

Acoustic adjustment of large Sports Halls. Case study: correction of the acoustic response of an Ice Arena for uses other than skating.

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ABSTRACT

In 2016, the municipality of Folgaria - North Italy - decided to use its ice arena for various activities due to the difficulty in the economic management of a structure exclusively dedicated to ice skating.

This is a structure with a playing field of 2,500 m² and 1,000 m² for the grandstand. The roof has two flaps with a variable radius curved course and a maximum height of 19 meters. The total volume, equal to 53,000 m³, was initially characterized by a reverberation time of about 8 seconds at the middle frequencies.

The author has been commissioned for the feasibility study aimed at verifying possibilities for intervention. The second step involved the detailed design of the interventions and their cost for the preparation of the competitive tender. At the beginning of 2018 the building process was contracted and the works, of which the author was the Construction Supervisor, were completed in November. The reverberation time is now equal to 2.2 seconds and allows the use of the environment for concerts, meetings, parties and sporting events of various kinds.

This contribution reports the whole history of the project, going from the construction phases until the final approval tests.

Keywords: Ice arena, Reverberation time, Interventions.

1. INTRODUCTION

In 2016 the town of Folgaria in Trento (Italy), given the difficulty in the economic management of a structure dedicated to ice skating only, decided to evaluate the possibility of its use for different activities.

It is a structure with a play area of 2.500 m² and 1.000 m² dedicated to the stands. The roof, made of a wooden structure, has two curved flaps with variable radius and a maximum height of 19 meters. The total volume, equal to 53.000 m³, was characterized by a reverberation time at the central frequencies of about 8 seconds. The preliminary study was aimed at verifying the feasibility of the work and propose solutions. The executive design of the interventions and the economic quantification of the works for the preparation of the call for tenders continued. At the beginning of 2018 the works were contracted out and the intervention was completed in November.

The reverberation time is now equal to 2.2 seconds, in line with the forecast data.

2. BACKGROUND

The ice arena of Folgaria is a structure built in different phases, initially there was only an outdoor plate, used for skating and events of various kinds. The ice rink has been covered and finally the administration has provided to close the perimeter of the structure. Following completion, the difficulty of managing the space for musical or "spoken" events identified significantly due to the high internal reverberation.

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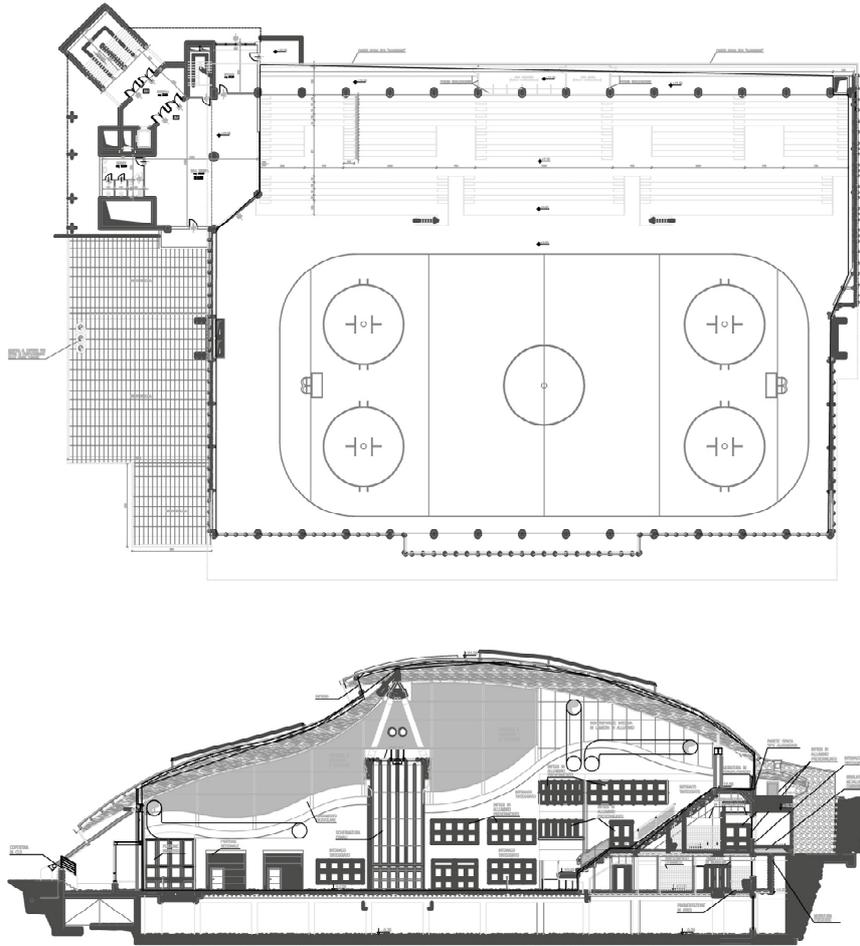


