall with a capacity of 766 has been discussed in this paper which includes both experimental and simulated studies. From the history of the hall it has been gathered that a large number of seminars, meeting and cultural programmes have been conducted. They are found to be successful.

Key words: Acoustics, ODEON, simulated.

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1. INTRODUCTION

The study of Acoustical characteristics of a hall either before or after construction are very important. In this particular paper s case study describing the architectural features of a multipurpose hall which is used for lectures ,musical performances ,and other cultural events has been chosen. Asimulation study Using Odeon software followed by experimental results have been highlighted. The acoustical characteristics of a hall depend on cubic volume, interior shape, density of materials and on surfaces and size, spacing and number of the chairs, carpets or other sound absorbing materials. The acoustical quantity that can be measured fundamentally is the reverberation time (Ref1).The auditorium chosen for the study has seating capacity of 766.In this paper, the acoustical quality of the hall evaluated through simulation studies and experiments conducted subsequently have been discussed. A fully air conditioned auditorium rated as one of the best auditoriums with excellent acoustics and

spacious seating arrangements. Several cultural, educational and social organizations in and around Chennai patronize the hall to conduct seminars, meetings and cultural programs.

2. ARCHITECTURAL FEATURES

The auditorium is fan shaped, the main hall is 533 sq.m and the stage is 267sq.m(Fig 1).A fully air conditioned auditorium with spacious seating arrangements, ensuring comfortable access to seats inside the auditorium without causing inconvenience to other occupants. The upper ceiling is circular plan in the center with sound reflecting panels. The side walls are treated with fiber wool and the flooring is treated with wood. The balcony is accessed through the first floor with two main doors. With sufficiently large foyer in the front and spacious verandas on both sides of the auditorium.

3. ACOUSTICAL MATERIALS

Ceiling: Plaster over concrete planks.

Walls: Treated with fiber wool materials.

Carpets: On aisles of main hall and balcony directly affixed to concrete.

Stage side walls: Wooden planking about 1mm thick from the stage floor up to height 10m.

Stage floor: Wood.

Stage height: 0.75m

Seating: Backrest is 12cm thick molded plywood. Top of seat bottom and front of backrest are upholstered, porous fabric over open cell foam. Armrests are wooden.



Figure 1 Plan of Tapovan Hall

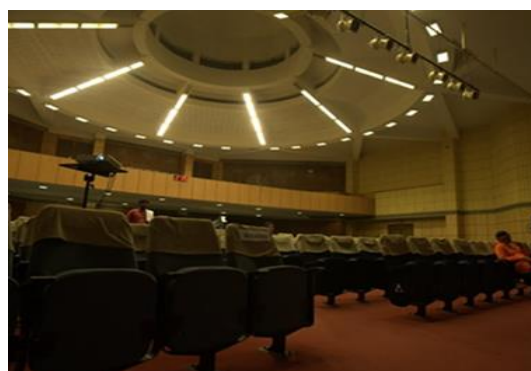


Figure 2 View of Tapovan Hall

4. ACOUSTICAL MEASUREMENTS

Reverberation time measurements have been made in the hall (unoccupied) at different locations; using the instrument Nor sonic Sound Level Meter (Nor 132).

Table 1

LOCATION	RT VALUES (sec)					
	250	500	1000	2000	4000	8000
1	1.11	1.99	1.80	1.99	1.90	1.72
2	1.51	1.61	1.69	1.68	1.73	1.53
3	1.35	1.99	1.85	1.11	1.02	0.81
4	1.68	1.23	0.93	0.99	0.87	0.67
5	1.08	1.67	1.61	1.69	1.525	1.39
6	1.52	1.66	0.94	1	0.94	0.6

5. SIMULATION MODEL USING ODEON –ACOUSTIC SIMULATION SOFTWARE

Modeling of the auditorium has been done using ODEON acoustic simulation software to evolve the various objective parameters. The modeling involves the following steps.

5.1. Constructing the Model

3D room geometries can be modeled and imported using google sketch up, Bim software and CAD programs in the DXF format.

