Stadium Sound Reinforcement: Immission Protection in Spite of High Useful Levels

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Abstract

This contribution explains how acoustical quality criteria for a stationary stadium sound reinforcement system were elaborated with particular regard to minimizing immission to neighboring areas, and how forthcoming concepts from bidding firms were evaluated.
Thanks to the inclusion of the results obtained by sound-reinforcement computer simulation (EASE) in the calculated immission prediction it was possible to assess various sound-reinforcement concepts with regard to the sound quality to be expected within the stadium, but also in respect of immission avoidance.

Useful sound level versus Noise level

In designing a sound system for an open stadium we have to find a compromise between the useful sound level for the audience in the bleachers and the amount of sound energy radiated into the environment. In the case of the Berlin stadium a new roof was designed which the preservationists had to be architecturally detached from the „old" stadium. This resulted in a wraparound gap, a light membrane roof and a non-roofed stadium area, which are altogether prone to emanate noise to the neighborhood. The authors were confronted with the task of ensuring on the one hand a sufficiently good sound reinforcement in the stadium and on the other hand to achieve, for reasons of immission protection, a minimization of noise propagation to the neighborhood caused by the sound reinforcement system.
The prevailing situation was firstly the existence of tenement houses in the immediate neighborhood of the stadium (at 200m distance a detached house, at 400m the 60m high Corbusier-Haus). Secondly there is the installation of a professional sound reinforcement system in the stadium, which is designed for irradiating a direct sound pressure level of 102 to 105dB in the spectator areas.
The use of the stadium includes:
Regularly: Soccer (German Football League, Uefa, etc.); seasonal: American Football and on rare occasions: open-air concerts, Church congresses as well as track and field events. In general, the events take place at the week ends, and that not only at day-time, but also in the evening and sometimes also after 22:00h.

Problems arising from Immission Legislation

A legal evaluation takes place with regard to the Regulation on Noise Protection in Sports Installations („18. BImSchV").

- It stipulates that the recommended immission values established therein must not be exceeded during utilization of a sports installation (a portfolio protection in case of expansion of the utilization profile is not granted).
- Owing the immediate neighborhood to the local residents, the recommended immission values stipulated for „pure" and „general" residential areas are at least during the resting and night hours not complied with.
- The importance of a sports installation is no point of consideration in this respect („18. BImSchV": for sports installations of nation-wide importance there apply the same criteria as for a village football ground).
- Local residents sue for compliance with the recommended immission values stipulated in „18. BImSchV", with a view to an envisaged expansion of the scope of utilization (which is, however, necessary for assuring a cost-covering operation).
- Alternatively the local residents demand compensation payments.
- Due to the existence of several sporting facilities on the Olympic Terrain and the nearby situated open-air concert bowl (Waldbühne), assurance of operation above the 18 exceptional days permissible according to „18. BImSchV" can be excluded.

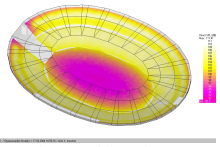
Possible Solution based on Immission Legislation

- Short-term: The residential areas border on the special area of the Olympic Terrain. This implies that the recommended immission values would not have to be complied with that rigorously.
- Short-term: The noise immission into the neighborhood is to be reduced to a technically feasible minimum; **this was the main task of the authors .**
- Medium-term: Juridical clarification as to whether a sports installation (validation according to „18. BImSchV") or an industrial enterprise (validation according to TA-Lärm (noise control) offering the possibility of classification as an individual special case) is concerned.
- Long-term: Application of § 23 „BImSchG", according to which it is possible to prescribe by a federal legal regulation that on application by the responsible body for a project there may be applied the same procedure as provided for an installation requiring a license (validation according to TA-Lärm (noise control) offering the possibility of classification as an individual special case)

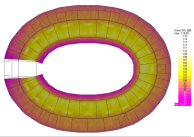
Way of solution for minimizing the noise immission caused by the ProSound System

