BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LIX (LXIII), Fasc. 5, 2013
Secţia
CONSTRUCŢII. ARHITECTURĂ

ADAPTING THE ACOUSTICAL PROPERTIES OF A MODERN CINEMA IN ORDER TO USE IT AS A CHAMBER MUSIC HALL

BY

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Received: Octomber 7, 2013
Accepted for publication: Octomber 22, 2013

Abstract. The sound field perceived within an enclosure is very different from that in an open space, due to the existence of two overlapping fields, direct and reverberant, which cause an increasing of the sound intensity level. A good understanding of the audition rooms design prescriptions and the purpose for which these were designed lead to a proper acoustic comfort in the interior space of the hall. Each audition hall is conceived with a specific purpose, for a certain type of activity. Thus, every room intended for music or speech performances should be treated differently from an acoustical standpoint. Although cinema and chamber music halls are designed for different values of the acoustical parameters, both must ensure sound clarity and quality according to the current design standards requirements. This paper investigates the possibility of using a cinema as a chamber music hall without compromising its acoustical properties. Thus, reverberation time values were determined in order to give a practical solution to this extent.

Key words: sound absorption; reverberation time; acoustic treatment.

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1. Introduction

Audition room design implies in addition to technical, functional and aesthetic requirements, an adequate acoustical comfort for every listener, too.

The sound propagation in a closed space is influenced by various factors, such as: room geometry and volume, delimiting surfaces finishing, background sound level, which establish the acoustical impression of the room.

In order to use a cinema as a chamber music room, without a sound amplification system, it is necessary to ensure new acoustic characteristics which do not compromise the existing room acoustical properties.

An important parameter used in the acoustic field characterization is the reverberation time which is equal to the time required for the sound pressure level in a room to decrease by 60 dB after the sound source is stopped.

Reverberation time values were obtained by using two methods: theoretical with Sabine eq. and practical through acoustic measurements.

A series of reverberation time determinations were conducted in order to analyse the possibilities of different acoustic treatment proposals.

2. Interior Space Presentation

The studied cinema is located in Cluj-Napoca, having a seating capacity of 283 upholstered chairs (Fig. 1). It works both as a cinema and auditorium for various types of live shows on special occasions such as chamber music performances. The hall meets the acoustical requirements for cinemas.

Fig. 1 – Interior view (http://www.cinemavictoria.ro/).

The room is fan-shaped and has an approximate volume of 2,070 m^3. The height of the room is 7.95 m. Since the room’s main utilization is as cinema, the walls and floor are provided with a large area of absorbing materials. The doors are covered with curtains to prevent sound reflection and noise transmission from outside.

3. Theoretical Determinations

The reverberation time values were calculated using the Sabine formula which depend on the volume of the interior space and on the total amount of sound absorption materials within the enclosure (ISO 3382, 2009)

$$T = \frac{0.161V}{A}, \tag{1}$$

where: T is the reverberation time, [s]; V – volume of the room, [m^3]; A – the equivalent absorption area, [m^2].

The equivalent absorption area can be determined with the formula (ISO 3382, 2009)

$$A = \sum_{i=1}^{n} S_i \alpha_i + \sum_{i=1}^{n} a_i \ , \tag{2}$$

where: S is the delimiting surfaces area, [m^2]; α – absorption coefficients of the delimiting surfaces; a – absorption of a person or object.

4. Field Measurements

The measurement equipment, type Bruel&Kjaer, is composed of an omnidirectional sound source, which was placed central on the stage at a height of 1.5 m, an acoustic analyser, microphones, a power amplifier and a portable computer system (Fig. 2).

