Acoustic behavior of a tense-structure

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Abstract: in this paper the acoustic behavior of a tense-structure has been analyzed. The experimental measures underlined the particular behavior of the ceiling that provoked sound focusing and a lack of intelligibility. A numerical model was obtained to gain improvements of the acoustic quality in the theatre; some hypotheses on disposing panels on the ceiling were studied, and a procedure to obtain an equivalent absorption of the ceiling was undertaken.

THE TENSE - STRUCTURE

Since the 1970s in the city of Pergine Valsugana (TN) a tense-structure has been utilized to perform ensemble performances as well as prose and cinema. But since the beginning the acoustics of the hall, especially the intelligibility, seemed to be very poor.

A thorough acoustical study was then undertaken, in order to achieve an acceptable sound quality in the hall, with particular reference to the intelligibility, being the hall utilized mainly for speech and cinema.

FIGURE 1 the tense-structure and the CAD drawing of the model

ACOUSTICAL MEASUREMENTS

In order to improve the sound field in the theatre, binaural measurements were performed in the hall by using an omnidirectional loudspeaker, fed by the signal produced by a MLSSA board installed in a portable PC, and sampled through a dummy head. From the measured IRs the acoustical parameters defined in (1) were calculated, as well as the preference index maps suggested by Ando (3).

The results of the measurements underlined the limitations of the sound field. Due to the shape and the dimensions of the hall, the listening quality was poor, the sound resulted to be focused, the intelligibility very little, especially in the seats where the strong late reflections coming from the roof covering were determining. The experimental measures were repeated, with different climatic conditions, and they pointed out the influence of weather on the acoustic behavior of the tense-structure, that “sounded” differently with different climatic conditions.

ACOUSTICAL SIMULATIONS

In order to determinate the sound benefits of an acoustical treatment in the hall, a numerical model was developed, as shown in fig 1. For evaluating the accuracy of the numerical model, a comparison between the experimental
measures and the computed values was made. An array of different seats under the curtain was chosen as criteria to verify the degree of agreement between measured and simulated EDT. The sound absorbing coefficients of the roof covering were modified with an iterative procedure, until the values of EDT agreed.

To obtain a reasonable values of the sound absorbing coefficient of the roof, some measurements were made on the ceiling, by measuring a calibrated pressure-IRs as close as possible to the cloth, and a calibrated velocity-IRs directly on the cloth. From the ratio of the two different measurements it was possible to obtain precious information on the acoustical and dynamic behavior of the ceiling.

In a following step, a set of panels were inserted in the numeric model in order to limit the strong reflections coming from the ceiling, and give stronger early reflections in the middle of the hall, where the measurements pointed a set of late reflections not useful for intelligibility.

![Figure 2](image)

**FIGURE 2** Point n. 21, set of reflections coming from the ceiling

**CONCLUSIONS**

The measurements clearly showed that such a tense-structure cannot give a good acoustical field. From the numerical model many hypotheses were conducted, and auralization examples were obtained as well. The simulations too underlined the impossibility to obtain good acoustical results without a heavy architectural modification of the theatre. A procedure to determine the sound absorption coefficient of this kind of curtain has been just investigated, and new experimental measurements are required to improve some numerical problems related probably to the presence of poles during the ratio between the two functions.

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