Room acoustics for 4 uses – Großes Haus Staatstheater Mainz

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Introduction

Auditoria for varying uses (e.g. concert, opera, ballet, theatre) seem to call for variable acoustic environments including such cost-intensive measures as providing coupled reverberation spaces and installing electro-acoustic support. The "Großes Haus" of the Staatstheater in Mainz has been redeveloped from ground. This opportunity was taken and the "house" was given a new room acoustic design which serves 4 uses in one. This was based on smoothing the room response over the whole frequency range in the auditorium and the coupled stage tower. By an enlargement of the volume of the auditorium and the invisible installation of novel sound absorbers, which effectively work at low frequencies only, this goal has been achieved. The feedback from spectators, musicians and conductor regarding this innovative "acoustics for all uses" is remarkably positive.

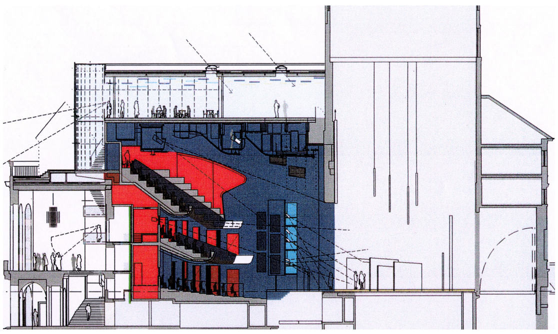

Figure 1: Cross-sectional view of the building

Sound directing measures

The originally cylindrical shape of the auditorium dating back to the early 19th century, was optically retained yet acousticcally invalidated by 6 large insertions forming geometrically well-defined slants, parapets and barriers on 2 tiers (Figure 1). The favourable effects of 6 sets of large-scale reflectors (Figure 2) above the proscenium and over the pit, on both side walls, the back wall and a considerably elevated ceiling were described in a more elaborate paper [1].

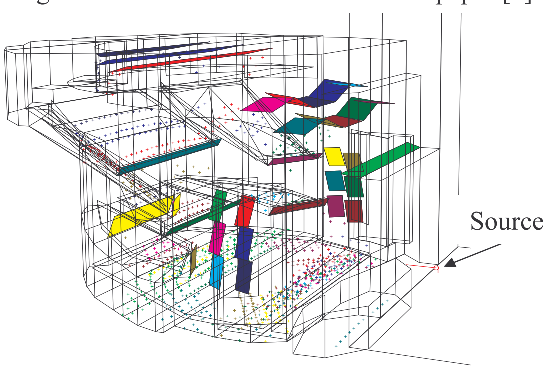

Figure 2: Installations directing the sound from the stage to the auditorium

Sound absorbing measures

A flat response of the enclosure as a whole, expressed by a constant reverberation time between 63 and 4 000 Hz, supports the clarity of music as well as the distinctness of speech in an auditorium of such heterogeneous uses [2, p 309]. An almost inevitable increase towards the low frequencies in a space with only 7 to 8 m³/person, is intentionally prohibited here, probably for the first time, by a number of unusual sets of low frequency and broadband absorbers selected from a family of Alternative Fibreless Absorber ALFA modules [3]. These were installed in a novel manner to enhance acoustic "transparency" throughout all parts of this enclosure for the benefit of all performances.

A total of 78 m² of Compound Panel Absorbers CPA and Broadband Compact Absorbers BCA [3] was mounted on the walls of the **orchestra pit**, well tuned to the respective instrument groups predominantly placed there. Additional mobile absorber modules may be introduced according to varying occupation and formations [4].

On the ceiling and the upper part of walls of the **auditorium** a total of 360 m² of bass absorbers (effective only below 125 Hz) was carefully and, of course, invisibly for the audience installed. All other claddings and decorations were designed and manufactured so as to strictly avoid any unwanted absorption at medium and high frequencies. The chairs were, following well accepted traditions [5], selected to achieve roughly the same absorption for the empty as for the seated auditorium [1].

With the large stage volume of 14 000 m³ coupled to the relatively small (7 000 m³) auditorium the acoustics would, as usual, heavily depend on the respective performance and scenery. In order to minimise the influence on the acoustical condition of the whole space for all uses, 220 m² of CPA (Figure 3) and 516 m² of Micro-perforated metal cassettes 10 to 80 cm apart from otherwise rigid surfaces were permanently installed in the **stage tower**. Basic Formats

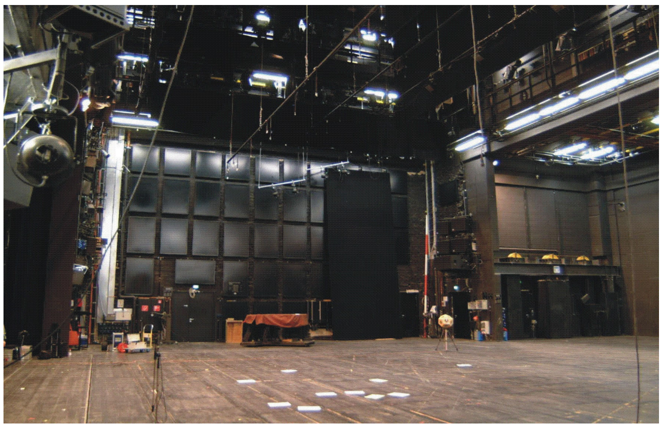

Figure 3: Low-frequency absorbers installed in the stage tower.

