DETAILS ON THE PROPOSED ARCHITECTURAL MEASURES

Jens Jørgen Dammerud, September 2011

BACKGROUND

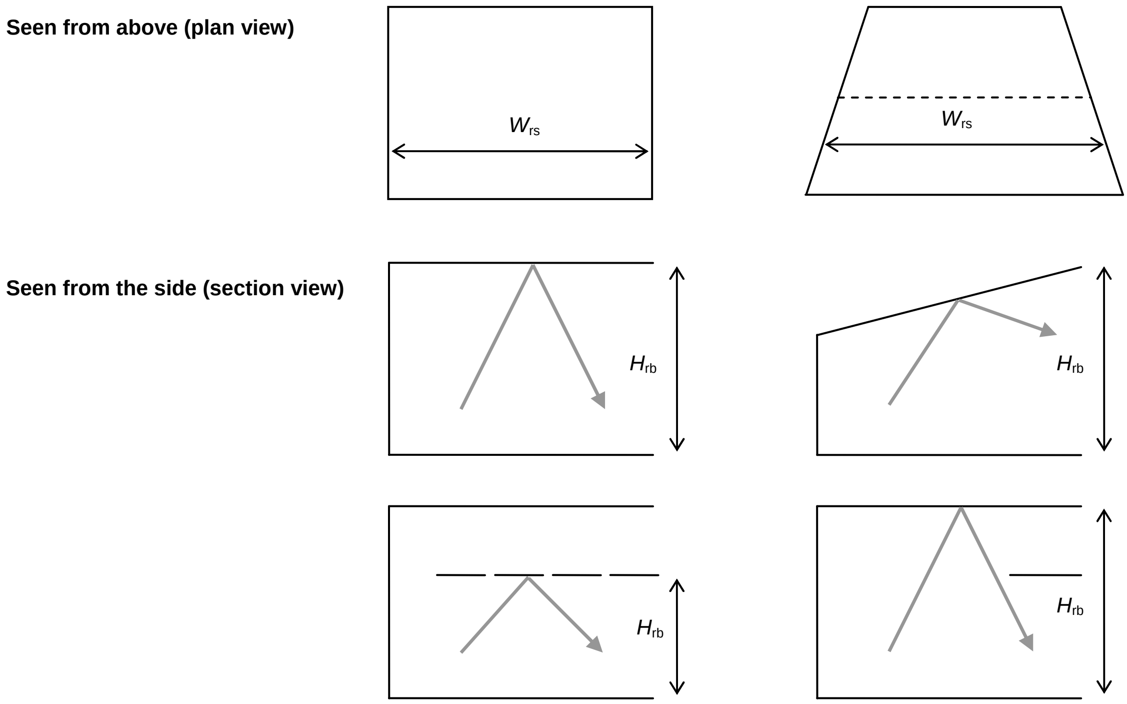
Some of concepts that evolved from the author's PhD study (Dammerud, 2009) were the within-orchestra sound level and reflections from the stage enclosure regarded as either compensating or competing relating to the within-orchestra sound level balance between instrument groups. The within-orchestra level is the sound levels imposed by the symphony orchestra itself without any reflecting surfaces present apart from the floor and risers the players sit on. A compensating reflection contributes to raise the level of the weak instruments and consequently improve the perceived level balance between the groups. String players are typically the instrument groups that have low sound levels on stage. On the contrary, competing reflections are categorised as those reflections that contribute to raise the level of instruments on stage that are loud without any stage enclosure present. The percussion and brass are found to have the highest sound levels on stage without any stage enclosure. One of the hypotheses that evolved from these concepts is that reflecting surfaces at the sides close to the string players will be most effective as compensating reflections, while reflecting surfaces above or behind the orchestra can contribute with competing reflections.

The best way to test the subjective relevance of the concept described above would be to measure the acoustic response on stage with a full symphony orchestra present and with information regarding the direction of all sound reflections on stage. Alternatively the conditions on stage could studied in a computer modelling software where the orchestra can be included as well as the directivity of the radiated sound and the direction of reflections easily studied (though with some limitations regarding the validity compared to the real situation). In such a case the acoustic response mutually between string players across the stage and between strings and the players at the back of the stage (percussion and brass) could be studied. The established method for assessing concert halls stages (the *ST* measures) includes neither the orchestra on stage or information regarding direction. As a pragmatic alternative a set of architectural measures were proposed as part of the PhD work. The major motivation behind these architectural measures was to get an idea of the level of the sound reflections from the percussion and brass down towards the string players, and the level of reflections that could compensate for low mutual levels between the string players. By having quantitative measures it would also be possible in a simplified manner to test the subjective relevance of the location of reflecting surfaces on stage. The proposed architectural measures showed significant correlation with the musicians' judgment of overall acoustic impressions and therefore suggest that the location of reflecting surfaces on stage is relevant. The use of the architectural measure must be seen as primarily for detecting reflecting surfaces within the stage enclosure that have clearly positive or negative consequences for the orchestra. There are a lot of other details of a stage enclosure that not would be included in these simplified measures. But proposed architectural measures are therefore most relevant for detecting stage enclosures that have either a low or high potential of leading to optimal conditions for the orchestra.