1. Determination of immission-relevant reference surfaces
   - non-roofed center of the stadium
   - membrane-covered roof area
   - open gap between roof and upper circle

2a. Calculation of the sound pressure levels inciding on the three reference surfaces, by means of acoustic simulation (EASE), as a prototype solution:
The simulation calculations were carried out with the third-octave maximum level predetermined by the manufacturer. Location-dependent level and delay adaptations, in this case between the main loudspeaker locations above the lower circle and the loudspeaker locations (delay positions) near de upper circle, were simulated in the model.
The direct sound pressure levels were ascertained in so-called mapping files for the stands areas, the roof opening, the roof membrane and the gap below the roof.

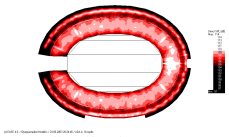


Mapping on bleachers,

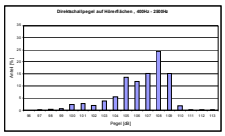


on roof membrane (example)

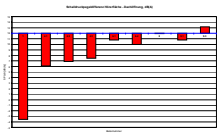
For examining the noise-protection aspect a frequency-response evaluation considering the most frequent utilization, i. e. the reproduction of music. From the above-shown graphs the medium value of sound level was calculated per third-octave. Then the frequency-response of the bleachers was weighted by means of the average value with due consideration of whether the sound reinforcement system would be able to reproduce it.
This resulted in a level correction per third-octave, which was now linearly included by addition or subtraction in the calculated results for the noise-protection-relevant irradiation surfaces opening, membrane and gap.
The A- and linear weighted, averaged direct sound pressure levels of the bleachers were then subtracted from the corresponding levels of the sound-emitting surfaces. With regard to these differences there existed based on corresponding preliminary theoretical investigations, results of which had to be complied with by the individual bidders. These final results were then compared in a gain/loss chart.
Decisive for quality considerations was, of course, apart from the noise protection aspect, also the uniformity of sound supply to the bleachers. Statistical information on level distribution could be ascertained from the above-mentioned calculation data for the bleachers for all points of calculation in the audience areas.

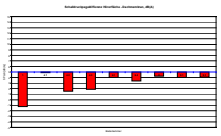


SPL distribution



SPL level frequency





comparison: bleacher – roof opening bleacher - membrane

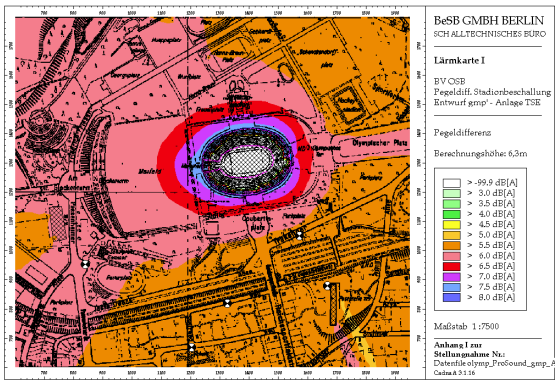
2b. Transfer of the calculation results from the sound reinforcement simulation into the immision prognosis program
   - calculation of the noise immission into the neighborhood
   - determination of the level differences to be achieved between the audience areas and the respective reference surface, as a requirement for the ProSound tenders

3. Checking of the sound pressure levels on the three reference surfaces by sound reinforcement simulation for the respective bidder concept according to item 2.
   - distribution of a uniform three-dimensional EASE models to the bidders for the ProSound system
   - the bidders incorporate their respective concepts into the EASE model

4. For checking the respective bidder concepts, transfer of the calculation results from the sound reinforcement simulation into the immision prognosis program

Result

With full maintenance of the sound quality at the listeners' seats, is was by comparison with a conventional sound reinforcement concept possible to reduce the noise immission into the neighborhood by approx. 5dB.



Level difference between conventional sound reinforcement concept and optimized concept, calculation height: 6,3 m