Acoustic improvements of the working conditions for musicians in orchestra pits

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Introduction

During a design process of an opera house the working conditions of musicians in the orchestra pit are often neglected. This might be due to the fact that from the acoustic and architectural point of view the auditorium and the stage are more prominent and attractive.

Musicians are exposed to a substantial acoustic exposure in an orchestra pit. The sound level depends on the kind of the music, size of the orchestra, geometry of the pit and the room acoustic conditions in the pit. Equivalent (averaged over a performance) and maximum sound levels are given in Table 1. The authors of [2] and [3] report similar levels. In [4] the maximum levels are even higher. Under such circumstances industrial workers would be forced to wear ear plugs. Musicians refuse to wear such protection, since they feel handicapped in their ensemble play.

Recommendations for geometry design, sound reflection and absorption may be found in [5, 6, 7]. Regarding absorption, the tenor is, on the one hand it is desirable whereas on the other hand it hampers reflections. In [7] the marked sound field at low frequencies and the over-damped high frequencies are pointed out. [5] also mentions, that because of masking effects below the overhang musicians tend to play louder in order to assess their own and the play of others.

Instruments	L_m [dB(A)]	Maximum level [dB(A)]
Violin / Viola	86 - 93	110
Woodwind	88 - 97	117
Brass	87 - 96	122

Table 1: Sound levels in orchestra pits according to [1].

A room acoustic approach will be presented, which helps to considerably reduce the acoustic load in orchestra pits, by enabling musicians to assess their own play and better hear other instruments, in other words by increasing the acoustic transparency.

Investigations in orchestra pits

During the last decade 9 orchestra pits have been investigated and their acoustic working conditions have been improved by the Fraunhofer IBP. Currently the redevelopment plans for the pits of the Hippodrome Theatre, Birmingham and of The Royal Opera House, London take place. By means of oral and written questioning musicians and directors are asked to assess the acoustic quality of the actual pit. According to musicians the major pit problems are: high sound levels, poor hearing and assessing of the own and others play, inadequate coupling of the pit to the stage and auditorium as well as poor cross communication in wide pits. Especially the kettle drum, percussions, brass and piccolo have been identified as painfully loud instruments. The situation deteriorates dramatically below the overhang.

Room acoustic approach

The best situation for orchestra musicians is to play on stage. The second best situation would be to play in a large uncovered pit. But the worst case is to play in a mostly covered orchestra pit. In an optimised acoustic environment, in which reverberation and sound reflection are properly adjusted, the acoustic transparency and the difference between maximum and background sound pressure level may be optimised, Figure 1. In such case musicians are in a position to play only as loud as the music (and the conductor!) demands.

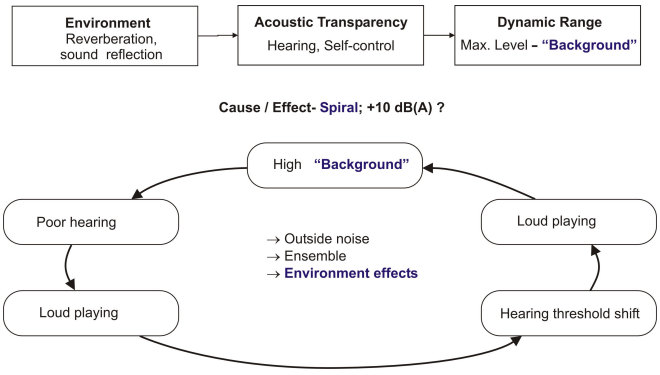

Figure 1: Cause / Effect spiral in an orchestra pit due to improper room acoustic environment.

In an unconditioned environment, as often found in orchestra pits, the transparency and dynamic range are poor, forcing musicians to play louder than necessary. Especially those, who due to long lasting exposures already suffer from hearing loss, tend to give more than demanded [8] thus, accelerating the aforementioned spiral.

The minimisation of the negative influence of the pit on the working conditions must be part of the acoustic design [9]. Orchestra pits usually exhibit reflecting surfaces such as concrete, masonry etc. and mid and high frequency absorbing panelling. Especially below the overhang a modal sound filed, is generated at low frequencies, which is strongly position dependent. Therefore the low frequency sound field below the overhang should be tackled in a first step. This is now made possible by installing Compound Panel Absorbers CPA, on the rear and side walls as well as on the overhang of the pit. As a second step Broadband Compact Absorbers BCA should be placed in the immediate proximity of the kettle drum and percussions, Figure 2.

Figure 2: CPA and BCA mounted below the overhang in the pit of the Staatstheater Mainz.

The design and construction of the novel CPA and BCA modules is e.g. described in [10, 11]; their absorption characteristics is shown in Figure 3.

In a coupled system consisting of an auditorium and a pit, the Early Decay Time EDT characterises the decay in the pit, especially below the overhang. In Figure 4 the effect on EDT of the acoustic measures is shown for the pit of the Staatstheater Flensburg. In this case $^2/_3$ of the musicians attested an improvement and $^1/_3$ even a considerable improvement in their working conditions.

