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URBAN SQUARE SOUND FIELDS DURING ROCK CONCERTS

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1 ABSTRACT

The sound during rock concerts in urban areas is a compromise between sound quality for the audience and tranquility for the city dwellers. To investigate different acoustic parameters at open-air rock concerts, a measurement campaign at four different squares in Flanders, Belgium was performed. Of particular interest in this paper are the spectral and temporal characteristics of the sound field. In addition, the uniformity of the sound level and quality can be useful background information for legislative purposes. Indeed a more thorough insight in these parameters can potentially improve the way noise at urban rock concerts is controlled.

2 INTRODUCTION

For years now, the popularity of open-air concerts and festivals has been growing steadily. With this, the complexity and elaborateness of the amplification system has evolved to deliver high quality sound to all locations at the festival scene[1]. Line-arrays and so-called delay-lines are widely used nowadays to accomplish that goal. Their ability to produce high sound pressure levels is strong[2,3]. This may seem pleasing for well-experienced concertgoers, unaware of the hearing damage they can suffer. However, others can get irritated by the high levels, diminishing their musical experience. If the festival is held at an urban square, the tranquillity of inhabitants and city-dwellers will also be at risk. Therefore the government enforces limitations on the sound pressure level to minimize the annoyance for the bystanders and the risk of hearing loss for concertgoers[4,5]. However, as the complexity of the amplification system is further extended, legislation needs to be adapted continuously to fill the gaps.

Prior to the creation or adaptation of legislation, an intensive measurement campaign must be conducted to identify the different factors which should be taken into account[6]. In this paper we will focus on the analysis of the sound pressure level distribution at urban city-squares, as this is still the common design parameter for sound engineers. These sound pressure level measurements are part of a larger study in which also impulse related parameters were investigated[7,8]. The measurements were performed at four different urban squares during life-concerts.

After a short overview of the measurement method, the uniformity of the sound field at the four squares will be investigated together with the influence of delay-lines on the sound pressure level.

3 MEASUREMENT METHOD

Relative sound pressure levels were measured at four urban squares in Belgium (the Oude Markt and Vismarkt during ‘Marktrock 2008’ in Leuven, and Grote Markt and Vismarkt during ‘Maanrock 2008’ in Mechelen). About six measurements positions were selected randomly over the square, together with a fixed reference position near the mixing console, where the law officer usually conducts his measurements. The geometry of the squares and location of the different measurement positions is depicted in Fig. 1.

Leuven – Oude Markt

Mechelen - Vismarkt

Leuven - Vismarkt

Mechelen – Grote Markt

Figure 1 : Geometry of the four investigated squares. Two squares at Leuven during 'Marktrock 2008' and two squares at Mechelen during 'Maanrock 2008'. In red the measurement positions and speaker arrays with the time-delay are indicated. The reference position is also indicated.

At the reference position, a calibrated SVANTEK SVAN 959 sound analyzer continuously logs the 1/3-octave sound pressure level with a MK250 microphone and SV12L amplifier. The position dependent measurement is conducted with a similar calibrated SVANTEK SVAN 949 sound analyzer with microphone and preamplifier. At each position the 1/3-octave sound pressure level is logged twice, during approximately 15 min. The integration time of both reference and position dependent measurement is set to 1 s.

After measuring, either A- or C-weighting is applied. For the analysis, only the data containing music fragments were taken into account. These useful samples are manually extracted from the spectrogram and LeqA/C of the position dependent measurement. Fragments with more or less equal LeqA/C point to non useful passages such as applause, where most of the energy is concentrated in mid-frequency bands and little in low or high frequency bands. The course of the Leq and a spectrogram of a measurement at one location are depicted in Fig. 2, where the borders of the useful parts have been selected.

