AIRPORTS: A STUDY OF THE INFLUENCE OF SPECTRAL ADAPTATION TERMS ON THE SOUND INSULATION OF FACADES REINFORCEMENT

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Abstract

One of the measures currently used to improve the sound insulation provided by facades of existing buildings, is based on the acoustic reinforcement of their transparent areas, such as doors and windows, by more efficient solutions (eg. double glazed systems).

With regard to air traffic noise and in order to minimize the corresponding impacts in terms of acoustic comfort inside homes, this reinforcement is a solution that can be proposed for buildings located in zones under the influence of airport operations (fly-over, ground operations, etc.). However, the performance of the glazed systems (double or not) is strongly dependent on the incident noise spectrum, a fact that is enhanced by the values assumed by the adaptation terms associated with these solutions.

This paper presents the results of a study on the efficiency of typical windows, considering their sound insulation and the corresponding adaptation terms, which were calculated on the basis of C_{tr}, parameter defined for an average noise spectrum of each type of aircraft. Thus, aircraft spectra were analysed, during a typical operation day at Lisbon airport, determining the respective adaptation terms and evaluating their influence on the sound insulation of a selected glazing set.

The results obtained and the conclusions drawn, can be considered important elements for proposals of mitigation measures related to the evaluation of environmental impact studies of air traffic infrastructures.

Keywords: sound insulation, sound spectra, air traffic noise.

1 Introduction

Air traffic noise has always been the major environmental issue for residential communities close to airports. Even though aircraft are becoming less noisy due to technological improvements, the expected increase in the number of flights emphasizes the importance of noise mitigation measures for residential areas around airports. In this way, operational measures (like air traffic management or land use planning) and passive measures (increasing the sound insulation provided by the weakest façade elements, like windows and doors) can play a significant role to establish acoustic comfort inside dwellings.

Acoustics standards for rating airborne sound insulation in buildings define procedures for expressing the sound insulation with a single-number value. The measured sound insulation values, in octave or one-third-octave frequency bands, are compared to a reference curve, as a weighting procedure for obtaining the single-number values. The ISO standard 717-1 [1] gives the spectrum adaptation terms (C, Ctr) applied to weighted sound reduction index, Rw when the representative spectrum i.e., pink noise or traffic noise, is assumed as impacting noise. Ctr value is to be applied when a representative urban traffic noise is assumed as the impacting noise, and it is applicable for urban road traffic, railway traffic at low speeds, aircraft propeller-driven, jet aircraft, disco music, and factories emitting mainly low and medium frequency noise. The spectrum adaptation term C is calculated from A-weighting pink noise spectrum and is applicable to living activities, children playing, railway traffic, highway road traffic, jet aircraft, and factories emitting mainly medium and high-frequency noise. The suitability of a reference spectrum for rating sound insulation depends on how well its shape matches the average spectra of actual noises existing in dwellings (or in the surrounding environment). In fact, variations of the reference spectra values, even in certain frequency bands only, can produce considerable variations of the calculated descriptor values [2]

In the Portuguese building acoustics code, when the translucent area is greater than 60% of the façade element under analysis, it must be added to the index $D_{2m,nT,}w$ the appropriate adaptation term, C or Ctr, according to the type of noise dominant in the emission, for the frequency range 100-3150 Hz. Bearing in mind that the major Portuguese airports are very close to the cities (even Lisbon Airport is located in almost "inside" Lisbon urban area), there was a need to estimating the spectrum weightings from the actual sound source characteristics for air traffic noise and compare them with the standardized spectrum adaptation terms.

Taking into account the perspective of the construction of new airport in Portugal, as well the proximity of the existing ones to urban centres, there is a need to assess the added value due to the use of spectral adaptation terms based on specific sound spectra representative of air traffic conditions from Portuguese airports, instead of the standardized ones. In this context, continuous air traffic measurements were carried out near Portela Airport, in Lisbon. Then the A-weighted normalized sound spectra noise was obtained. These sound spectra were applied to laboratory measurements of sound insulation of windows with single and double glazing, to check he possible differences that may occur in terms of their effective sound insulation.