Figure 1 – Plant and section of the ice arena.

In Folgaria there is no tradition related to ice hockey or competitive skating. The administration has identified the need to use the structure for activities other than skating at the amateur level. These activities could include concerts, conferences, parties and other sporting activities not related to the world of ice. Initial checks showed an average reverberation time of 6.2 seconds from 125 to 4000 Hz, with positions where 9 seconds were exceeded at 500 Hz.

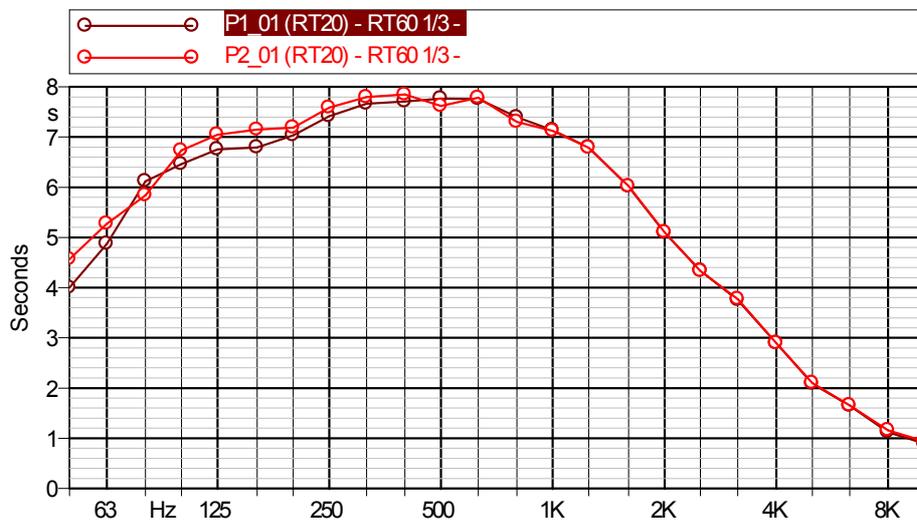


Figure 2 – Reverberation time for two source positions.

3. PLANNING OF INTERVENTIONS

The objective of the adaptation project was determined by the need to guarantee ideal conditions for the diffusion of music and speech with respect to the "stadium" configuration, in which reverberation plays an important role in creating an involving climate for sports fans. For this reason, the minimum objective was set at 3 seconds, with the will to go below 2.5 seconds.

The intervention points concerned:

- Creation of a sound-absorbing ceiling covering the board partially damaged by the humidity to which it was exposed before the complete closure;
- Realization of partial sound-absorbing coatings on vertical surfaces.

The project hypotheses were simulated using the ray tracing software Ramsete. The impulse responses generated by the model were then used to auralize the audio tracks to show the client the effect of the various intervention steps proposed.

Following the definition of the areas of intervention and the budget available, we started the phase of executive design and economic calculation for the next tender of the works.

