CONSIDERATIONS ON THE AIRBORNE SOUND INSULATION OF A MODERNISED HOTEL

MUNTEANU Constantin, TÂMAŞ-GAVREA Daniela-Roxana*,
Technical University of Cluj-Napoca, Faculty of Civil Engineering,
*e-mail: roxana.tibrea@cif.utcluj.ro (corresponding author)

ABSTRACT
This paper concerns the manner in which the rating of airborne sound insulation in buildings and of buildings elements is provided in a hotel in a large process of rehabilitation, that aims at turning the hotel from a two star hotel into a four star hotel. As an example, the results of the noise measurements found for the rating of airborne sound insulation in a partition wall of two rooms of the hotel at intermediate level are given. The calculations were made according to the new standards and norms in force in our country that comply with the European Standards.

Keywords: acoustics, building and building elements, rating, airborne sound insulation

INTRODUCTION
The paper concerns the checking of the essential requirement related to noise protection in the case of a hotel in refurbishment that aims at changing its status into a four star hotel from a two star hotel. The noise protection is mentioned as an essential requirement in the Directive of the European Council no. 89/106/CEE and the Interpretative Documents approved on November 30th 1993. In Romania, “noise protection” is both a quality requirement (F) in the context of Law no. 10/1995 and an essential requirement (e) in Law no. 123-2007, which makes Romanian Law no. 10/1995 to comply with the laws of the European Union. Measurements were performed in this hotel to check the insulation levels of the partition walls and of the façade at airborne noise and of the floors to the impact noise. However, this paper will include only references to airborne sound insulation with respect to a partition wall of two rooms from the central zone of the hotel at the second floor of the building.

MATERIALS AND METHODS
1. Place description
The hotel built in 1967 and having basement, ground floor, mezzanine and 8 floors has a structure made of reinforced concrete.

It is situated near the central parc of the city of Cluj-Napoca. In this moment, the hotel is fully updated up to the 6th floor, the rest of the 7th and
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8th floors being at the end of the renovation process. The hotel façade has also been rehabilitated by the building, over the old façade, of a metal structure with mineral wool included among the metal profiles; over it, composite plates of aluminium of type ALUCOBOND were added.

The old windows on the façade were replaced with insulated glazing which improve a lot both the thermal insulation and sound insulation against external noise.

2. The partition wall between rooms

The initial wall was built with solid brick masonry of 15 cm thickness and of $\rho=1800$ kg/m$^3$ plastered on both sides with a cement and lime based mortar of 2.5 cm thickness and of $\rho=1800$ kg/m$^3$.

In the rehabilitation process, on one of the wall faces a metallic skeleton was added, in which mineral wool of 5 cm thickness and of $\rho=100$ kg/m$^3$ was inserted and over the profiles gypsum plasters of 1.25 cm thickness and of $\rho=1200$ kg/m$^3$ were put (Fig.1).

![Fig.1. Detail of partition wall: 1 - cement and lime based mortar; 2 - solid brick masonry; 3 - cement and lime based mortar; 4 - mineral wool inserted in metallic skeleton; 5 - gypsum plasters](image)

The length of the partition wall between rooms is 6.70 m and the height is 2.70 m (Fig.2).

![Fig.2. Dimensions of the partition wall](image)
The plating of the initial walls was performed in alternation, that is in one wall on the left side, and in the other on the right side, but a better solution, from an acoustic point of view, would have been the plating of the initial wall with a frame, mineral wool and gypsum plaster plates on both sides, not only on one face.

The wall is joined to a reinforced concrete beam to the upper part, to the bottom by a reinforced concrete floor and vertically by two reinforced concrete columns. The walls are finished with wall paper, the ceiling with emulsion paint and the 12 cm reinforced concrete floor was covered with a special fire protection carpet with good sound insulating properties.

3. Equipment

The airborne noise level was measured according to [1] and [2] with a multi-analyzer system Brüel & Kjaer type PULSE 3560-B, a portable notebook, where the data processing software PULSE were installed and a type 4189 microphone unit fixed on a tripod.

In the emission room, standard noise (white noise) was produced by a multidirectional speaker and a Brüel & Kjaer power amplifier type 2716, connected to the frequency analyzer. In the emission and receptive room the noise level was measured with the microphone unit fixed on a tripod connected to the frequency analyzer and to the laptop.

4. Field measurements

In the receptive room, the airborne noise level was measured in 5 microphone positions (in the four corners and in the middle of the room). The height of the microphone was 1.30 m from the flooring.