2 Field Study and Results

Continuous measurements of air traffic noise were carried out, at a distance of approximately 1500 m from the beginning of the airport runway at Humberto Delgado Airport (Lisbon, Portugal), in Campo Grande area, in Lisbon, between the 4th and 5th of July 2019 (see Figure 1). A Symphonie measuring system from 01 dB with a GRAS 40 AF Microphone attached to the 26 AK Pre-Amplifier was used. In Figure 1, the location of the noise measurement point (marked as A) is shown (it takes into account the beginning of the 03/21 runway of the Lisbon airport).

Figure 1 – Relative location of the measuring system (marked as A) to the 03/21 runway of the Lisbon airport

More than 200 spectra of plane were analysed, and the type of plane associated with each model was recognized, using the Fightradar24 application. Later, all the planes were aggregated into 12 Classes, according to the type of plane, with an extra class labelled "Others" that included more expressive models of various aircraft. For each class, the spectra that presented deviating values were eliminated. The spectra of all classes were added, and the average value was determined. Once again, the deviant values were eliminated, leaving a total of 180 spectra of airplane passing-by. Figure 2 shows the spectra with linear frequency weighting between 16 Hz and 20 kHz, and the corresponding average value in bold.

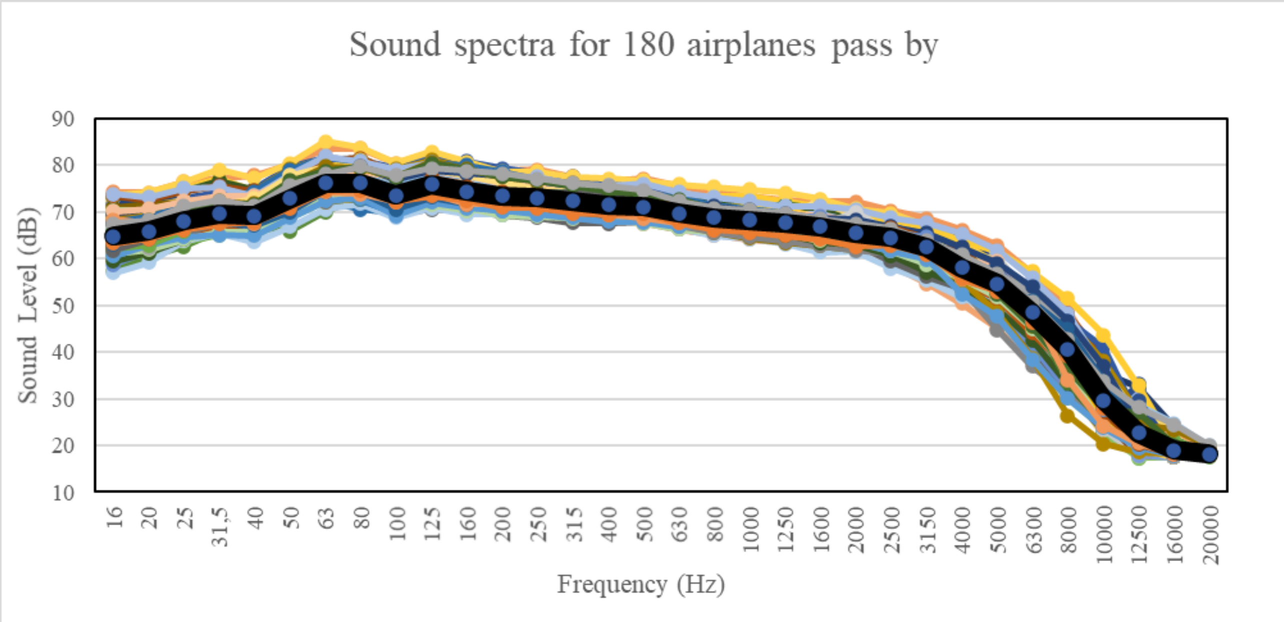

Figure 2 – Sound spectra in third octaves bands (from 16 to 20000 Hz)