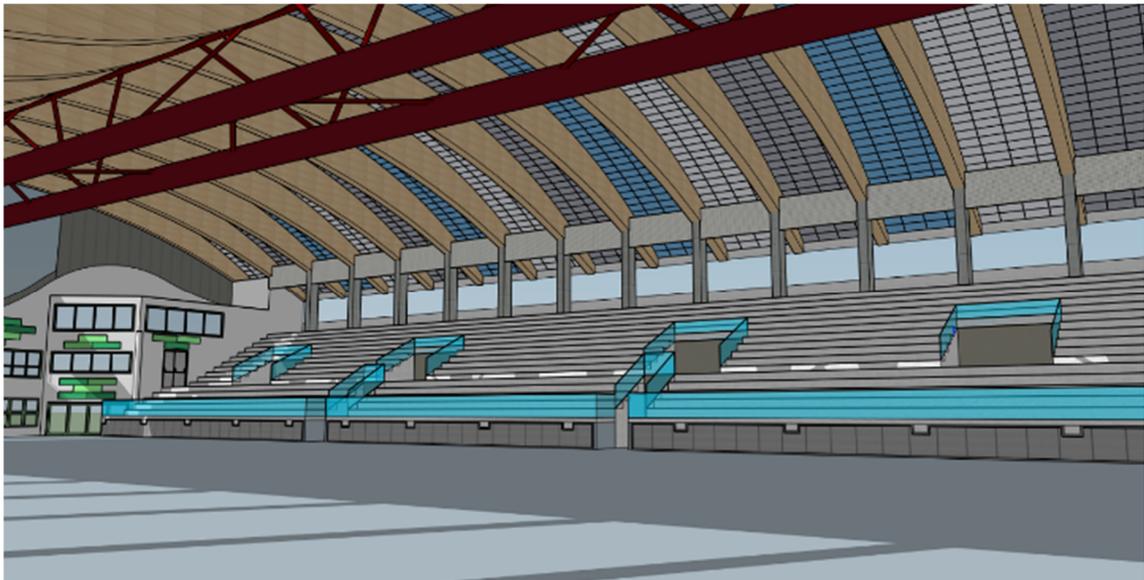


Figure 3 – View of the 3D model.

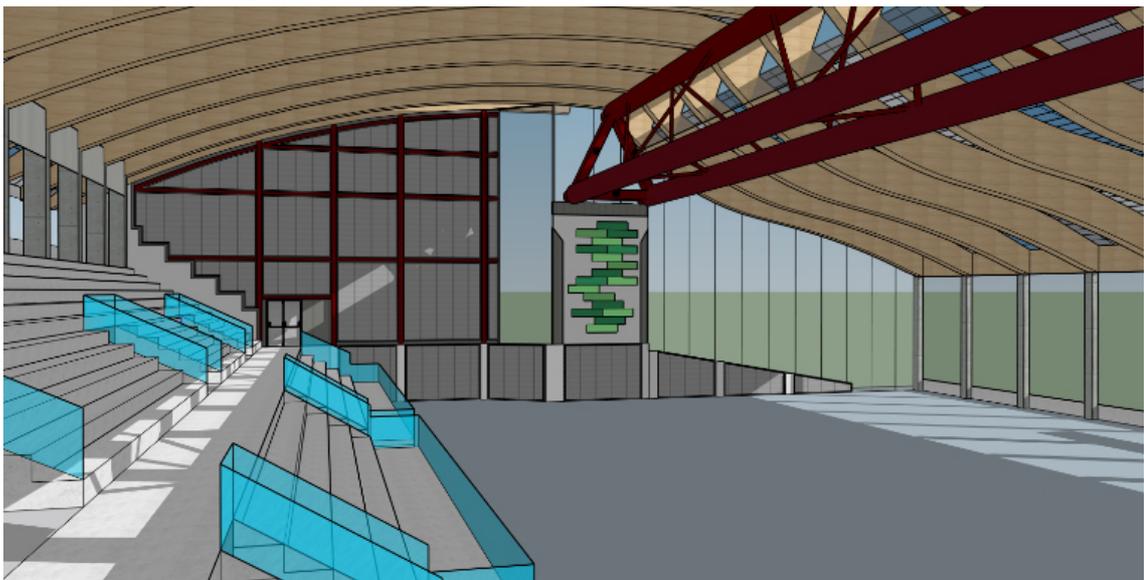


Figure 4 – View of the 3D model.

