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ZARAGOZA'89 ENVIRONMENTAL ACOUSTICS

8º SYMPOSIUM FASE'89
«ACUSTICA AMBIENTAL»
Zaragoza, Abril 1989

ACOUSTICAL CHARACTERIZATION OF A THEATRE BY INTENSITY METHODS

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INTRODUCTION

We present the acoustical characterization of a theatre based on the measurements of the sound intensity vector. Essentially this kind of technique, differs from the traditional one (characterization by reverberation time) because of the steady state conditions of the sound field in which measurements are carried out. Precisely, let consider a system consisting of a stationary noise source at a point r_o radiating $n(\tau)$ noise into a concert hall and transducers for measurements. If $h(t)$ is the impulse response of the system, then the signal received at a receiving point r is expressed by

$$s(t)=\int_{-T}^{o} n(\tau)h(t-\tau)d\tau .$$

Suppose now to make acoustical measurements at the time $\tau=0$. If sound intensity tests are carried out, the correct condition in the above formula is $\langle n(\tau)\rangle=\langle n(-\tau)\rangle$ (where brakets means averaging properties of noise) while for reverberation time testing the condition becomes $n(\tau)=0$ for $\tau \geq 0$. Note that the first kind of measurement require steady state conditions while the last one typically apply to a decay phenomenon. To get the steady state condition, the noise should be radiated for a sufficiently long time $T\rightarrow\infty$.

MEASUREMENTS

a) Characterization by a power paramenter K.

In steady state conditions a reference noise source which power emission in free field is known, may be used to globally characterize the environment around it by simply measuring the power emission again within the new contour conditions for the sound field. You can in fact obtain the spectrum of the characterizing parameter K by subtracting the measured power emission from the reference one.

In our case [1] the source was placed at the centre of the stage in the Municipal Theatre of Ferrara and power emission was calculated from pressure measurements carried out over a 6 m. ray emisphere centered on the source. The basis of the emisphere covered about 90% of the full stage surface. The results of our measurements are reported in table 1.

TABLE 1.

FREQ Hz	LW(ref.) dB	LW(meas.) dB	K dB	FREQ Hz	LW(ref.) dB	LW(meas.) dB	K dB
100	74.4	77.5	3.1	1250	81.6	84.3	2.7
125	74.7	77.9	3.2	1600	81.3	82.3	1.0
160	75.7	78.9	3.2	2000	80.4	82.3	1.9
200	76.4	79.8	3.4	2500	79.1	81.9	2.8
250	76.1	80.0	3.9	3150	78.8	82.5	3.7
315	76.3	80.5	4.2	4000	77.9	81.2	3.3
400	76.2	80.5	4.3	5000	77.7	79.1	1.4
500	76.2	80.1	3.9	6300	76.3	78.0	1.7
630	76.3	81.0	4.7	8000	74.4	75.4	1.0
800	78.5	82.6	4.1	10000	72.6	72.9	0.3
1000	79.7	83.2	3.5				
Integral Value:				100-10000	91.0	94.0	3.0

b) Characterization by iso-intensity maps.

In the same steady state conditions as before, the normal component of the sound intensity vector was measured in an array of 6x10 points over the vertical plane between the stage and the hall (the proscenium plane) as shown in fig. 1a. In figs. 1a, 2a, 3a, are displayed sound intensity levels obtained for different frequencies using numerical interpolation algorithms. Each map overlaps the proscenium plane as seen from the hall. Continuous lines represent positive intensity (energy flow coming from the stage towards the hall) while the negative ones are represented by dotted lines.

CONCLUSIONS

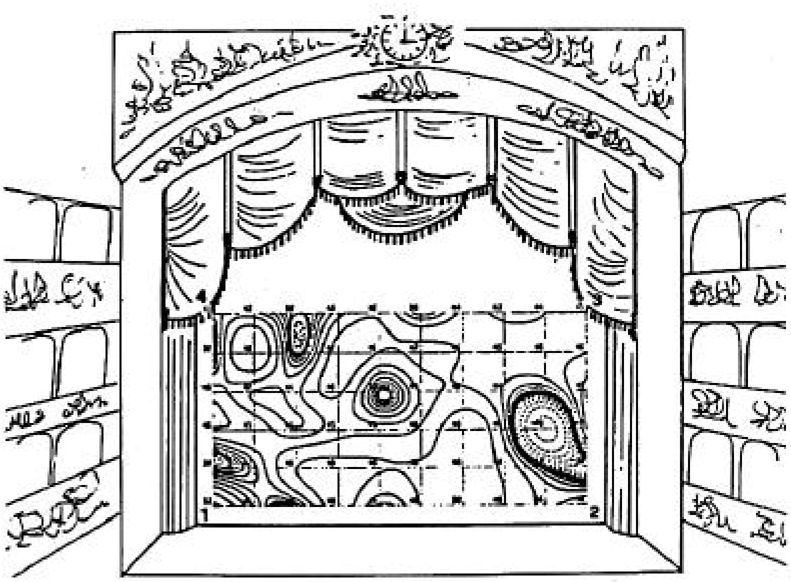
Intensity methods as objective acoustic test technique for Concert Halls result complementary to reverberation time test. This because of the steady state conditions of the sound field where intensity measurements must be carried out. The direction of the sound energy flow may be found very useful in obtaining qualitative characterization of theatres and concert halls. Iso-intensity maps over the open coupling area are specially useful in theatres where the acoustic coupling of two rooms (stage and hall) is case of interest.