To the average spectra, the frequency weighting A was applied (between the frequencies of 50-5000 Hz) and the yielded spectra was normalized to 0 dB (labelled as Spectrum Airplane, in Figure 3). In Figure 3, the measure sound spectra in this work (labelled as Spectrum Airplane), the spectrum adaptation terms C (used for jet aircraft, in short distance) and Ctr (used for aircraft, propeller driven, and jet aircraft at long distance) from ISO standard 717-1, are present. Also, for comparison purposes, two other spectra for aircraft noise were included, from the Nordtest method NT ACOU 61, named as A6 for Aircraft noise representing starting DC-9s, and A7 for Aircraft noise representing propeller aircraft.

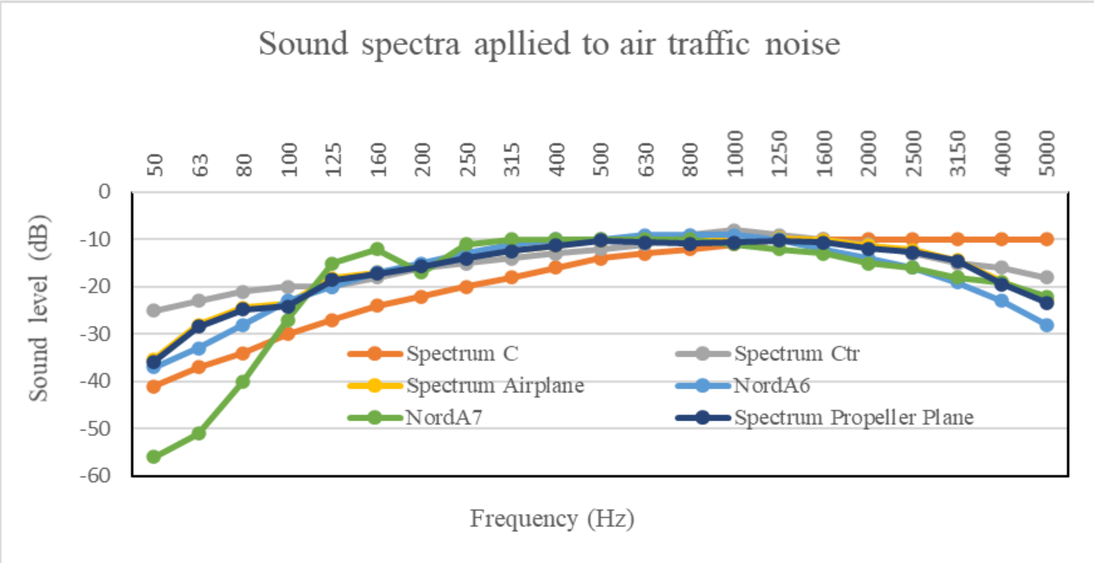

Figure 3 – A-weighed normalized spectrum for air traffic noise

Figure 3 shows that measured spectra (Spectrum airplane) is more similar to the sound spectra Nord A6 (representing the Mean value of 59 starts at Kastrup airport 500 m from the runway [4], and with the spectra Ctr).

3 Application of the proposed spectra and comparison with reference spectra

To compare the effects of using the measure sound spectra (Spectrum Airplane), adapted for the Portuguese air traffic noise conditions, the measured A-weighted normalized sound spectra were applied to laboratory measurements of sound insulation for windows with, single and double glazing.

For single glazing windows, the sound insulation index - single number quantities - vary between Rw = 34 dB and Rw =38 dB, having 2 or 3 different spectral sound insulation for the same value of Rw (labelled as Rw_1; Rw_2 or Rw_3), as shown in Figure 4. Also, the results were treated for the frequency range 100-3150 Hz (used in the Portuguese building acoustics code) and frequency range 100–5000 Hz, separately. The results are presented in Figure 4 for the single glazing windows analysed (frequency range 100-3150 Hz), and in Figure 5 for the frequency range 100–5000 Hz .