Results and assessments

This project concludes a room acoustic design strategy which started 10 years ago with distinctive low-frequency absorption measures in small spaces like orchestra pits and rehearsal rooms [6, 7] and confirms Mc Cue's judgement that conventional "design criteria have misled many architects into designing „boomy" environments with no control over low frequency sound energy from percussion and bass instruments. A room with uneven response upsets the balance between sections of the ensemble and masks many of the sounds that define timbre and articulation "[8, p. 36].

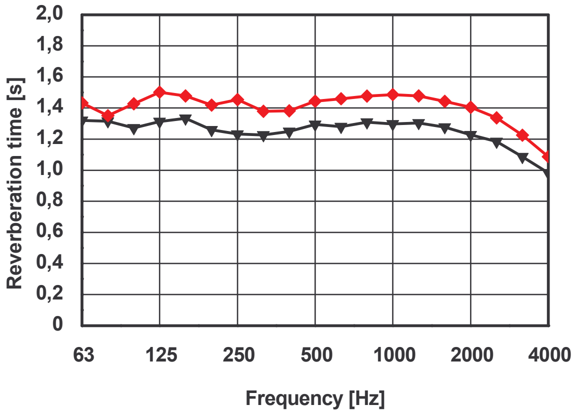

Figure 4: Reverberation time T_{60} with (▼) and without (◆) the stage tower coupled to the auditorium

The **reverberation time** T_{60} in the auditorium (Figure 4) is almost constant just around 1.4 s for opera use. When the stage tower is coupled to the auditorium, T_{60} varies but slightly due to the very basic absorber installations there. For concert use a large rigid and completely closed orchestra shell was planned which would have raised T_{60} to 1.7 s ±10%. Unfortunately this installation (Figure 5) left a 4 m broad gap open at its rear part and 2 m at its front part. Thus unwanted coupling of high absorption to the concert hall kept the reverberation time almost to the same value as for opera use.

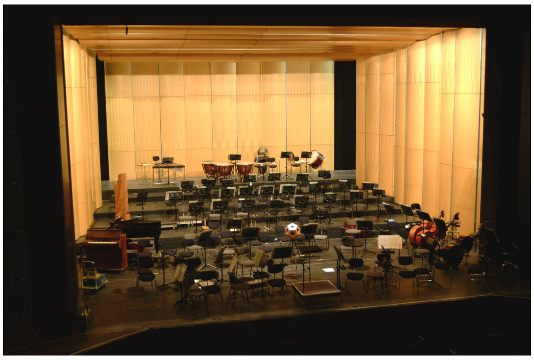

Figure 5: Partly open orchestra shell on the stage

The **sound pressure level** distribution (for sources on the stage) varies by less than ± 3 dB throughout the auditorium, even in the middle of the stalls i.e. in the centre of the cylinder, thanks to the numerous large-scale reflectors permanently installed.

Figure 6 shows the **clarity** C_{80} as averaged over the stalls and both tiers for opera and concert use, respectively. Its slight reduction towards lower frequencies is still within expectations between –1 and 4 dB in accordance with [9]. The orchestra shell, incompletely closed, increases $C_{80(3)}$ on the stage by more than 3 dB.

Lateral fraction $LF_{F(3)}$ according to [4] exceeds values of 20% on all 3 audience levels for opera use. The shell for concert use further increases this important room acoustic criterion considerably. The A-weighted **background noise** level in the auditorium does hardly exceed 20 dB(A), increasing towards the lower frequencies.

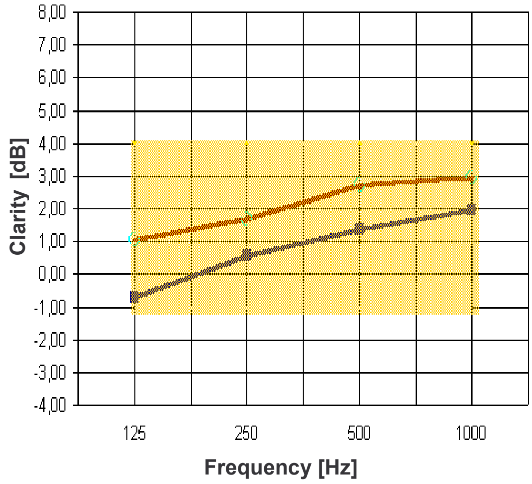

Fig. 6: Clarity C_{80} in the auditorium for opera (○) and concert use (●) (with shell).

In summarizing one may state that the recently reconstructed Großes Haus of the States Theatre Mainz is suitable for all 4 uses without any restrictions. The objective room acoustic parameters show good results without cost-intensive variable or electro-acoustically supported acoustics being employed.

References

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