COMPUTATIONAL PREDICTION OF SOUND PROPAGATION IN URBAN CANYONS

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INTRODUCTION

Problems associated with increased noise exposure – especially due to road traffic in the urban context – are well known[1]. However, the acoustic planning of outdoor urban areas and the potential of simulation still does not receive sufficient attention. The present contribution focuses on urban canyons via comparison of measured and simulated sound levels of two inner-city areas in the city of Vienna, Austria. The research includes also a sensitivity analysis that takes into account variations in model assumptions. This makes it possible to explore the calibration potential of acoustical simulation tools in urban planning applications.

INPUT DATA DERIVATION

The workflow included the implementation of the real locations with carefully chosen first approximations with regard to input data. Towards this end, geometry data was obtained from an existing repository and subsequently adjusted to fit the input requirements of the selected application. Furthermore, multiple sources of information were used to specify material properties such as the absorption coefficients of the relevant surfaces. Similarly, assumptions pertaining to the sound power of pertinent sources were made based on applicable standards[2] and in-situ observations. Similarities and differences between the two locations could be thus established. Moreover, modelling considerations with regard to the level of details and the sky representation were investigated.

IMPACT ANALYIS

The first simulation results were contrasted to in-situ measured datasets obtained at different heights above the ground in front of the facades. Furthermore, scenarios with different surface characteristics, traffic flow, receiver positions, weather conditions, and simulation tool's settings were generated from the baseline model and their level of impact on sound pressure levels (SPL) was studied. The datasets were analysed and compared considering the linear SPLs and their root mean square deviation (RMSD) over the octave bands from 63 Hz to 8000 Hz. Thus, the level of impact, the direction of the change, and the degree of frequency dependency of the results by the alteration of input parameters were captured.

RESULTS AND DISCUSSION

The results of the contribution are twofold. On the one hand it provides a methodology and a systematic overview on input data that is needed for using room acoustic simulation tools for urban sound propagation applications. On the other hand, it uncovers the potential of such simulations through a comparison with measured data and a sensitivity analysis. The agreement between simulations and measurements were found to be satisfactory. However, the level of congruence is a function of frequency. Thereby, lower bands usually display higher deviations. The impact of input parameters was characterized both by the SPLs and RMSD. Additionally, a classification of scenarios into high, moderate and low impact categories was considered. Furthermore, the impact of frequency band and receiver position was explored. The results show that modelling considerations such as the sky representation and the vertical closing surfaces of streets have low impact on the results. Likewise, room setup settings such as number of late rays and impulse response length does not affect SPLs unless they are set to an insufficiently low level. Hence, reliable results are obtainable already at a rather low computational cost. Also, it was found that small alterations in the absolute values of absorption and scattering coefficients did not influence SPLs to a great extent. Similarly, weather conditions are of interest only in case of high uncertainties regarding temperature or relative humidity, and even then, only high frequencies are affected to a noticeable degree. On the other hand, the scenario with fully scattering surface properties resulted in a significant rise of the SPLs, while a significant increase of the facades' absorption caused a remarkable fall of the same metric. Moreover, even moderate and realistic variations in the traffic flow characteristics such as vehicle speed and traffic density caused a notable deviation of the results. Larger differences between measured and simulated datasets can occur, especially at low frequencies. These may be attributed to the insufficiently accurate representation of the time varying traffic flow and sound propagation at low frequencies.

CONCLUSION

Overall, it was found that sound propagation in urban canyons can be modelled by a room acoustic software with good precision and at a low computational cost. In general, the findings suggest that little changes have small impact and even a high degree of simplification of the geometry is permissible. Therefore, if the order of magnitude of the input data is appropriate, then the simulation yields reliable results, in agreement with the in-situ measured SPLs. On the other hand, the results suggest that a more sophisticated urban situation, which includes miscellaneous objects such as trees and parking cars or an urban canyon, which has a lower height to width ratio can introduce additional uncertainty in input parameters. Consequently, a higher degree of deviation of the results from the reference can be expected. Moreover, the impact analysis uncovered the most influential input parameters, namely characteristics of the road traffic and surface quality of the materials, which could be of interest of urban planners in future. Accordingly, further research should concentrate on the impact of traffic composition on one hand, and additionally, explore the potential of implementing acoustically effective external finishing for building surfaces. Furthermore, simulation results gained at different weather conditions could be analysed in the context of in-situ measurements. Additional analysis of the geometric attributes of the input model could also be useful. Finally, different national standards with regard to the sound power attributable to road traffic could be compared in view of their impact on the SPLs.

REFERENCES

[1] WHO-JRC, 2011. Burden of disease from environmental noise - Quantification of healthy life years lost in Europe. Available from http://www.euro.who.int/__data/assets/pdf_file/0008/136466/e94888.pdf; accessed 15 January 2018.

[2] Kephalopoulos, S., Paviotti, M., Anfosso Lédée, F., 2012. Common Noise Assessment Methods in Europe (CNOSSOS EU), EUR 25379 EN. Luxembourg: Publications Office of the European Union, 2012.