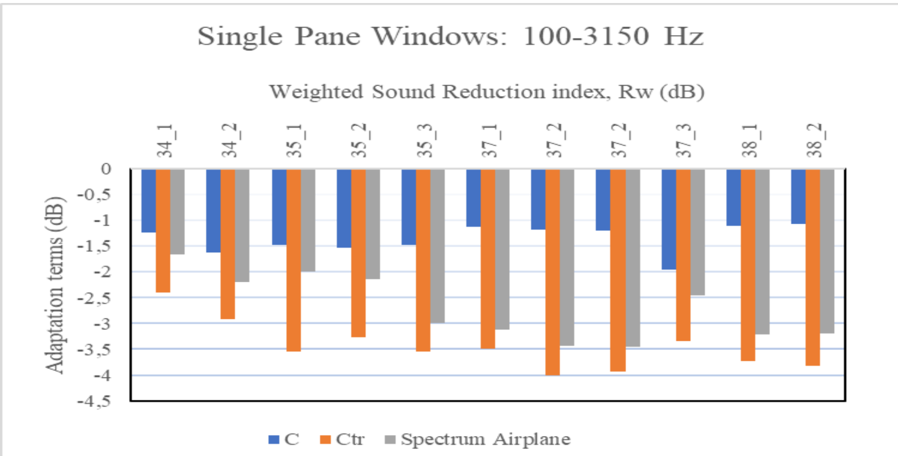

Figure 4 – Weighted sound reduction index and spectral adaptation terms for single glazing windows (100-3150 Hz)

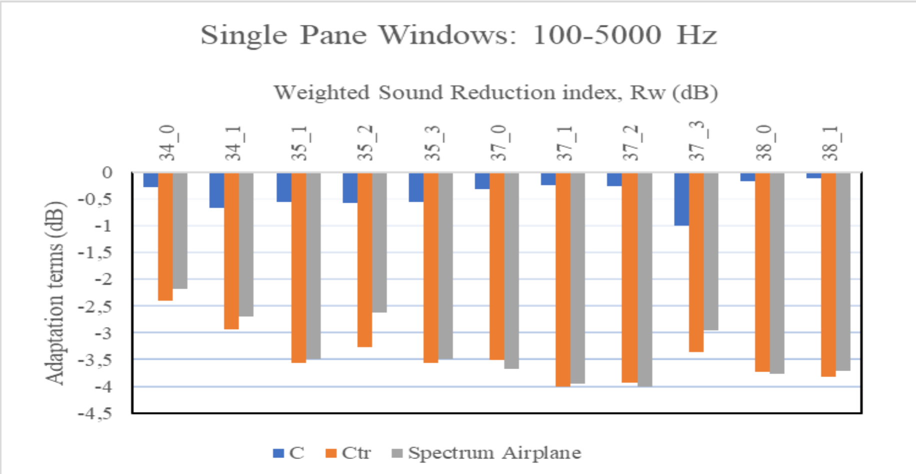

Figure 5 – Weighted sound reduction index and spectral adaptation terms for single glazing windows (100-5000 Hz)

For double glazing windows, the sound insulation index - single number quantities - vary between Rw= 37 dB and Rw=49 dB, labelled as Rw_1; Rw_2; Rw_3 or Rw_4, as in the former case for single glazing windows. The results are presented in Figure 6 (100-3150 Hz) and in the extended frequency range (100-5000 Hz), as shown in Figure 7.