4. SUPERVISION OF WORKS

The works, which began in June and then suspended in the summer to allow sports events already planned, were completed in the autumn. In total, the following materials were installed in 60 working days:

Table 1 – Summary of the materials used and their location

Position	Material	Quantity
Roofing	Glass fiber panels	3814 m ²
Upper area tribunes	Perforated plasterboard slabs	238 m ²
Side wall and bottom area of tribunes	Perforated metal panels	376 m ²
Aeration system unit	Suspended elements – Baffles Dimensions 200x100x20 cm	26 pcs
Side walls	Aesthetics glass fiber panels Dimensions 120x60	84 pcs



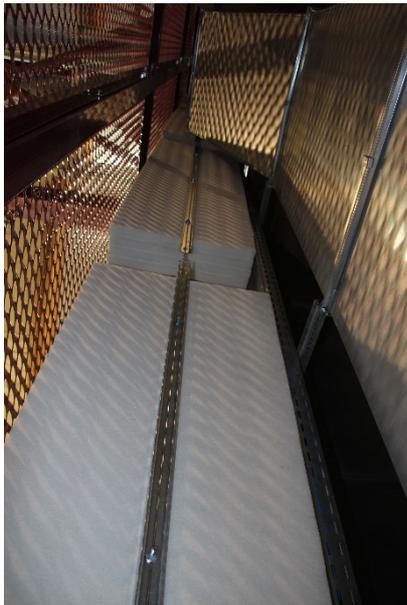
Figure 5 – Installation of the ceiling. Design and execution of the project.



Figure 6 – Realization of the acoustic ceiling. Installation of the grid and glass fiber panels.



Figures 7 – Installation of perforated metal panels on the side walls and under the grandstands.



Figures 8 – Installation of polyester baffles inside the aeration system unit.



Figure 9 – Installation of aesthetics glass fiber panels.

During the construction phases, various impulse response measurements were performed to verify the variation with respect to the quantities of material installed.

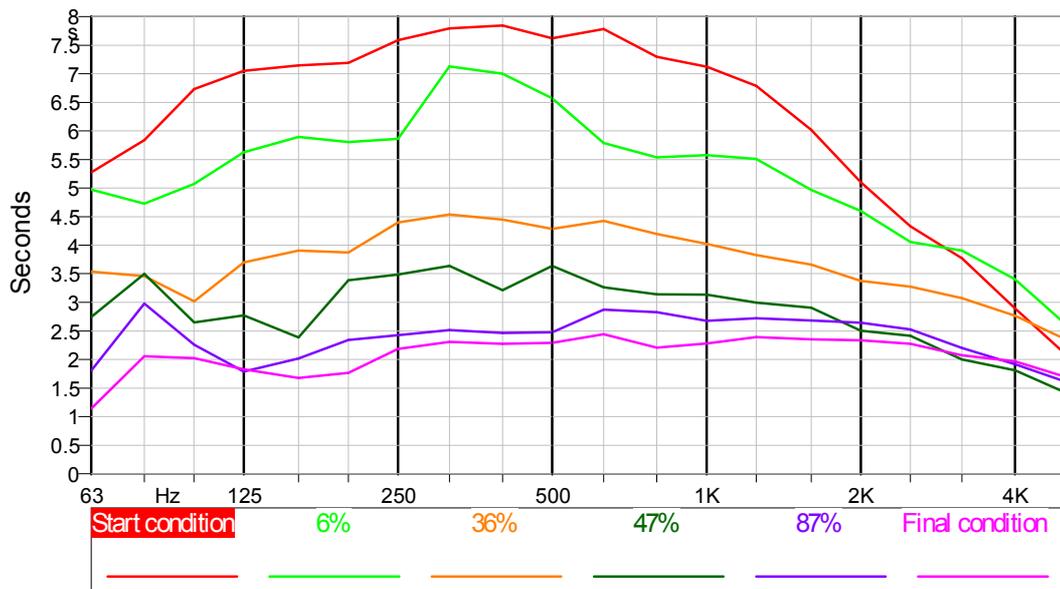


Figure 10 – T20 depending on the progress of works.