5.2. Prediction

The 3D model is exported to the ODEON. Sources on the stage have been modeled as point source (Fig 3). The sources can be assigned described the properties of directivity pattern, gain, equalization and delay, allowing the definition of natural sound sources as well as loudspeaker systems. The software has a list of common sources to choose from and also supports the common loudspeaker format. Materials are selected and identified with the absorption coefficients from 63 to 8000 Hz and a scattering coefficient. To ensure that calculations results are reliable, it is essential that geometries are consistent and the software includes a number of tools for geometry verification. The ray tracing display can also be used in the verification of room geometry as the ‘3D Billiards’(Fig 4)

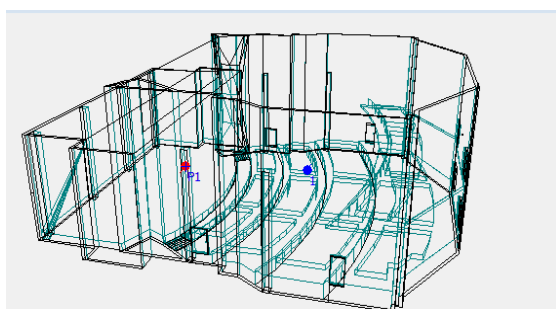


Figure 3 3D Sources and receivers of the auditorium in ODEON

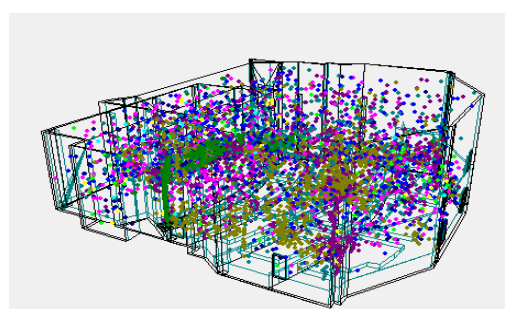


Figure 4 3D Billiards

The source is on the stage at a height of 2.6m from the edge of the proscenium with 1 receiver location computed using room geometry. For large halls, sound pressure level is 65-70 dB (A) at listener ears where in the SPL arrived is 66 dB which means the sound will reach the audience symmetrically.

6. RESULTS AND DISCUSSIONS

The objective parameters evaluated are discussed further. The table 2 shows the acoustical measures intended for audience seats in the hall for performances. The measured and simulated value of the halls unoccupied is discussed with values of the acceptable range.

Table 2 The summary of Audience parameters from ISO 3382-1.(Ref 4)

Type of Measure	Measures	Notes
Decay Times	T 60, reverberation time	Physically important
	EDT , early decay time	Subjectively important
Clarity Measures	D 50 Definition C 80 Clarity STI Speech Transmission Index RASTI Rapid Speech Transmission Index	Clarity of speech
Spatial Impression	LF, Lateral Fraction. Articulation Index	Apparent source width

6.1. Reverberation Time

Reverberation time (RT) is the time required for sound to decay 60dB, whereas early decay time (EDT) refers to the early part of the first 10dB of the sound decay. The preferred value is 1.3s to 1.6 s for good auditorium (Ref 3). The RT and EDT value generally range between 1s to 1.8s (Fig 5 & 6). The hall has greater value in mid frequency and lower value in higher frequency value. The field measurements showed that the finishing materials used resulted in fulfilled attaining optimum reverberation time. It is observed that the measured and simulated RT values have better agreement (Ref 2). This indicates that the decay is completely linear and the hall has attained a satisfactory diffuse sound field.

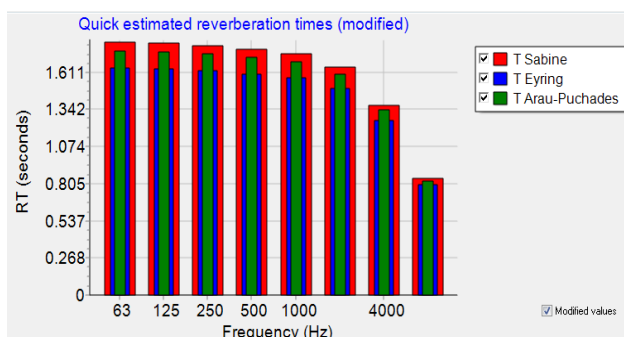


Figure 5 Graph showing RT values.

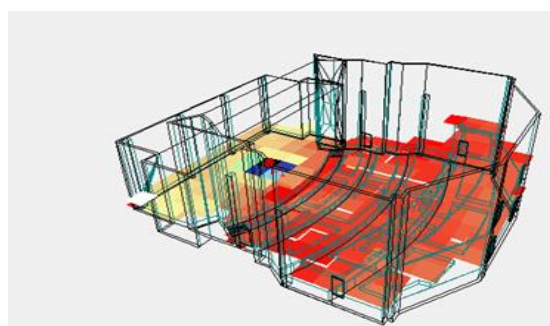


Figure 6 Calculated EDT Mapping

6.2. Definition

Definition (D₅₀) is the ratio of early to total sound energy. The early sound is the direct sound and the energy that arrives within 50 m sec after the direct sound is the remaining reflected energy. From the above equation D₅₀ is

$$D_{50} = \frac{1 + (r_h/r)^2 - e^{-0.69/r}}{1 + (r_h/r)^2}$$

r = source to receiver distance, r_h = reverberation distance. The desirable D50 value is 0.7 where the associated value is 0.31 at 500 Hz is low.

