

# Compromises in orchestra pit design; a ten year trench war in The Royal Theatre, Copenhagen.

Anders Chr. Gade \* Bo Mortensen □

\* Department of Acoustic Technology, Technical University of Denmark, Build. 352, 2800 Lyngby, Denmark  
□ School of Architecture, Royal Academy of fine Arts, Philip de Langes Allé 10, 1435 Copenhagen K, Denmark

**Abstract:** In 1984 the orchestra pit on the "Old Stage" of The Royal Theatre in Copenhagen was enlarged and its size made flexible. This new flexibility soon caused a formal battle between orchestra, singers and management regarding how the pit should be configured for each new production. In 1995, increased concern about the musicians' hearing and the increase in popularity of opera opened up for a new renovation adding even more flexibility to the pit including compromises which were tolerable for all parties; but during the ten years between the two renovations numerous objective measurements, subjective surveys and computer simulations were carried out in order to illuminate the effects of pit configuration on the acoustic conditions for performers as well as for listeners. The results of these investigations may help in balancing the different concerns in future orchestra pit design.

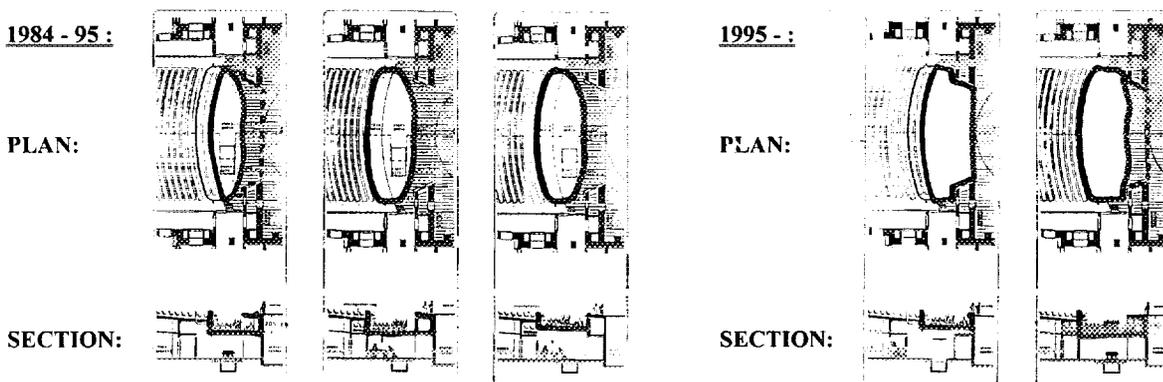
## INTRODUCTION

The "old stage" of the Royal theatre in Copenhagen is the primary opera and ballet theatre in Denmark and home of the Royal Danish Ballet and Royal Danish Orchestra. Inaugurated in 1874, the theatre is built in the classical Italian horse shoe shape with about 1400 seats distributed on an almost flat floor plus four balcony levels.

## THE PIT RENOVATION 1984 - AND ITS PROBLEMS

In connection with a major renovation and enlargement of the back stage facilities in 1982 - 86, also the orchestra pit was enlarged and made flexible in order to accommodate large orchestras as needed for the operas e.g. by Verdi and Wagner. The floor in the new pit was split up in three individually adjustable elevator sections, of which one could be raised to audience level and fitted with two seat rows, while the one closest to the stage was overhung by a new fixed forestage (Fig. 1). Consequently, a modest size orchestra occupying only two of the elevator sections could either be placed in a low position partly under the forestage, or it could be positioned in a fully exposed pit (with a more flexible floor height) in front of the forestage - at the expense of the first two seat rows. In cases where the total pit floor area was demanded, some members of the orchestra would have to be covered by the new forestage. The singers liked the idea of the orchestra being partly covered fearing that otherwise they would be overpowered.

However, the orchestra soon started complaining fiercely about being placed under the forestage and also about the then necessary low level of the floor elevators, both factors leading to lack of communication with the stage and lack of being able to develop the former famous timbre quality of the orchestra in the room. Also the new pit floor construction with the wooden floor flush mounted on a layer of gypsum boards (required by fire protection regulations) was claimed to be a reason for the reduced timbre quality of the orchestral sound.