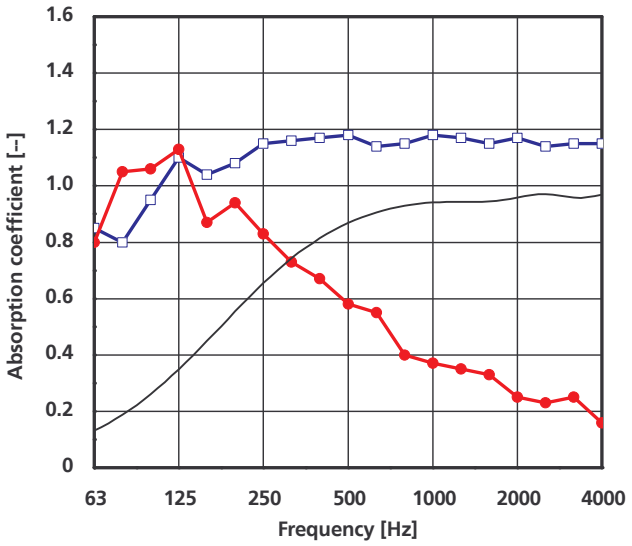

Figure 3: Sabine absorption coefficient α_s of CPA (–●–), BCA (–□–) and a 10 cm thick porous layer (——).

Even under these improved circumstances it may still be too loud in the near field of strong instruments e.g. violas in front of trumpets. Occasionally used conventional screens are not appreciated by the brass, since they considered as are too reflective. Thus, partly absorbing transparent screens on the basis of micro-perforated absorbers have been developed [12, Fig. 2]. In order to improve the left / right communication in a wide pit, reflecting measures in the proscenium area must be taken. To improve the hearing of the strings these should be positioned on rostra.

In order to show whether measures in the pit affect the acoustic quality in the auditorium, impulse responses were recorded at several positions of the Staatstheater Flensburg. As one might expect, there is no change in reverberation time RT, Figure 4, or in clarity C_{80}.

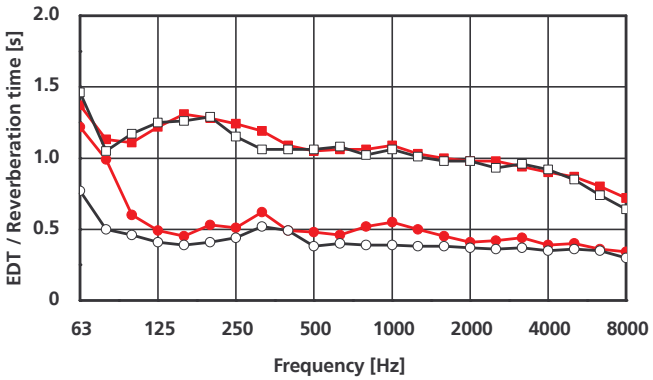

Figure 4: Measured EDT in the pit before (–●–) and after (–○–) and RT in the auditorium before (–■–) and after (–□–) installing acoustic measures in the pit.

Summary

Musicians are exposed to too high sound levels in pits. By means of innovative absorbers installed in the pit the acoustic transparency as well as the dynamic range can be increased. This enables a better hearing and assessment of the own and the play of others. This helps musicians to play only as loud as demanded by the music.

References

[1] Kwiatkowski, et al.: Schalldruckpegel im Orchestergraben eines Opernhauses. Zbl. Arbeitsmed. 36 (1986), 58 – 64

[2] Naylor, G. M.: Problems and priorities in orchestra pit design. In: Proc. Inst. Acoust. 7 (1985), 65 – 71

[3] Mikl, K.: Orchestral music: An assessment of risk. Acoustics Australia 23 (1995), 51 – 55

[4] Fearn, R.W.: Hearing loss in musicians. J. Sound Vib. 163 (1993), 372 – 378

[5] Mackenzie, R. K.: The acoustic design of partially enclosed orchestra pits. Proc. Inst. Acoust. 7 (1985), 237 – 243

[6] Barron, M.: Auditorium acoustics and architectural design. London: E&FN Spon, 1998

[7] Tennhardt, H.-P.: Raumakustische Probleme bei der Anordnung eines Orchestergrabens im Musiktheater. IEMB Informationsblätter, 1998

[8] Zha, X. et al.: Raumakustische Verbesserungen im Orchestergraben der Staatstheater Stuttgart. Bühnentechnische Rundschau 91 (1997), 22 – 31.

[9] Zha, X. et al.: Improving the acoustic working conditions for musicians in small spaces. Appl. Acoust. 63 (2002), 203 – 221.

[10] Fuchs, H.V. et al.: Creating low-noise environments in communication rooms.. Appl. Acoust. 62 (2001), 1375 – 1396.

[11] Fuchs, H.V. et al.: Broadband compact absorbers for anechoic linings. In: CFA/DAGA 04, p. 272

[12] To be published in: Bühnentechnische Rundschau (2004)