The noise level was also measured in the emission room. During all the measurements the doors of the two neighbouring rooms were closed. The instrumentation and calibration of the acoustical equipment were developed in conformance with the manufacturer’s recommended procedure.

The noise curves measured values represent the average of the measurements in those 5 points. The measured values were confronted with Romanian legislation allowed limits, presented in [3]. Images of the two neighbouring rooms and of the central hall from the second floor of the hotel, where sound related measurements were made, are presented in Fig.3.
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Fig. 3. a - multidirectional speaker in emission room, b - amplifier, laptop with data processing software PULSE and frequency analyzer; c - microphone in the receptive room

5. Main results

The in situ sound attenuation indices $R'_i(f)$, in dB, were determined according to [3] with relationship:

$$R'_i(f) = L_1 - L_2 + 10 \log \frac{S}{A} [\text{dB}]$$

where:
- $L_1$, $L_2$ – noise levels in the emission space, respectively in the reception space, in dB;
- $S$ - the wall surface, in m$^2$;
- $A$ – the equivalent absorption area, in the receptive room, in m$^2$.

The reverberation time $T$, expressed in seconds, was measured and calculated, with a special Brüel & Kjaer software dedicated to this kind of measurements, in the receptive room. A was found from the calculus of the reverberation time $T$ determined according to [3] with relationship:

$$T = 0.163 \frac{V}{A} [\text{s}]$$

where:
- $V$ – the volume of the room;
- $A$ – the equivalent absorption area, in m$^2$.

Hence:

$$A = \frac{0.163 V}{T} [\text{m}^2]$$

The surface of the partition wall between the emission room and the receptive room is $S = 6.70 \times 2.70 = 18.09$ m$^2$ and the volume of the receptive room is $V = 18.3 \times 2.70 = 49.41$ m$^3$.

The rating of airborne sound was done according to standards [3], [4] and [5]. The airborne sound reduction index for the partition wall, noted
R′_w_, is defined with the method presented in [4] and [5], by comparing the curve of the acoustic damping coefficients \( R'_1(f) \) obtained in 1/3 octave bands over the range 100Hz to 3150Hz and the reference (calibrated) curve of the sound damping coefficients. The curve \( R'_1(f) \) and the reference (calibrated) curve are presented in Fig.4.

![Graph](image)

**Fig.4. The curve of the acoustic damping coefficients \( R'_1(f) \) and the REFERENCES curve (calibrated curve)**

The comparison of the acoustic damping coefficients’ curve \( R'_1(f) \) and of the reference (calibrated) curve, presented in Fig.4, is made in Table 1.

**Table 1. The comparison of the \( R'_1(f) \) curve with the REFERENCES curve**

<table>
<thead>
<tr>
<th>Freq. ( f ) Hz</th>
<th>Noise level ( L_1 ) dB</th>
<th>Noise level ( L_2 ) dB</th>
<th>( T ) s</th>
<th>( A ) m²</th>
<th>( 10 \log \frac{S}{A} ) dB</th>
<th>( R'_1(f) ) dB</th>
<th>The REFERENCES curve dB</th>
<th>Detrimental deviation dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>69</td>
<td>36.4</td>
<td>0.390</td>
<td>20.65</td>
<td>-0.575</td>
<td>32</td>
<td>33</td>
<td>-1</td>
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<tr>
<td>125</td>
<td>72.2</td>
<td>35.3</td>
<td>0.571</td>
<td>14.13</td>
<td>1.072</td>
<td>38</td>
<td>36</td>
<td>2</td>
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<tr>
<td>160</td>
<td>75</td>
<td>34.7</td>
<td>0.273</td>
<td>29.50</td>
<td>-2.125</td>
<td>38.2</td>
<td>39</td>
<td>-0.8</td>
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<tr>
<td>200</td>
<td>81.8</td>
<td>27.4</td>
<td>0.264</td>
<td>30.51</td>
<td>-2.269</td>
<td>52.1</td>
<td>42</td>
<td>10.1</td>
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<tr>
<td>250</td>
<td>80.5</td>
<td>32.7</td>
<td>0.510</td>
<td>15.79</td>
<td>0.592</td>
<td>48.4</td>
<td>45</td>
<td>3.4</td>
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<tr>
<td>315</td>
<td>77.8</td>
<td>28.6</td>
<td>0.267</td>
<td>30.16</td>
<td>-2.218</td>
<td>47</td>
<td>48</td>
<td>-1</td>
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<tr>
<td>400</td>
<td>80.8</td>
<td>25.8</td>
<td>0.510</td>
<td>15.79</td>
<td>0.592</td>
<td>55.6</td>
<td>51</td>
<td>4.6</td>
</tr>
<tr>
<td>500</td>
<td>76</td>
<td>25.5</td>
<td>0.483</td>
<td>16.67</td>
<td>0.354</td>
<td>50.9</td>
<td>52</td>
<td>-1.1</td>
</tr>
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</table>
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<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>630</td>
<td>76.6</td>
<td>25</td>
<td>0.420</td>
<td>19.18</td>
<td>-0.254</td>
<td>52.5</td>
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<td>27.2</td>
<td>0.363</td>
<td>22.19</td>
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<td>47.6</td>
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<tr>
<td>1000</td>
<td>75.9</td>
<td>25.7</td>
<td>0.543</td>
<td>14.83</td>
<td>0.864</td>
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<tr>
<td>1250</td>
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<td>0.592</td>
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<tr>
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<td>25.9</td>
<td>0.357</td>
<td>22.56</td>
<td>-0.958</td>
<td>53.4</td>
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<tr>
<td>2000</td>
<td>81</td>
<td>26.9</td>
<td>0.390</td>
<td>20.65</td>
<td>-0.575</td>
<td>53.5</td>
<td>56</td>
<td>-2.5</td>
<td></td>
</tr>
<tr>
<td>2500</td>
<td>81.5</td>
<td>27.2</td>
<td>0.357</td>
<td>22.56</td>
<td>-0.958</td>
<td>53.3</td>
<td>56</td>
<td>-2.7</td>
<td></td>
</tr>
<tr>
<td>3150</td>
<td>80.4</td>
<td>27.8</td>
<td>0.333</td>
<td>24.19</td>
<td>-1.261</td>
<td>51.3</td>
<td>56</td>
<td>-4.7</td>
<td></td>
</tr>
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</table>