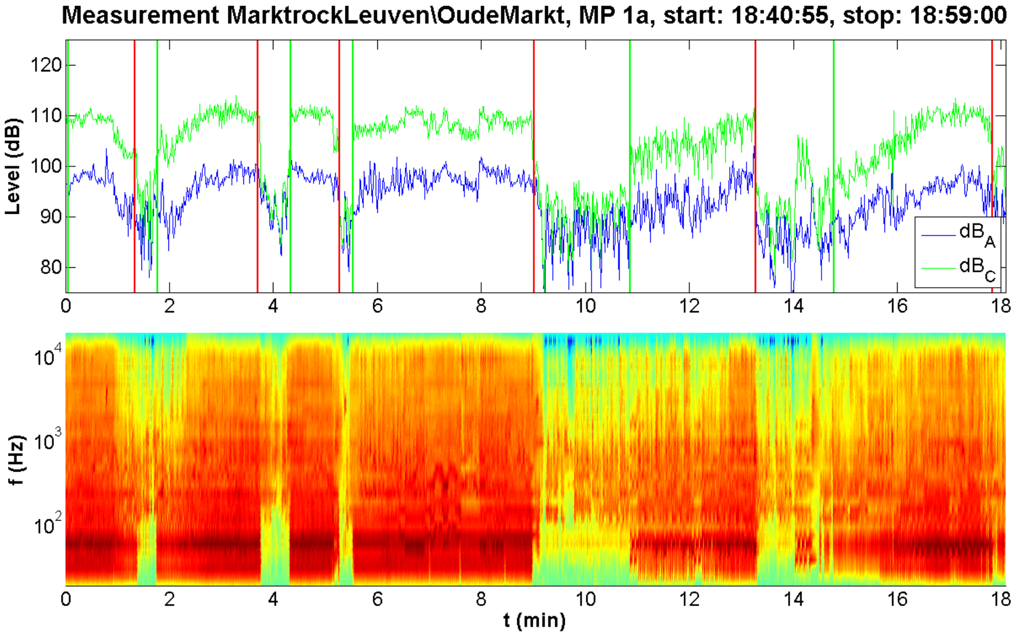


Figure 2 : Manual selection of the useful data-samples by comparing LeqA and LeqC over time. The spectrogram is also depicted. Useless parts contain little energy in the low and high frequency bands, leading to almost equal LeqA and LeqC. The green lines indicate the start of useful data-parts, the red lines indicate the end.

4 MEASUREMENT RESULTS

For the analysis of the data, different methods can be used. First the uniformity of the sound field will be studied by comparing the evolution of the 1/3-octave Leq spectra over each square. Secondly, the course of the total LeqA and LeqC over the square will be investigated in order to characterize the sound field decay.

For easy notation the squares will be abbreviated: LO for the Oude Markt in Leuven, LV for the Vismarkt in Leuven and MG and MV for the Grote Markt, respectively Vismarkt in Mechelen.

4.1 Uniformity of the sound field

To investigate the uniformity of the sound field at the different measurement positions, a comparison is made between the 1/3 octave spectra at each location. Firstly, the useful data-samples are energetically averaged over approximately 17 min. over each 1/3 octave band. From this location dependent value, the reference Leq, calculated from the corresponding data-samples, is subtracted to calculate the relative Leq. In this way the result will be independent of possible speaker level changes made by the sound engineer. However, in order to calculate an absolute LeqC value, all the data-samples of the reference position are C-weighted and their energetic average is added to the position dependent Leqs. Results for the different locations and reference position at each square are given in Fig. 3.

General conclusions for the four squares are not easily drawn. An individual discussion is appropriate. We mention however the high energy contained in the low frequency components, especially around the 63 Hz octave band. This low frequency sound originates from subwoofers beneath the stage and it proves to be useful to include C-weighting to take this low frequency energy levels sufficiently into account (see Section 4.2), as a common A-weighting will minimize the low frequency components.