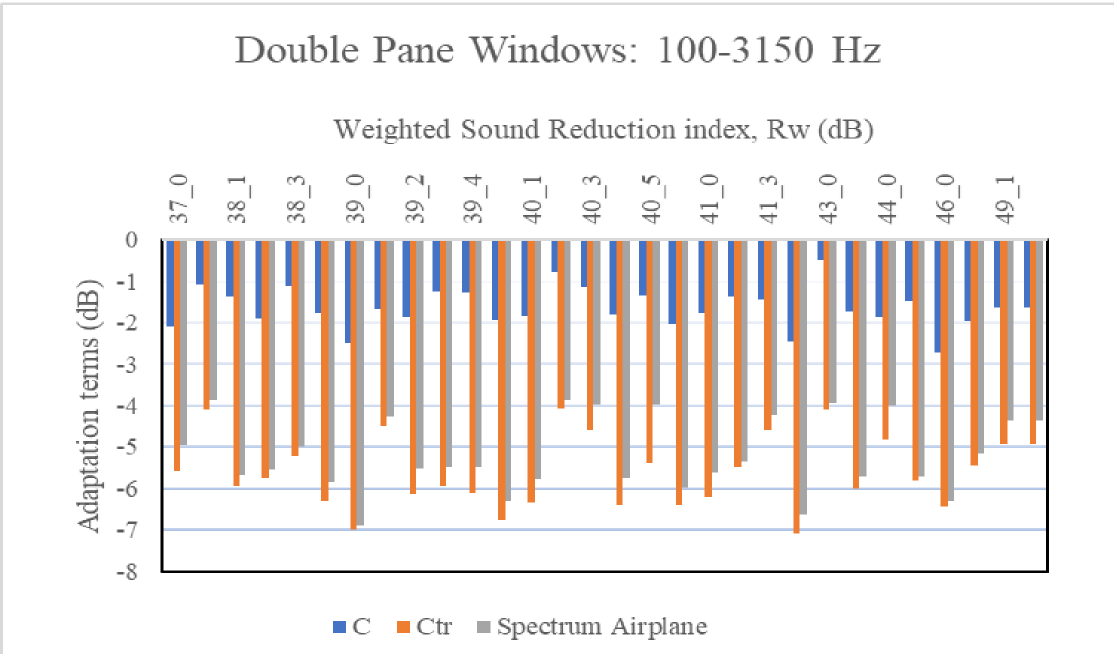

Figure 6 – Weighted sound reduction index and spectral adaptation terms for double glazing windows (100-3150 Hz)

