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Study on the acoustic rehabilitation of a church

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Abstract

Everyday stress has become the main reason that affects people's health causing numerous types of emotional dysfunctions. Spiritual life represents a refuge from the daily lives agitation felt due to the accelerated technological progress impact on society. An ideal environment for inner peace regeneration is the church. Deficient acoustics caused by different design factors could have a negative effect on speech intelligibility with impact on the socio-emotional participation and inner communication of the church members. This paper presents an acoustic study of a church located in Cluj-Napoca municipality, Romania. The reverberation time, considered the most important criteria used in the acoustic field appreciation, was determined by two methods: theoretical and acoustic measurements. The obtained results were compared with the norms recommended admissible values. Based on the acoustic field evaluation, a rehabilitation solution which takes into account the interior design of the audition hall was proposed.

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Keywords: Reverberation time; acoustic measurements; acoustic rehabilitation; Sabine's formula; audition hall.

1. Introduction

In Romania, in most of the cases, church buildings were designed without a proper acoustical care, fact that has led to poor conditions of sound transmission in these halls. When the performances are negatively influenced by the

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speech intelligibility, the expected result may create discomfort. Due to the complex geometry of these audition halls, the acoustic design process can be difficult.

The single most important parameter characterizing a room for its acoustical properties is the reverberation time [1, 2, 3]. This defines the time required for the sound to decay by a sound pressure level of 60 dB [4]. The reverberation time decides whether a room or hall is fit for performing a programme [5].

This paper aims to obtain values of the reverberation time using both acoustical measurements and theoretical research. Finally, the obtained values are corrected with proper acoustic materials in order to achieve good listening conditions.

2. Acoustic evaluation

2.1. Characteristics of the audition hall

The analyzed church is located in Cluj-Napoca municipality, Romania, having a Greek Catholic rite. The construction of the church was made over several years, starting with 1996 until 2007. The building itself presents a complex geometry involving domes or vaults. It has a maximum length of 39.00 m and a maximum width of 21.05 m. The audition hall, with a height of 18.05 m in the central dome, has a volume of approx. 3000 m^3 and a capacity of 245 seats. The liturgical activity takes place on the ground floor of the building and first floor, where a balcony designed for the choir members is placed (Fig 1).

Fig. 1. Audition hall interior: (a) orientation towards altar; (b) orientation towards balcony.

The resistance structure of the building is made of reinforced concrete frames infilled with brick masonry walls. Interior walls are plastered and painted. The upper enclosing elements and the altar are painted with frescoes. The ground floor slab is covered with marble and the balcony with ceramic floor tiles. Interior furnishing consists of benches and chairs made of wood. Windows and doors are realized of PVC profile.

2.2. Measurement method

The sound field analysis was performed on November 29th 2012, in unoccupied room conditions. Therefore, the measurement results were not influenced by occupancy conditions. The relative air humidity in the room was recorded at the value of 60% and the temperature of 10º C.

According to SR EN ISO 3382-1 [6], the acoustic equipment (Fig. 2), type Brüel & Kjær, consisted in a sound source configured dodecahedral which radiated sounds in a spherical distribution, a microphone with preamplifier