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# Deepening the studies of the Roman theatre of Verona: acoustic effects from the installation of a barrier shielding the break-in of road traffic noise.

Lamberto Tronchin[1]; Antonella Bevilacqua[2]; Yan Ruoran[3]

[1] University of Bologna, Italy, lamberto.tronchin@unibo.it
[2] University of Parma, Italy, antonella.bevilacqua@unipr.it
[3] University of Bologna, Italy, ruoran.yan2@unibo.it

## ABSTRACT

The Roman theatre of Verona has always been subject to great interest under an acoustic perspective due to the continuous development of technologies that allow scholars to study monuments with more accuracy. Acoustic measurements have been carried out across the *cavea* to understand the existing conditions of the Roman theatre, been used for live musical events especially during summer seasons. The archaeological site is bounded to south-west by a road called Rigaste Redentore, which is an important arterial for the vehicular traffic crossing the city centre along the south-north direction. On this basis, the authors propose the installation of an acoustic barrier to protect the artistical performance from the road traffic noise. A deep analysis has been carried out by highlighting any difference in terms of acoustic parameters between the existing conditions, measured on site, and a digitally simulated condition with the insertion of a barrier.

Keywords: Acoustic measurements, Roman theatre, acoustic simulations, cultural heritage

## 1. INTRODUCTION

Recent research studies have been focused on the reconstruction of the original shape of the Roman theatre of Verona based on historical documents and archaeological excavations [1]. Furthermore, the employment of new technologies has contributed to complete the knowledge with respect to the early and late reflections hitting the architectural components of the Roman theatre [2].

This paper deal with the acoustic simulation of a barrier planned to be on the border line between the roadside and the archaeological site. The barrier has been designed to be 6 m high from the road level, considered in the model to be composed of a solid material (wood) capable of shielding the road traffic noise from Rigaste Redentore. The simulated results related to the main acoustic parameters have been compared with the measurements undertaken across the *cavea* of the Roman theatre. Differences and similarities have been widely commented.

## 2. SOME FEATURES OF THE THEATRE

The Roman theatre of Verona has been built along the slope of St Peter's hill by covering a surface area of 150 m wide and 100 m deep. The scenic building, realised on the edge of the river Adige, was composed of three doors, and the dimensions of this structure are 6 × 72 × 27 (W, L, H). The diameter of the orchestra is about 30 m and the proscenium is 1.4 m above the orchestra level. The original capacity should be of 3000 seats.

## 3. SITE CONDITIONS OF THE ROMAN THEATRE

The existing conditions of the Roman theatre have been developed since the first century AC, when the theatre fell in disuse and has been destroyed by Germans [3]. Further damage has been provoked by post-humous constructions that invaded the *cavea*, as visible by the prominence of the staircase of St Siro & Libera's church (built in 913), although other residential constructions have been removed during the archaeological excavations of the 20th century.

Another structure that is considered part of the site is the convent of St Jerome, developed during the 15th century due to expansion of the religious congregation [4].

### 3.1 Design Improvements

Since the Roman theatre of Verona has been restored to be one of the performing arts spaces to be active especially during the summer season due to the productive live musical events, the existing conditions of the road traffic noise breaking in the archaeological site is a main concern for the overall result of a peaceful listening condition. During summer season, a temporary wooden barrier is built for shielding the performance running outdoor from the road traffic noise, as shown in Figure 1.

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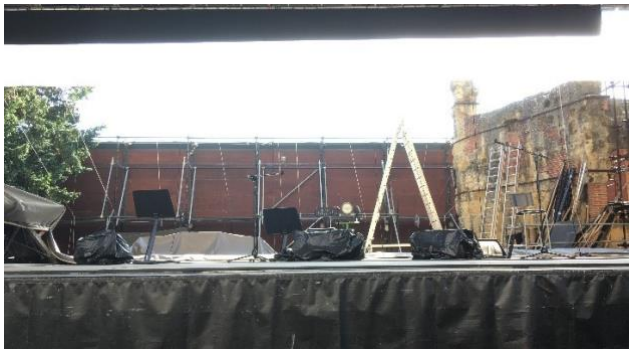

Figure 1 – View of a temporary acoustic barrier mounted behind the stage.