C. CLARITY:

$$C_{80} = 10 \log_{10} \left(\frac{\int_{t=0}^{t=80ms} p^2(t) dt}{\int_{t=0}^{t=\alpha} p^2(t) dt - \int_{t=0}^{t=80ms} p^2(t) dt} \right) dB$$

For Symphony halls with lower clarity are judged to be the best. (Acceptable values are -1dB to -4dB). At higher and mid frequencies, the relatively more reverberant hall has lesser C80 value. Here clarity is -2 which is within the desirable range (Fig 7).

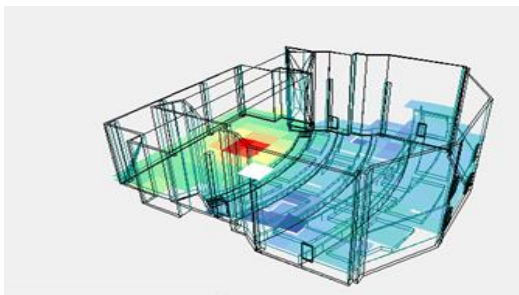


Figure 7 Calculated Clarity Mapping

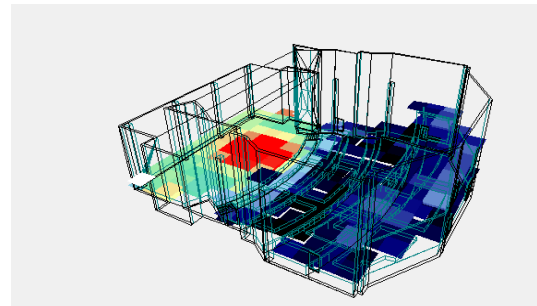


Figure 8 Calculated STI Mapping

6.3. RASTI

RASTI is objective way of the speech intelligibility. The associated RASTI value is 0.5 whereas the expected is 0.75 which is fair with EDT.

6.4. Articulation Index

Articulation Index is a measure of Speech intelligibility influenced by acoustical environment rated from 0 to 1 (Ref 3). The higher the number the higher the intelligibility of words and sentences understood from 0-10%. The estimated AI is 1 within the desirable value so the words are clear (Fig 9).

6.5. Lateral Energy Fraction

Lateral Energy Fraction is the ratio of lateral energy received by a figure of eight microphone to the lateral energy measured by an Omni-directional microphone.

$$LF = \frac{\int_0^{0.08} p_{l2}(t) dt}{\int_0^{0.08} p^2(t) dt}$$

Where Pl(t) is the lateral response from the figure of eight microphones. LEF is related to the subjective sense of spatial impression or envelopment and is inversely related to the width of the hall. The desirable good range is 0.07 < LF80 < 0.2 (Ref 4). The associated value is 0.3 is good (Fig 10).

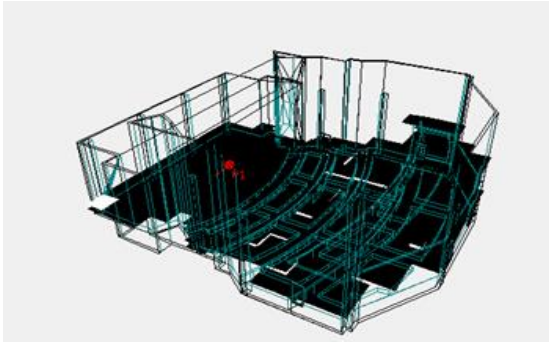


Figure 9 Calculated AI Mapping

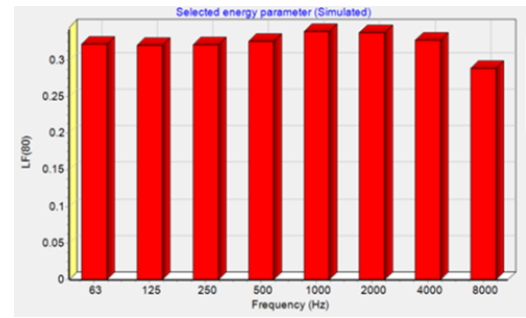


Figure 10 Graph showing LF values

7. CONCLUSIONS

1. The ODEON Acoustic Simulation Software have proved to be a useful tool for predicting the objective parameters in this hall.
2. The values of RT, EDT within this hall ensures the uniform acoustic conditions in the hall.
3. STI and RASTI are lower in this hall indicates the quality of sound is less.
4. It is observed that the measured and simulated RT values have better agreement. This indicates that the decay is completely linear and the hall has attained a satisfactory diffuse sound field. The acoustical parameters and the materials used have resulted in deciding the acoustical quality of the hall.

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