The method through which the two curves are compared consists in displacing the reference curve (calibrated curve) with 1 dB steps, versus the measured and calculated curve $R'_i(f)$, until the sum of the negative deviations reaches the highest value, but does not exceed 32.0 dB (at 16 thirds of an octave).

The deviation is seen as negative, at a certain frequency, if the measured or calculated value is lower than the reference value. Only negative deviations are considered.

If the movement follows the mentioned procedure, the value of the reference curve expressed in dB at 500 Hz is $w_{R'}$.

Because the detrimental deviation 28 dB is the highest value that does not exceed 32.0 dB it is not necessary to translate the reference curve.

In this case we have:

$$R'_w = 52 - 0 = 52 \text{ dB}.$$  

According to [3] the admissible value of the airborne sound reduction index for the inner partition walls in a hotel is 51 dB.

In the case of the hotel in Table 1, it yields:

$$R'_{w} = 52 \text{ dB} > R'_{w,\text{ nec}} = 51 \text{ dB},$$

therefore the wall ensures the insulation against the airborne sound.

A comparison of the curves of acoustic attenuation indices $R'_i(f)$ with the curve Cz 30 was also made. This comparison is given in [3] as the admitted limit of the inner airborne sound in dwelling rooms or sleeping rooms in a hotel (Fig.5).
From Fig. 5 one can see that at high frequencies (4000 Hz and 8000 Hz) the admitted values are exceeded but only with 1.1 dB respectively 1.4 dB. This means that measures should be installed for additional sound insulation.

CONCLUSIONS

- In general, one can appreciate that, the partition wall between two rooms of the hotel presented in the paper ensures the insulation against the airborne sound.

- A better solution, from an acoustic point of view, would have been the plating of the initial wall with a frame, mineral wool and gypsum plaster plates on both sides, not only on one face. This solution can solve also the problem of the noise levels at high frequencies.

- The verification of the sound insulation at the end of building works both for new and old constructions that are renovated is extremely necessary.

- Though checking for the requirement of sound insulation is provided as an essential requirement in the European norms, as well as in the Romanian ones, unfortunately, this is not observed in practice.

- It is essential to design in projects constructive solutions that result after consulting experts in sound insulation and it should be necessary to see how these solutions are practically applied during building.

- It is necessary that the competent authorities in our country require the verification of the essential requirement “noise protection” both during the design stage and in the final stage, by means of measurements made in situ.
REFERENCES


4. *** (2005), Normativ privind proiectarea și executarea măsurilor de izolare fonică și a tratamentelor acustice în clădiri, Indicativ C 125-05 (Norms related to the design and implementation of sound insulation measures and of sound treatments in buildings, indicative C 125-05).