5. FINAL TESTS

At the end of the work, completed in November 2018, the verification of the impulse response was repeated, comparing the results obtained with the initial situation and with the forecast data of the calculation model:

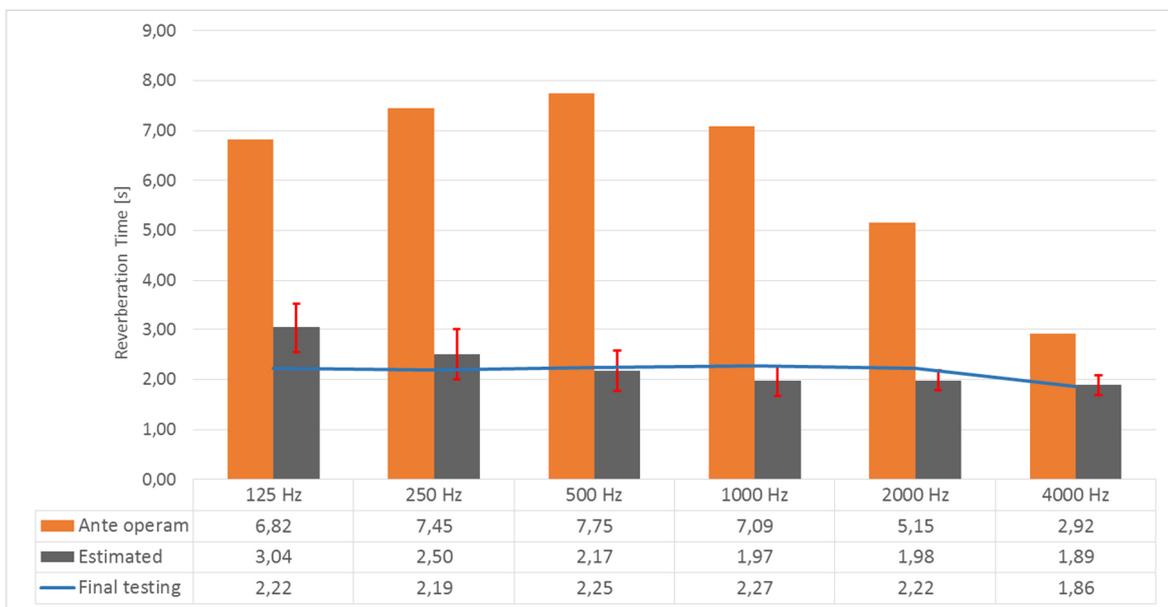


Figure 11 – Comparison of results (T20) ante/post operam and estimated.

Table 2 – Pre / post operam comparison of some quality indicators.

Parameter	Measured values		Suggested values	
	Ante	Post	Speech	Music
T20 [s]	6.20	2.23	1.2 ÷ 1.8	1.9 ÷ 2.5
C50 [dB]	-10.87	-2.83	> 2	-
C80 [dB]	-8.78	-1.17	-	-4 +2
D50 [%]	9.55	34.65	≥ 50	≤ 50
Ts [ms]	526	143	< 50	50 ÷ 250
BR	0.93	0.99	-	1 ÷ 1.25
STI	0.36	0.67	> 0.45	-