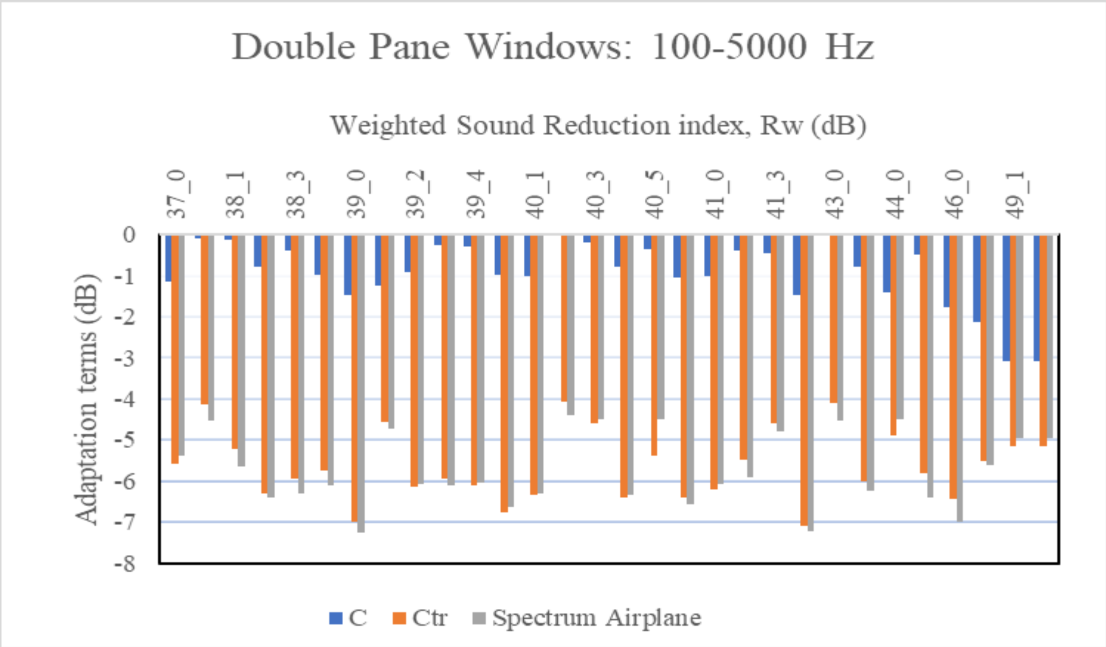

Figure 7 – Weighted sound reduction index and spectral adaptation terms for double glazing windows in extended frequency range (100-5000 Hz)

For both types of windows, the final result using the measured sound spectra (Spectrum Air Traffic) is nearer Ctr values than C values. In the extended frequency range (100-5000 Hz) this difference is even shorter.

Figure 8 presents the total results for windows (single and double glazing), for Rw values, varying between 34 dB and 49 dB, in the frequency range 100-3150 Hz. For the extended frequency range, the results are presented in Figure 9.

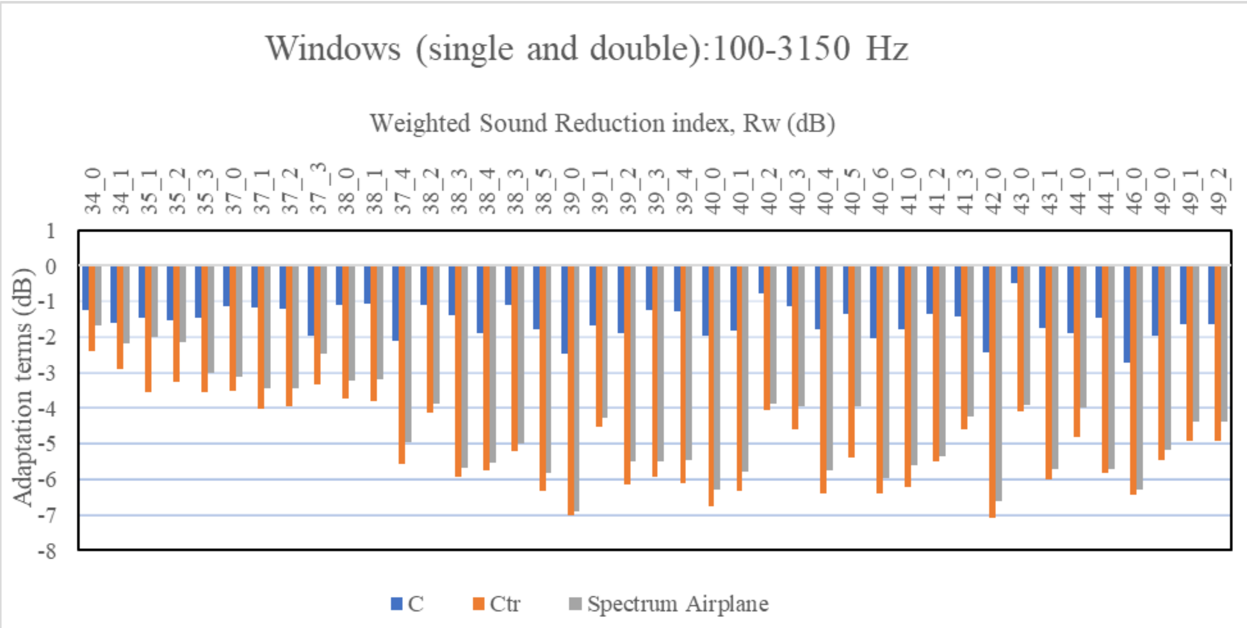

Figure 8 – Weighted sound reduction index and spectral adaptation terms for windows in the frequency range 100-3150 Hz