EXAMPLES OF VALUES OF ARCHITECTURAL MEASURES

The figure on the following page provides some examples of stage enclosures and the resulting values of the proposed architectural measures W_{rs} and H_{rb}. W_{rs} and H_{rb} represent respectively the distance between reflecting surfaces at the sides (within the front half of the stage depth) likely to reflect the string sound and the distance up to reflecting surfaces above the orchestra likely to reflect percussion and brass down towards the strings. These examples can hopefully contribute to clarify how the architectural measures correspond with details of the stage enclosure.

As seen from the figure, H_{rb} is set to the overall ceiling height with an outwards sloping ceiling where there will be no reflection from percussion and brass down towards the string. The same will be the case if a reflector array is above the string section only (or the woodwind as well), since this will also lead to no reflection of percussion and brass down towards the strings. A vertically tilted reflector would be treated similar to the outwards sloping ceiling (not shown in the figure). This leads to the reflector array section above the woodwinds and strings not being encountered for at all with the proposed architectural measures. This illustrates the limitations of the proposed architectural measures. Whether the reflector section above the woodwinds or strings will have a positive or negative effect for the different instrument groups or the conductor is not studied in detail in the PhD study. Meyer (2009) studied the conditions for the conductor in terms of location of reflecting surfaces surrounding the orchestra. The results suggested that reflectors above the strings can make the string section too loud, while overhead reflectors reflecting the woodwinds could be beneficial. Regarding a reflector array covering the whole orchestra, the level of reflections from percussion and brass will depend on the details of the array, like angling and diffusing (sound scattering) properties of the array panels. Carrying out real measurements of the acoustic response with the orchestra present, from percussion and brass to the string section and sideways across string section, will show the level of compensating and competing reflections in a much better way. But the architectural measures can be used for instance to reveal if the overall height available on stage is too limited or if the stage overall is too wide, deep or shallow (by including the proposed architectural measure *D*).



OVERALL COMMENTS

When studying quantitative measures as well as qualitative characteristics of the stage enclosure, the results from the PhD study overall suggest the following: with a sufficiently narrow and high stage enclosure (in terms of distances to reflecting surfaces) a reflector array above the orchestra is not needed regarding the conditions for the musicians. With a narrow and high enclosure the orchestra will also be well exposed to the acoustic response from the main auditorium and a build-up of reverberant sound at a high level within the stage enclosure itself can be avoided. Such conditions appear to make it easier for the players and conductor to be part of what the audience hears to some extent and adapt their performance to provide the audience with the best possible experience. But in several concert hall the stage is rather detached (enclosed) from the main auditorium and the ceiling height is limited. A recent proposed design of an overhead reflector array (Arau, 2011) is interesting in this regard, where the reflections of percussion and brass down towards the strings appear to be effectively reduced. An overhead reflector array may also be needed with respect to the conditions for the audience. But such a reflector array can be designed to not reflect much sound directly down towards the orchestra and instead direct the acoustic response from the main auditorium down towards the orchestra to improve the acoustic contact with the main auditorium on stage.

The situation on stage regarding both early reflections and late, reverberant reflected sound is complex. Previously the focus has been on absolute level of early and late reflected sound on stage without the orchestra present and where the direction of reflected sound and directivity of the musical instruments have been ignored. The absolute levels of reflected sound on stage appears to have some subjective relevance, but a common measure for absolute levels both within the audience area and on stage would be preferred. Using the well-established measure G is therefore proposed. By having measured G and C_{80} both in the audience area and on stage, the level of the early and late acoustic response can be found and compared. One of the significant findings from the PhD study is that the directions of early and late reflected sound appear highly relevant for the players on stage. The architectural measures assess to some extend the direction, level and delay of early reflected sound on stage in a simplified manner. It is hoped that inclusion of directional assessment, the concept of compensating and competing reflections as well as the level balance between the level of reverberant sound on stage and in the audience area can take discussions on stage enclosures and reflector arrays to a higher level.

REFERENCES

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