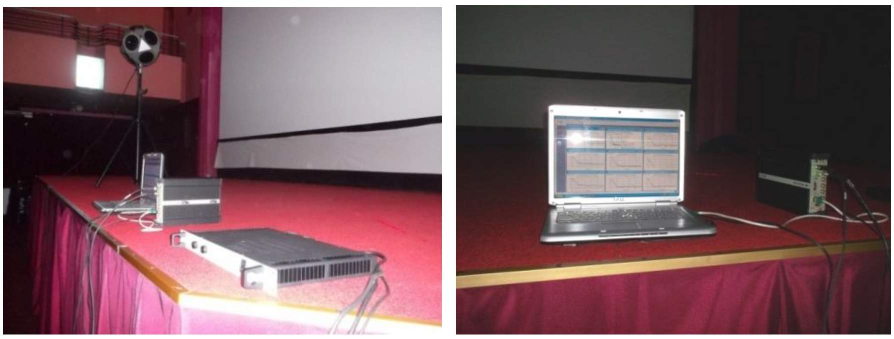
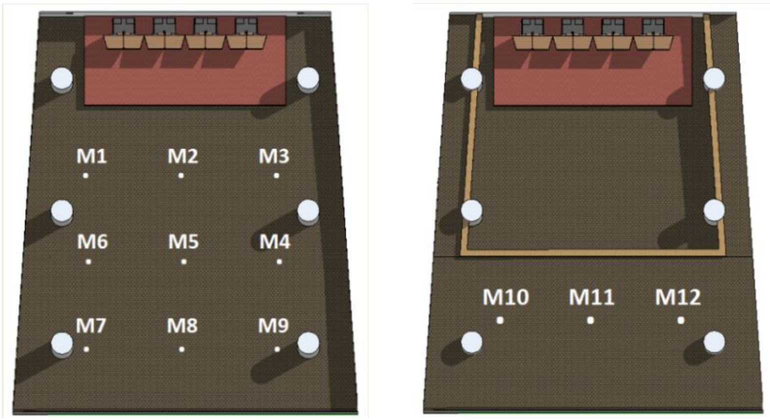


Fig. 2 – Acoustic equipment.

The microphone, located at least half a wavelength apart, at 1.2 m above the floor, in the most representative positions (ISO 3382, 2009) was used to record the emitted sound pressure levels in nine different points distributed uniformly across the audition area at the ground floor (Fig. 3 *a*) and three at the balcony (Fig. 3 *b*).



a *b*

Fig. 3 – Microphone displacement: *a* – ground floor, *b* – balcony.

The interrupted noise method for measuring the reverberation time values was used in empty room conditions.

The emitted sound pressure level ensured a decay curve starting at least 35 dB above the background noise in the corresponding frequency band (ISO 3382, 2009).

5. Results

The obtained results are presented in Table 1. A minor difference can be noticed between the field measurements and the empirical calculation values.

Table 1
Reverberation Time Values

Frequency, [Hz]	125	250	500	1,000	2,000	4,000
T_{Sabine}, [s]	1.00	0.98	1.03	0.89	0.85	0.95
$T_{Measurements}$, [s]	0.99	0.89	1.21	0.88	0.91	0.85

According to STAS 9783/0-84 for chamber music performances, a mean reverberation time, denoted T_m, of 1.13 s was chosen.

In Fig. 4, a ratio between the calculated values and the mean reverberation time, T_m, is used to be compared with the admissible values given in the mentioned design standard.

Based on the exposed results, the admissible values of the reverberation time are exceeded at the frequency of 1,000...2,000 Hz.

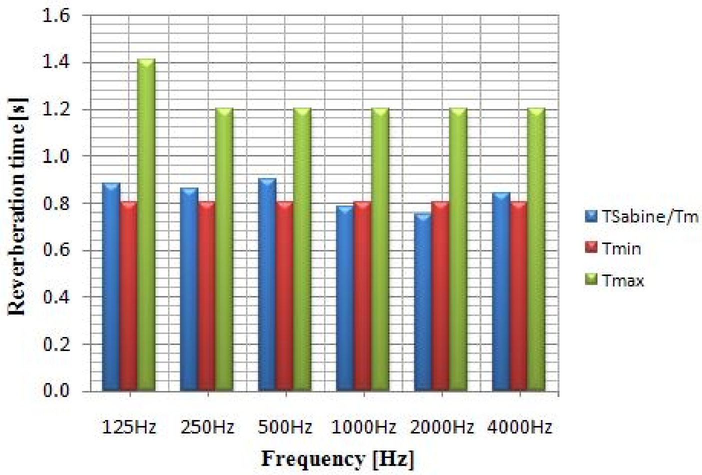


Fig. 4 – Reverberation time values compared with the admissible limits.

