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The influence of the simplified architectural model on the acoustical simulation results

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The sometimes complex architectural shape of halls creates modelling difficulties as the simulation computing systems need plane surfaces. In order to approach a perfect shape of curved surfaces, a big number of facets is necessary. This poses, as a consequence, computer memory problems which is the case of the horse shoe shaped Opera House with its richly decorated columns, balconies....... This paper compares the acoustical measurement results and the calculation results of a computer simulation software applied on several models (from the most simple till the most complex ones) of the Grand Theatre of Bordeaux.

INTRODUCTION

Most historical opera houses have curved shapes, both the inside geometry of the hall and the other architectural elements. During the modelling, in order to carry out the acoustical simulation calculations, we were forced to introduce simplifications as the software requires plane surfaces.

The best approach of curved surfaces necessitates a big number of facets. This often poses a problem for the computer program memories are limited.

The here presented research on the Grand Theatre of Bordeaux is a good illustration of this type of problems. In order to compare the Reverberation Time measures and the calculated values for different hall configurations (open flytower and closed pit, open flytower and open pit and closed flytower and closed pit) with the Epidaure software several models were constructed under Autocad.

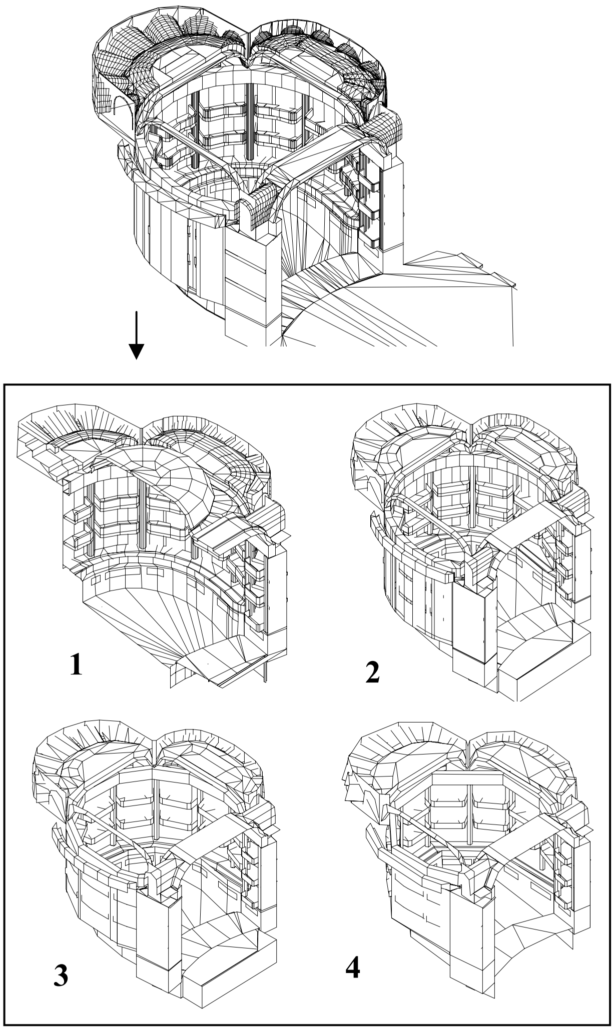

FIGURE 1. A completely modelled part of the GTB and the model simplifications (mod 1 - mod 2 – mod 3 – mod 4).

COMPARATIVE RESEARCH

Elaboration models

We compared each configuration listed above with the four hall models in all degrees of complexity (1-4).

The different models are presented on Figure 1. A completely modelled part of the GTB (26696 facets) is first presented. Below are the model simplifications (mod 1 : 3466 facets - mod 2 : 1784 facets – mod 3 : 1220 facets – mod 4 : 811 facets).

The model nearest to the actual hall shape possesses such a big number of flat facets that it necessitates to work on a half-hall. In this case a perfectly reflective plan closes the hall volume.

For that reason a comparison is only possible if we put a central sound source on the stage, even with the total models.

Concerning the other models, the facet reduction due to the shape simplification, allows us to work on the entire hall. Figure 2 shows the reduction process.