BIBLIOGRAPHY:

[1] D.Stanzial, E. Carletti and I. Vecchi, "Caratterizzazione Acustica del Teatro Comunale di Ferrara", Proc. of XVI AIA Conference, 1988.

[2] Y. Ando, "Concert Hall Acoustics", Springer, Berlin 1985.

[3] L. Cremer, H. A. Müller, "Principles and Applications of Room Acoustics", Applied Science Pub., 1978.



a)

Fig. 1 - a) Iso-intensity map for 50 Hz frequency band.
b) 3-dimensional view of positive iso-levels.
c) 3-dimensional view of negative iso-levels.

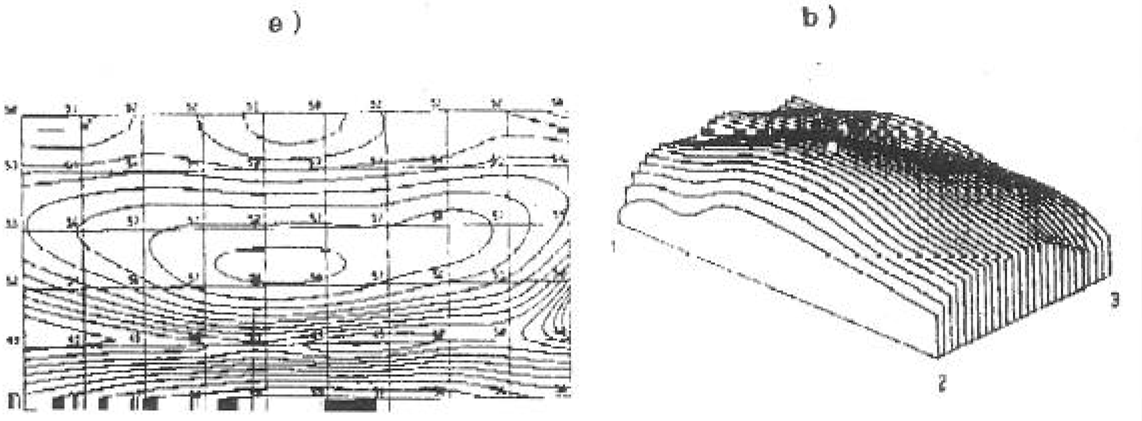


Fig. 2 - a) Iso-intensity map for 1600 Hz frequency band.
b) 3-dimensional view.

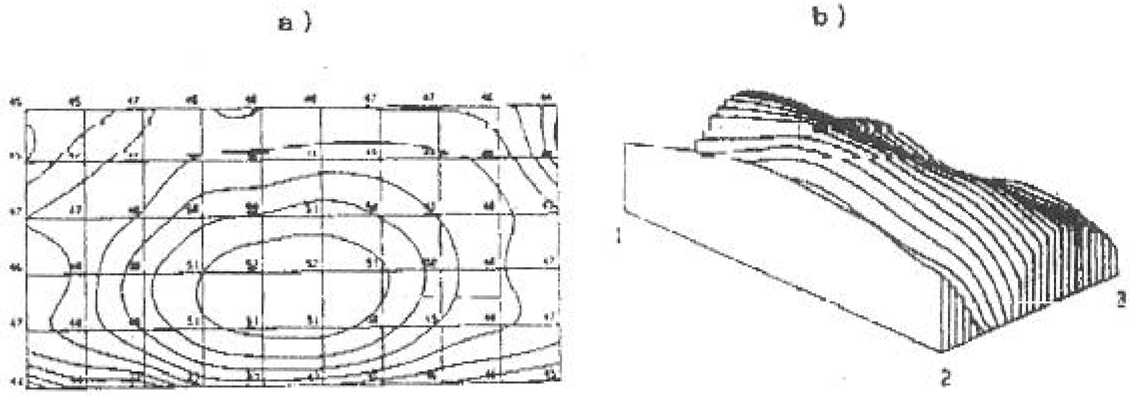


Fig. 3 - a) Iso-intensity map for 5000 Hz frequency band.
b) 3-dimensional view.