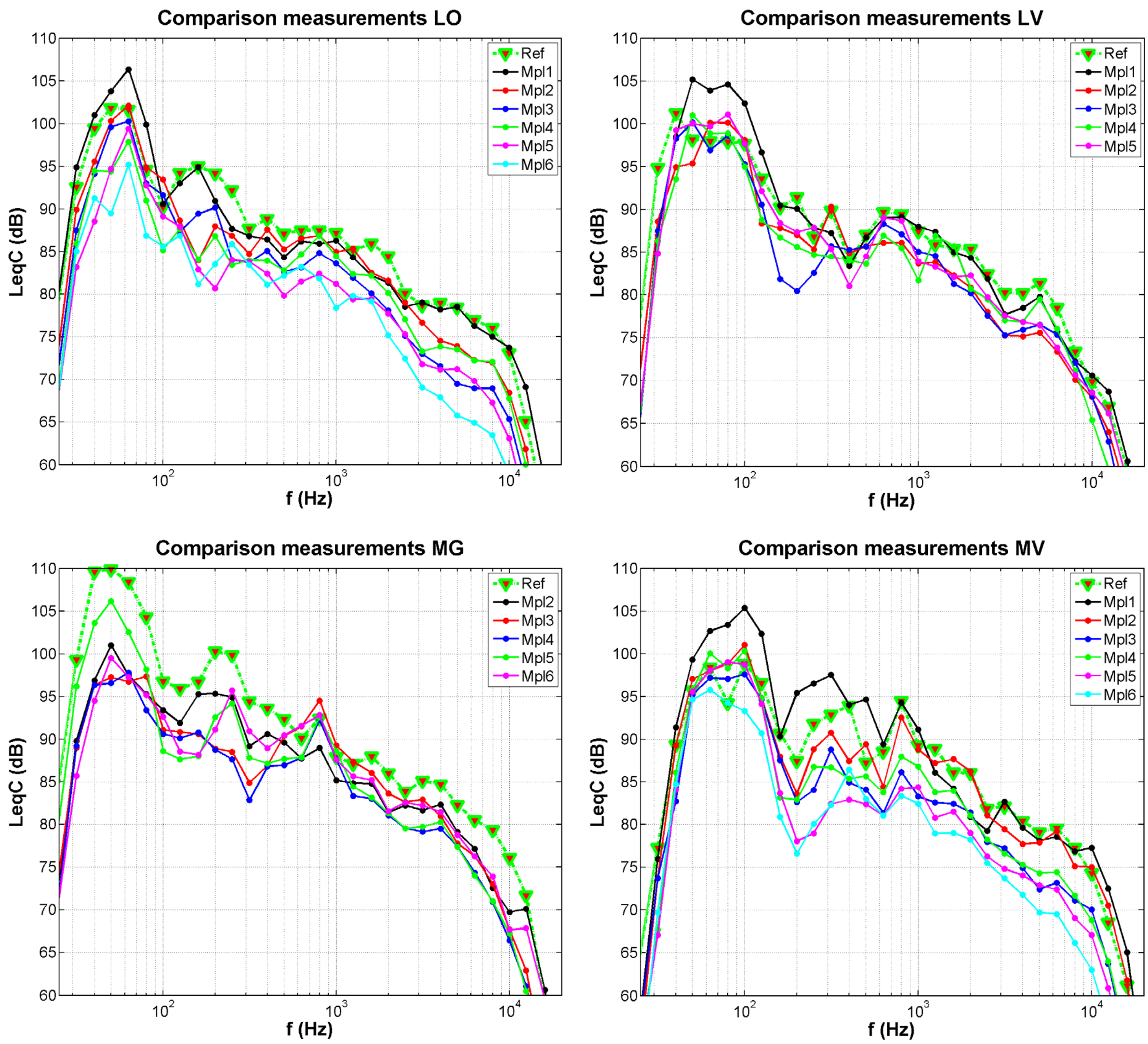


Figure 3 : Absolute 1/3-octave band C-weighted Leq spectra measured at different locations at the four squares. First the relative spectrum is calculated as the difference between the position dependent and reference measurement. For the absolute spectrum the total C-weighted energy average of the reference measurement (dashed line) is added.