Different could be the solutions that can be adopted for reducing the extraneous noise levels of the road during the artistic performance, but this paper takes in consideration the solution proposed by the local authority. On this basis, a design of a barrier to be 6 m high from the level of Rigaste Redentore road has been used for the acoustic simulations. The barrier would be composed of smooth wooden planks to be installed vertically behind the partially erected scenic building.

The simulated results of this configuration have been compared with the measured values reflecting the existing conditions.

## 4. DIGITAL MODEL

A digital model has been realised in AutoCAD software package where all the layers have been grouped based on the existing finish materials. Thereafter it has been exported in dxf format, ready to be used for the acoustic simulation carried out with Ramsete 3.02.

The model represents the existing conditions of the Roman theatre of Verona, whose results have been compared with the simulated values obtained by adding the acoustic barrier designed to be at the edge of Rigaste Redentore road.

The absorption coefficients assigned to the entities of the model have been tuned based on the acoustic measurements undertaken in situ [5]. Figure 2 shows the digital model representing the existing conditions of the theatre with the barrier highlighted behind the scenic building.

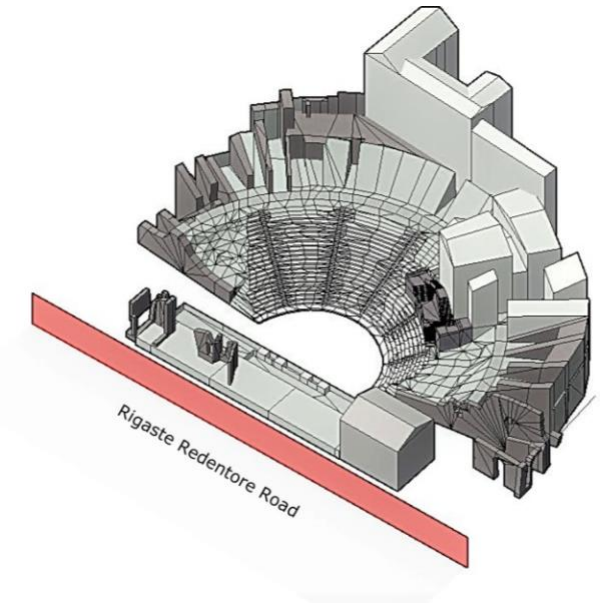


Figure 2 – View of the 3D model.

## 5. RESULTS IN COMPARISON

The main acoustic parameters have been analysed by comparing the measured values with the simulated ones representing the existing conditions with the addition of the barrier. The acoustic parameters have been analysed between 125 Hz and 8 kHz, to considered as the averaged values of all the receiver positions.

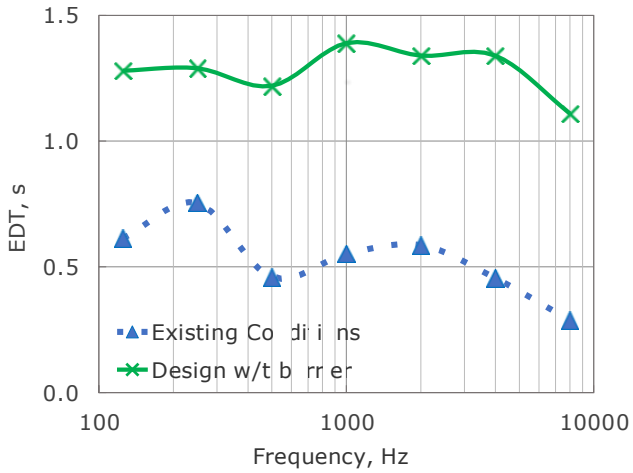


Figure 3 – Values of EDT.

Figure 3 shows that the EDT values have been found to be more suitable for music with the presence of a barrier behind the stage. The simulated results are up to 0.8 s more than the measured ones at each octave [6].