6. Proposed Solution

Because an increase in reverberation time values at 1,000...2,000 Hz is required, low sound absorption materials should be provided.

The need to maintain the existing acoustical properties into the room had an important influence on the acoustical material selection.

Thus an economical solution consisted in twelve mobile acoustic panels, disposed within the enclosure and chosen in order to optimize the recorded value, were proposed.

The panels, with a lightweight aluminum edging, are made of gypsum boards having a smooth unperforated surface.

Their absorption coefficients are presented in Table 2.

Table 2

Absorption Coefficients (http://www.rigips.ro...)

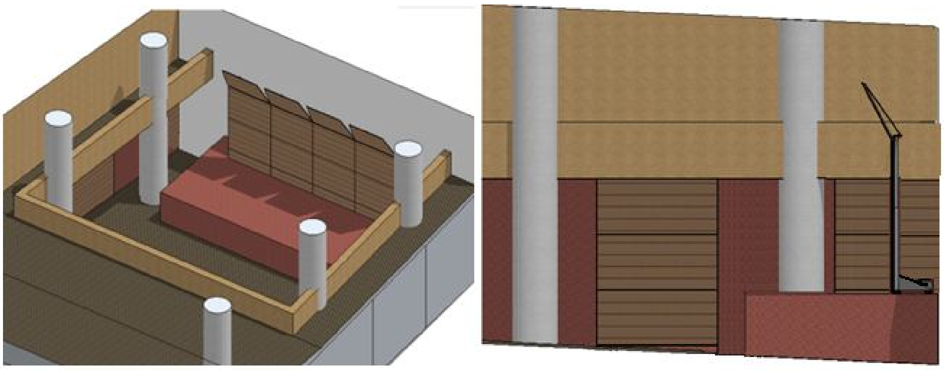
Frequency , [Hz]	125	250	500	1,000	2,000	4,000
α	0.10	0.10	0.05	0.05	0.00	0.05

Four tilted mobile panels (8.50 m^2 × 4 = 34 m^2) placed on the stage and eight vertical hanged mobile panels disposed in front of the walls (6 m^2 × 8 = = 48 m^2), four on each side, were designed.

The tilted panels were placed as close to the cinema screen as possible, facing the spectators and offering enough room on stage without disturbing the artists ongoing performances.

The eight remained panels were situated in an alternate position, such that they should not be placed one in front of the other, avoiding the flutter echo.

The distribution of the acoustic panels is presented in Fig. 5.



a *b*

Fig. 5 – Acoustic panels' disposal: *a* – on the stage, *b* – in front of the side walls.

Mounting a panel is a simple operation that can be done in a short period of time, enabling the room to change its acoustical properties according to the required performance.

The panels can also be folded. Thus, when not in use, they can be stored under the stage or in a small storage room.

The new results of the reverberation time values obtained with the proposed acoustical solution are presented in Table 3.

Table 3
Optimized Reverberation Time Values

Frequency, [Hz]	125	250	500	1,000	2,000	4,000
T_{Sabine}, [s]	0.99	0.99	1.05	0.94	0.94	1.05

In Fig. 6, the ratio between the new reverberation time values and the mean reverberation time, T_m, was compared with the allowable limits specified in STAS 9783/0-84 on each frequency.

A difference between the reverberation time values obtained with acoustical panels *versus* the reverberation times previously obtained can be seen.