**Fig. 1:** The orchestra pit in the Royal Theatre Copenhagen after the renovations 1984 and 1995 from left to right: 1984 - 95: low /partly covered, low/uncovered, high/uncovered ; 1995:- high without forestage, low/with forestage.

## ACOUSTIC INVESTIGATIONS

During 1986 and 1987, we carried out different subjective investigations during rehearsals and performances in order to illuminate the musicians' problems as well as the effects of different pit configurations on the balance between singers and orchestra in the three different positions of the pit: low and partly covered, low uncovered and high uncovered (as shown to the left in Fig. 1). Nearly all musicians reacted strongly against the partly covered situation (although only few musicians were actually placed under the forestage), and they also strongly preferred the high floor position to the low one. In contrast to this, it was not possible for a panel of trained listeners in the auditorium to agree on any difference in singer/orchestra balance between the three pit configurations. Also later listening to artificial head recordings showed that the configurations (or the performances ?) caused no clear differences - whereas large balance differences occurred between different seating areas. Eight years later, computer simulations with the ODEON program confirmed this results. In other words no trace of the orchestra overpowering the singers in the high uncovered pit could be found; but if the management was to satisfy the orchestra, they would never be able to sell the seats in the first two rows.

These findings were also supported by objective measurements in a few seat positions and in the pit with an omnidirectional impulsive source placed in the pit. While differences in total level (G) and EDT measured in the audience area were less than 0.5 dB and 0.1 sec. respectively between the three configurations, the energy of total reflected sound in the pit ( $ST_{total}$ ) increased by 3 dB and EDT (in the pit as well) decreased from 0.9 to 0.6 sec. between the high pit floor and the low and partly covered situation.

## THE 1995 RENOVATION - AND FURTHER INVESTIGATIONS

In 1994, when the Danish Working Environment Service demanded measures taken against excessive noise levels in the pit - and the increased popularity of opera had aroused the management's interest in better utilisation of the first two and most profitable seat rows, a new renovation became possible. The solution agreed on was to make the forestage moveable (see Fig. 1), so that the rear part of the orchestra would not have to be covered except in rare cases demanding both maximum pit size and forestage. This would also imply that the front seats could be sold for all performances requiring only medium orchestra size and no forestage. Removing the forestage made the balance question arise anew. However, ODEON simulations revealed that the forestage only affected the balance in certain upper balcony areas through reflecting the singers' voices to these areas.

This change was implemented during the summer 95 along with a reconstruction of the pit floor as a single layer pine construction supported by a special cross lath system for maximum "sounding board" mobility. A sample of this new floor had been tested objectively and by musicians with floor supported instruments (cellos and double basses). When mechanically excited the sound levels in the region 125 to 500 Hz produced by the single layer floor was about 10 dB higher than that radiated by the old floor, and this improved radiation was clearly preferred.

In order to satisfy the Danish Working Environment Service, also possibilities of adding variable absorption to the pit walls were mandatory in the new renovation. The effect of this was tested through measurements in the old, open pit without absorption and in the new open pit with absorption on the wall towards the stage. The floor elevator heights as well as the floor areas were equal in the two cases. The measurements in the furnished but empty pit aimed at revealing changes in early reflection energy ( $St_{early}$ ), in total level versus distance (G) as well as in EDT. The results showed no changes in G or in EDT as a result of applying the absorption; but a significant one to two dB reduction in  $St_{early}$ . In other words, the absorption on the walls would not reduce the levels at the musicians' ears as intended - most likely because this is mainly determined by the direct sound from nearly instruments - whereas the musicians feeling of support to their own instruments and ease of ensemble - known to be provided by the early reflections - is reduced. Actually, reducing the early reflection energy and so depriving the musician of the ability to balance his sound with that from his colleagues - and the singers - may even make him play louder and so increase the risk of hearing damage !

## CONCLUSIONS

Musicians dislike being hidden in deep and partly covered pits, and there seems to be good reasons for giving this fact high priority in design. As to the concerns about hearing damage, adding absorption to surfaces in the pit seems to have very little effect. Sound levels at the musicians' ears should be controlled through well planned seating arrangements, use of sound screens in critical positions - and probably a more considerate performance practice. Since 1995, the orchestra has been very satisfied with the pit, there have been no complaints about the orchestra overpowering the singers and the orchestra is said to have regained its former warm sound quality.