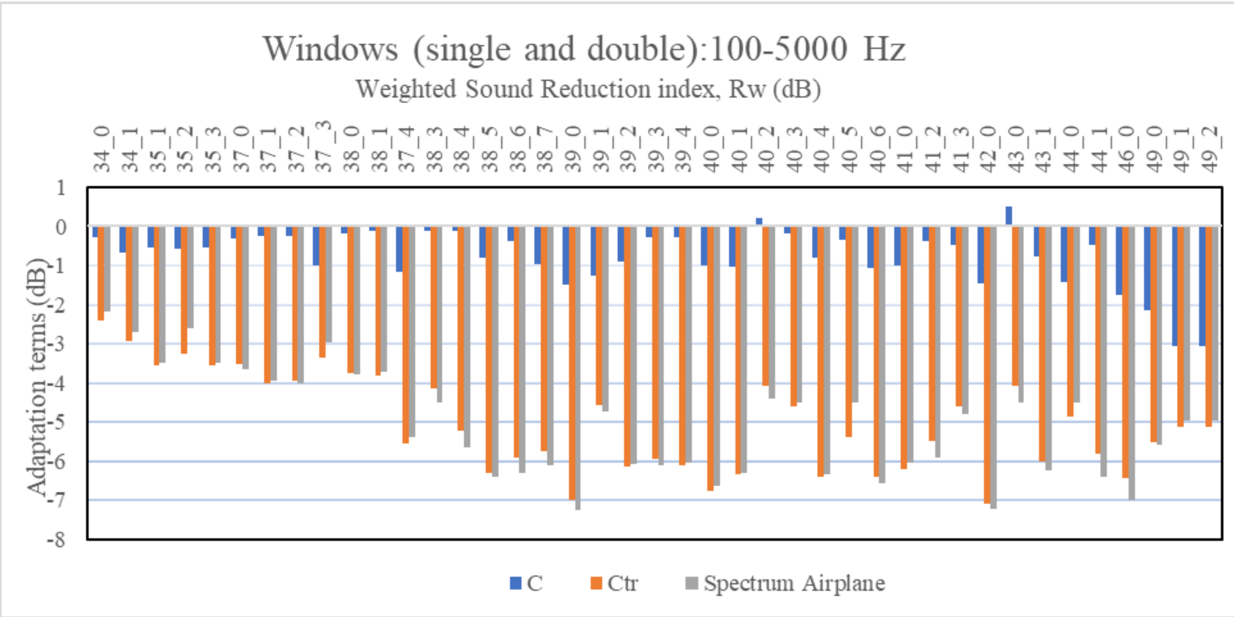

Figure 9 – Weighted sound reduction index and spectral adaptation terms for windows, in the extended frequency range (100-5000 Hz)

4 Conclusions

From the average sound spectra obtained in the measurements made, it is possible to infer an attenuation of about 10 dB, between the frequencies of 3150 and 5000 Hz. These results show the importance of extending the analysis until 5000 Hz, when considering the sound insulation of windows in noise mitigation measures related to air traffic noise.

Also, the sound spectra measured is very similar to the reference Ctr spectrum of ISO 717-1. Applying the values from the Spectrum airplane to sound insulation values of single and double windows in use in Portugal (laboratory values), the resulting values are very near to that obtained with Ctr. This coincidence is even greater when using the extended frequency range.

On the basis of the results of this work, and regarding Portuguese building acoustics code, when the translucent area is greater than 60%, general guidance can be given: use the Ctr adaptation term values, for all the situations related to air traffic noise; and use of extended frequency range from 100-5000 Hz.

In a future nearby, and considering the importance of this analysis, the authors find important to make a similar study for military aircrafts or minor recreational airports, in order to check if similar results are found, or if a better appropriate spectra could give more accurate results to improve the acoustic comfort inside homes.

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