The obtained results no longer exceed the bounds of the acceptable values given in STAS 9783/0-84, making the proposed acoustical treatment an efficient solution.

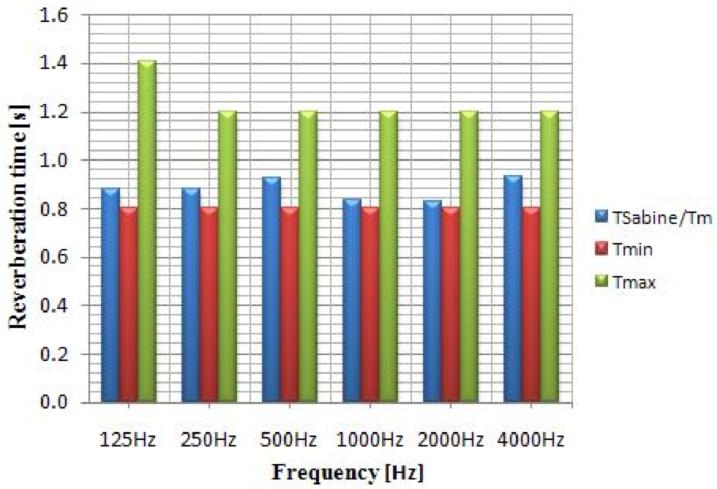


Fig. 6 – Optimized reverberation time values compared with the admissible limits.

7. Conclusions

Cinemas and chamber music rooms require different sound propagation properties in order to ensure an adequate acoustic comfort.

By elaborating an acoustical study and applying modern technological solutions, good acoustical properties of both cinemas and chamber music activities can be obtained for the same acoustic room.

While cinemas use sound amplification systems distributed evenly across the enclosure in order to ensure a good sound quality, chamber music rooms can rely on architectural acoustic in order to achieve the desired acoustical properties and a uniform sound wave distribution within the interior space.

Transforming a cinema, with a high number of sound absorbing surfaces, into a chamber music room that does not use electrical sound amplification system, without compromising its sound quality, can be achieved by providing mobile acoustic panels.

By using this solution, various advantages may be obtained: the panels can be installed (and removed) in a short amount of time, the storage space needed for the panels is relatively small, and in addition they are also aesthetically pleasing.

For the cinema presented in this paper a solution of twelve mobile acoustic panels was adopted, four tilted panels on the stage and eight hanged vertical panels on the side walls, which contributed to the acoustical improvement of the interior space multipurpose characteristics.

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ADAPTAREA PROPRIETĂȚILOR ACUSTICE ALE UNEI SĂLI MODERNE DE CINEMATOGRAF ÎN SCOPUL FOLOSIRII ACESTEIA CA SALĂ PENTRU MUZICĂ DE CAMERĂ

(Rezumat)

Câmpul sonor înregistrat într-un spațiu închis este diferit față de cel dintr-un mediu exterior, datorită suprapunerii a două tipuri de unde sonore, directe şi reflectante, care conduc la o creştere a nivelului intensității acustice dintr-o încăpere. O bună cunoaştere a prescripțiilor de proiectare acustică a sălilor de audiție şi a scopului pentru care au fost proiectate conduce la asigurarea unui confort acustic adecvat în interiorul spațiului construit. Fiecare sală de audiție este concepută cu un anumit scop, pentru un anumit tip de activitate. Astfel, fiecare sală destinată activităților de muzică sau vorbire trebuie tratată în mod distinct din punct de vedere acustic. Deşi sălile de cinematograf sau de muzică de cameră sunt proiectate pentru valori diferite ale parametrilor acustici, ambele trebuie să asigure claritatea si calitatea sunetului în funcție de cerințele existente in standardele în vigoare. În lucrare se analizează posibilitatea utilizării unui cinematograf ca sală pentru muzică de cameră fără a compromite proprietățile acustice existente. Astfel, au fost determinate valorile duratei de reverberație în scopul obținerii unei soluții practice adaptabile acestei situații.