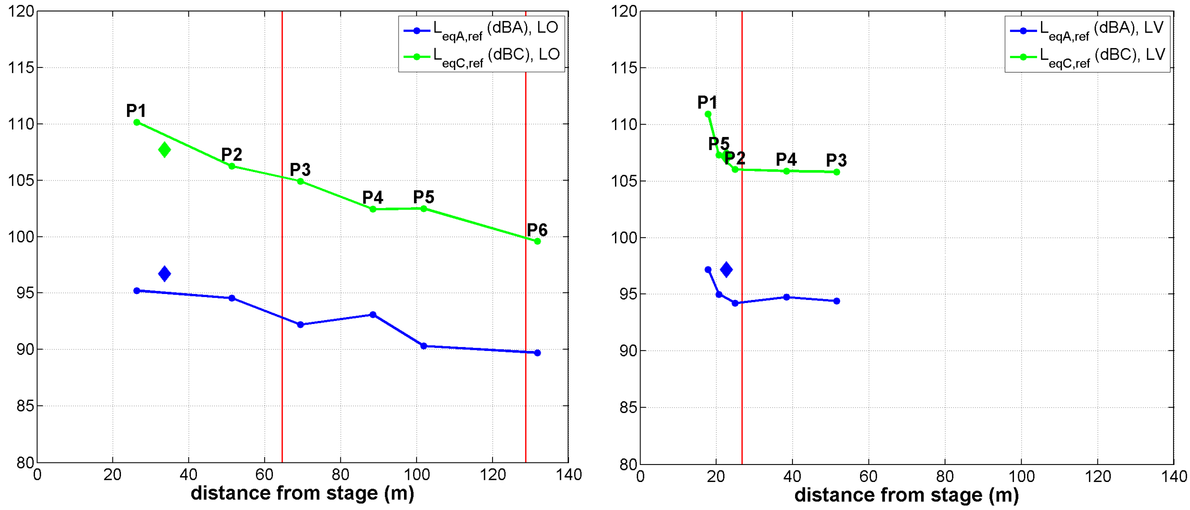
For a comparison of the spectra at LO, the influence of the delay-lines has to be taken into account. These delay-lines only reproduce the mid and high frequency components and are highly directional[1]. For the low frequencies, reproduced by the subwoofers beneath the stage, it can be seen that LeqC decays proportionally with distance. This proportional decay is not so evident for mid and high frequencies. Mpl 3, for example, is situated between two delay-lines and hardly benefits from their additional sound energy. Mpl 4 however, receives more energy in these higher frequency bands, despite the more distant location.
At LV, where one central delay-line is present, a similar effect can be noted as more distant locations not always have the highest attenuation. However, one should take into account the presence of trees near the side which can shield locations.
The spectrum at each position remains restricted to a limited range, which is a consequence of the smaller size of the square compared to LO. Two events are however noticeable. Mpl 1 has a relatively higher level of low frequency energy, compared to the nearby reference position. This is related to its location in the middle of the square, unshielded by obstacles. Secondly a ground dip near 200 Hz at Mpl 3 is seen, probably caused by different ground characteristics, changed as the audience was less dense at this location.

At the squares in Mechelen, no such delay-lines are used. Therefore, fluctuations of a different kind are expected. At MG it can be seen that more spectral differences between measurement locations are present. It is observed that the low frequency energy is significantly higher at the reference position and Mpl5. An explanation for this is the presence of an underground parking lot beneath the square, which can act as a kind of resonator, amplifying the low frequency components.
The spectral differences in mid frequency bands can be caused by a combined effect of the underground parking lot and the influence of the audience. At Mpl3 & 4 a smaller number of bystanders are present, causing the acoustic absorption to be different from other locations. Since the measurement positions are also bordering the underground parking, different mechanisms play a role compared to the centre of the square.
At MV the spectra are similar in good approximation. The attenuation is proportional to the distance from the stage, but higher than at other squares. This is caused by the half openness of the square. Although the square itself is small, its location near the river Dijle accounts for a higher energy loss, which is uncompensated for by delay-lines.

4.2 Sound energy decay

For a more thorough view on the sound decay at the square, the total LeqA and LeqC are calculated for each location from the 1/3 octave A- or C-weighted spectrum, as deducted in Section 4.1. Fig. 4 plots these Leq values in function of the distance from the stage. The position of the delay-lines is also indicated.