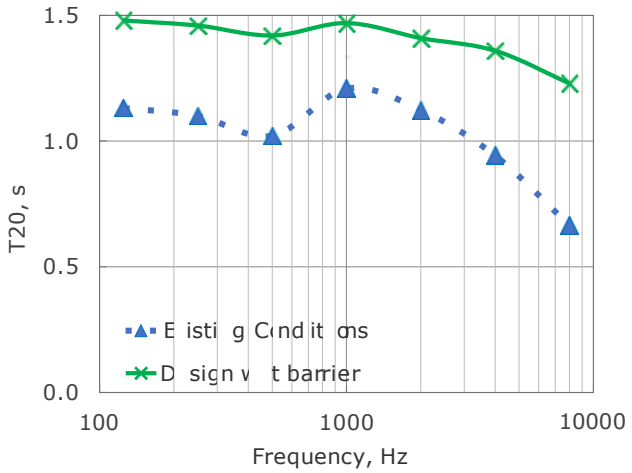


Figure 4 – Values of $T_{20}$.

Figure 4 indicates that the existing conditions of $T_{20}$ are around 1.0 s and the insertion of the barrier will increase the results of up to 0.5 s. Given the volume size of the theatre, to be composed of the *ima cavea* mainly, the $T_{20}$ will be more compatible with the musical shows that are usually performed [7].

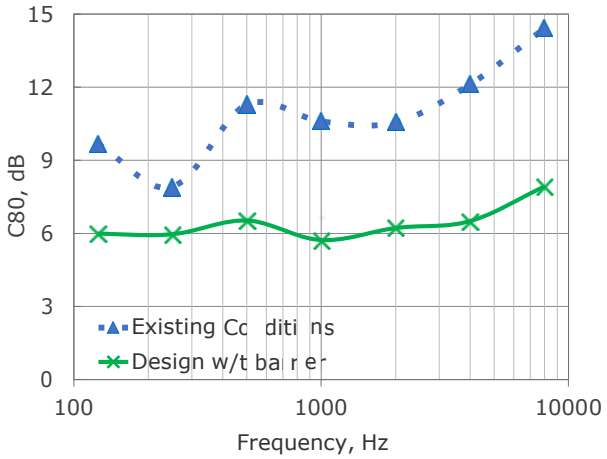


Figure 5 – Values of $C_{80}$.

Figure 5 indicates that the $C_{80}$ values related to the existing conditions are clear in terms of music [8]. The addition of the barrier makes the values clearer across all the spectrum, to be up to 6 dB more than the measured on site.

Figure 6 indicates that the values related to definition are comparable between both scenarios. The values fluctuating around 0.85 indicate that the speech definition is very good [9].

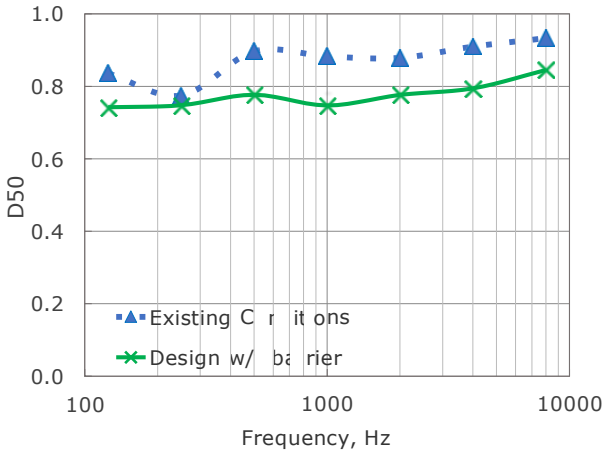


Figure 6 – Values of $D_{50}$.

## 6. CONCLUSIONS

This paper assessed the acoustic conditions of the Roman theatre of Verona by comparing the existing conditions with the addition of an acoustic barrier that contributes to limit the ingress of the road traffic noise, potential cause of a disrupting listening conditions during live performance inside the archaeological site.

The simulated values indicate that the insertion of a 6 m high barrier, placed behind the stage, will help to improving the acoustics of the theatre, by emulating the function of the scenic building that was covered by marble sheets. The addition of the barrier represents also a meaning of redirecting the sound towards the sitting area other than shielding the noise from the road.

Future research studies will be focused on the details of the barrier, in terms of texture and thickness, other than different options that could suggest the local authority to be considered for alteratives.

## 7. REFERENCES

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