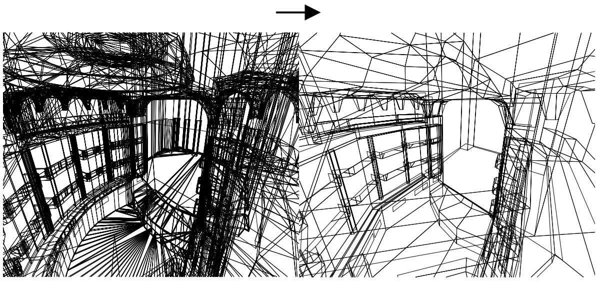

FIGURE 2. From the initial model (26696 facets) to the final simplified model (811 facets)

CALCULATION RESULTS

The here presented results concern only the closed flytower and closed pit configuration. We made a first comparison on the RT60 criterion between measurements and calculations on models whose material acoustical characteristics are taken from the literature [1]. Then we carried out a model adjustment based on measurements by changing the absorption coefficient values in order to approach the comportment reality of the used materials.

As during the shifting from model (1) to model (4) the number of facets reduces, it is necessary to take account of the absorption surface changement given to each set of facets constituting a part of the hall (f.e. the audience area or the proscenium...).

Figure 3 shows the reverberation time curves corresponding to the first comparison and figure 4 corresponds to the second one. The conditions in which the acoustical measurements of each configuration are made are described in a previous article [2].

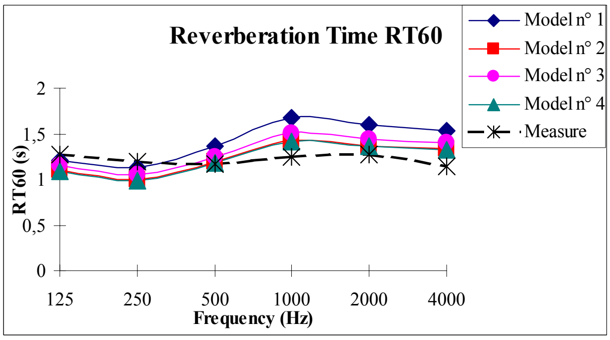

FIGURE 3 Before adjustment

Starting from model 1 we made the adjustment and as a consequence the material selection for all the models (see Table 1).

Table 1. Materials properties

Surface	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Wood 1	0.33	0.27	0.24	0.17	0.17	0.14
Plaster	0.11	0.09	0.07	0.04	0.04	0.05
Seats	0.15	0.30	0.37	0.43	0.40	0.38
Wood 2	0.03	0.04	0.08	0.12	0.12	0.20
Stage	0.15	0.10	0.05	0.04	0.04	0.04

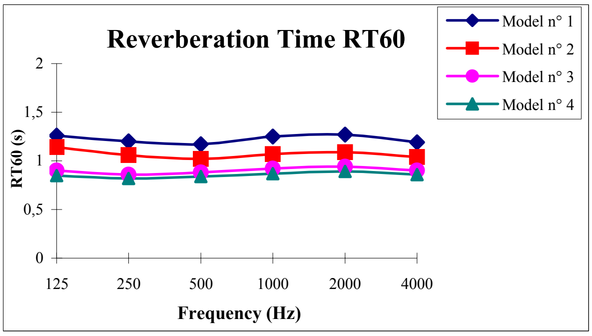

FIGURE 4. After adjustment

We can see in figure 4 the differences due to the form simplifications: the less facets the model possesses, the more the calculated RT 60 is small and as a consequence the expectation with regard to the reality will be incorrect.

CONCLUSION

We were able to give prominence to the simplification role of the geometrical form of a hall model on the simulation calculations. We can imagine that the more we simplify the model, the more the predicting results will be incorrect.

REFERENCES

1 Lamoral, R., *Acoustique et architecture*, Masson, Paris 1975, pp. 54-56.

2 Semidor, C., Barlet, A., *Journal of Sound and Vibration* **232(1)**, 251-261 (2000