As follows from Section 4.1, a distinction can be made between squares with and without delay-lines. At LO and LV it is clear that the sound pressure level decreases much less with the distance than at squares without delay-lines (MG and MV). At LV the sound pressure level even remains constant under influence of the delay-line. At MV, however, a much faster decay is noticed since the energy loss with distance is not compensated for.
At three of the four squares, the course of LeqC follows that of LeqA. However, at MG the course is much more different. A peak in LeqC is noticed at Mpl5, which is not detected when looking at LeqA. This was already explained in Section 4.1 as the influence of the underground parking lot. It now becomes clear that the high level of low frequency energy is only accounted for by LeqC. It seems thus important to include LeqC to detect low frequency energy at rock concerts. Indeed, during the measurement campaign at MG, many bystanders were complaining about the very annoying low frequency energy that was an annual phenomenon when the festival held place.



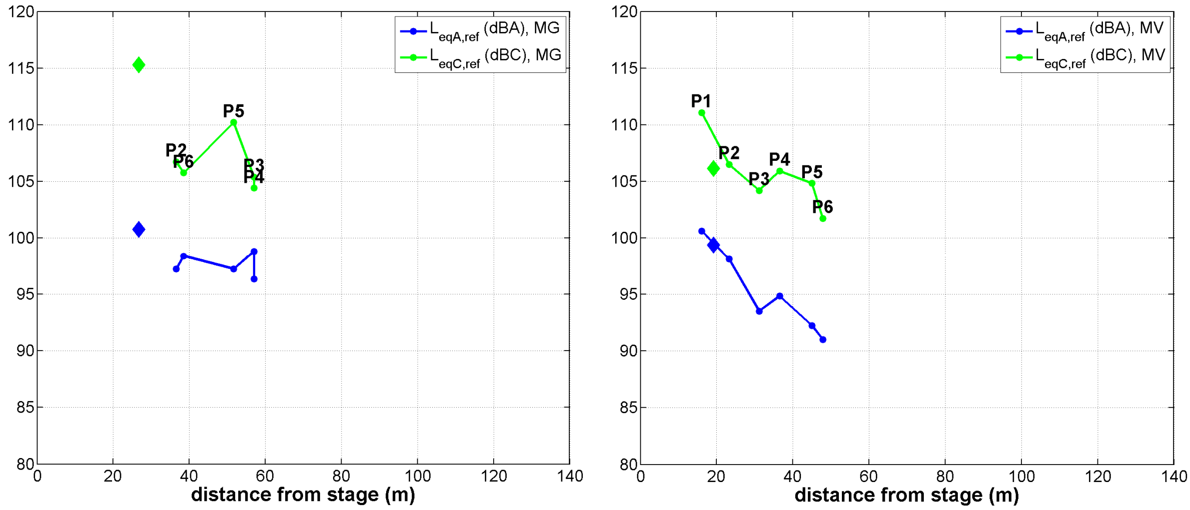


Figure 4 : LeqA/C in function of the distance from the stage at the four squares investigated. The total Leq values are based on the spectral values depicted in Fig. 3. The red lines indicate the positions of the delay-lines. The blue and green diamond indicate the LeqA, respectively LeqC, at the reference position.

5 CONCLUSIONS

Measurements of the distribution of the sound pressure level during festivals at four different urban city-squares were described in this paper. At different measurement positions, the 1/3 octave band sound pressure levels are compared to a reference level near the mixing console. It is concluded that the spectral content at the different locations is similar to the reference position. However, some differences in mid frequency bands are observed, probably caused by changing acoustic properties of the ground floor due to fluctuations in the audience density. Other level differences can be caused when directive delay-lines reproduce only mid and high frequency sound energy in a certain direction.

Further, it has to be noticed that, although uniformity of the sound field is more or less achieved at most squares, the attenuation is not proportional with the distance from the stage. Here it is seen that delay-lines greatly change the decay of the sound, keeping the sound energy on a higher level at more distant locations. This makes it difficult to estimate the sound pressure level at a specific location at the square.

Furthermore it is seen that it is important to sufficiently account for low frequencies e.g. by C-weighting. These lower frequencies play an important role at rock concerts and it was shown that the distribution of LeqA over the square might differ from that of LeqC.

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