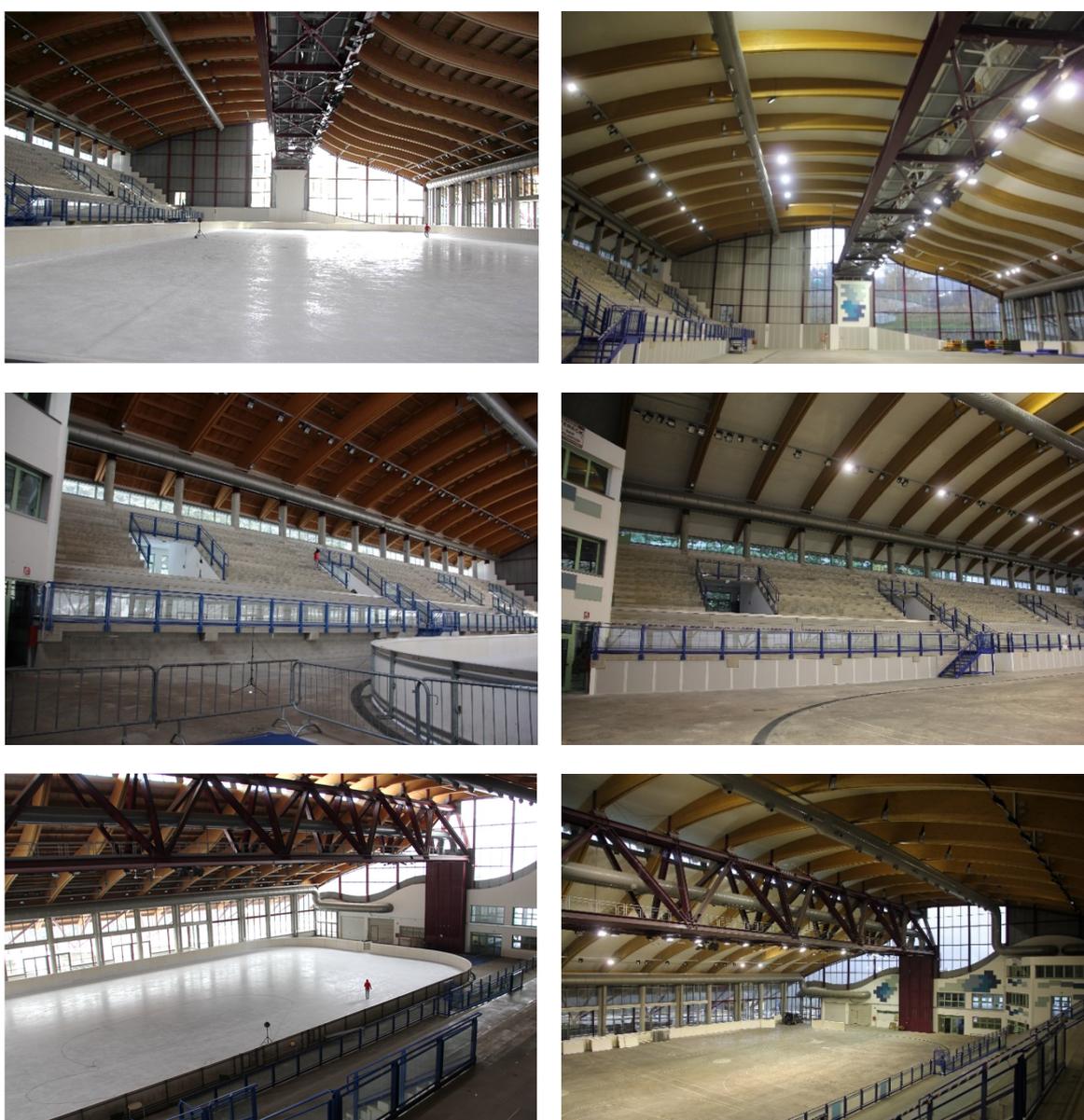


Figure 12– View of the inside of the ice arena before/after works.

6. CONCLUSION

The intervention has fully achieved the expected results. During the first events organized in the winter season 2018/2019 it was already possible to appreciate the considerable improvement in the intelligibility of speech and the clarity of music. From an economic point of view, the final amount of work was 5.7% lower than the cost of the project, with a cost of € 85 per square meter of material installed.

The acoustic characteristics obtained now make the ice arena of Folgaria a suitable place also for the organization of musical events. Thanks to the possibility of greater use of this space, the municipal administration will be able to amortize the investment made in an estimated period of time of 5 - 8 years.



Figure 13 – The ice arena after the end of the works.