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Comparison of the 3D acoustics of the Roman performing arts spaces in Pompeii

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ABSTRACT

Within the SIPARIO Project, a project founded by the European Community and lead by the Region Emilia Romagna, a specific acoustic survey has been carried out in the archaeological site of Pompeii. The ancient city includes three different Roman performing arts places: the theatre, the Odeon and the amphitheatre. The surveys have been conducted with different types of equipment: monoaural and binaural microphones, B-Format (4 channels) microphones and 32-channels probe (EigenMike EM32). This paper reports the most important outcomes obtained from the measurements, by including 360° acoustic maps that allow a study and the visualization of the early and late reflections. The panoramic acoustic maps have been compared among the above cited sites, and analyzed with reference to the standard requirements outlined by ISO 3382.

Keywords: SIPARIO Project, Pompeii Roman theatres, Intangible cultural heritage

1. INTRODUCTION

The development of the measuring technologies represents a great help for the researchers who actively attend deep studies on the ancient architectural patrimony. Especially for outdoor environments, the possibility of studying the direction of arrival of the sound rays during the IR is now possible to be achieved as experimented in the archaeological site of Pompeii. Scope of this paper is to compare the acoustic characterization of the Roman theatre, Odeon and amphitheatre of Pompeii based on 360° acoustic maps.

2. HISTORICAL DISCOVERIES OF THE ANCIENT POMPEII

The city of the ancient Pompeii has been taken under the attention of researchers especially after the excavations started during the 17th century [1]. The city has been buried since 79 AC under the lava of the volcano Vesuvius, but the archaeological discoveries allow the appreciation of the treasures of the Hellenistic style influenced by the previous Samnites [1].

Among the performing arts places, in Pompei it is possible to find the Roman theatre, located nearby the Odeon, considered the places for playing musical and prose events, and the amphitheatre located in the opposite side of the city, dedicated to the spectacles performed by gladiators and wild aggressive animals [2].

The Roman theatre of Pompeii had an original capacity of 5000 spectators, distributed across the *ima* and *summa cavea*, separated from the scenic building during the Hellenistic period and unified only by the Romans with the construction of corridors that link both structures, as shown in Figure 1.

Figure 1 – Roman theatre of Pompeii.

The Odeon built on the eastern side of the theatre had the function of playing proses (*odea*). This is the reason why the Odeon was provided with a contained volumetric space to be covered by a roof realised with a limited length of the wooden trusses [3]. The Odeon of Pompeii has a squared plan layout with a *cavea* not divided by horizontal corridors, as shown in Figure 2.

A different shape of a place dedicated for gladiators' spectacles is represented by the amphitheatre, built during 70 BC inside the *Regio II*. The dimensions of the axes are 131 m and 102 m, respectively related to major and minor [4]. The vertical division of the *cavea* in *ima*, *media* and *summa* follows the horizontal subdivision in

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wedged sectors, for a total capacity equal to 20000 spectators, as should be during the Roman Age, as shown in Figure 3.

Figure 2 – Odeon of Pompeii.

Figure 3 – Amphitheatre of Pompeii.

3. ACOUSTIC MAPS

Different campaigns of measurements were undertaken inside the theatre, the Odeon and the amphitheatre to understand the acoustic behaviour of the sound waves inside these specific volumes. The acoustic survey was carried out with the following equipment:

- Equalised omnidirectional loudspeaker (Look Line);
- Binaural dummy head (Neumann KU-100);
- B-Format (Sennheiser Ambeo);
- 32-channel spherical array (Mh Acoustic em32 Eigenmike®);
- Omnidirectional microphone (Bruel&Kjaer)

The excitation signal emitted by the sound source was the Exponential Sine Sweep (ESS) having a duration of 15 s in a uniform sound pressure level for the range between 40 Hz and 20 kHz.

The employment of a spherical array microphone allows the elaboration of 360° sound maps where it is possible to recognise the interaction of the surfaces with the sound waves, including early and late reflections [5]. The videos have been elaborated based on the receiver position across the *cavea*. The different sound energy has been represented by contour levels of a range of colors going between red tinge and blue-violet shades, representing a high and a poor energy, respectively, which might also depend on the external thermo-hygrometric conditions [6], in a global building analytics perspective [7].

Figure 4 to 6 show the direct sound inside the three case studies above described hitting the probe of the microphone. Whereas the shape of the wavefront is not perfectly round, the presence of wind was the main cause.

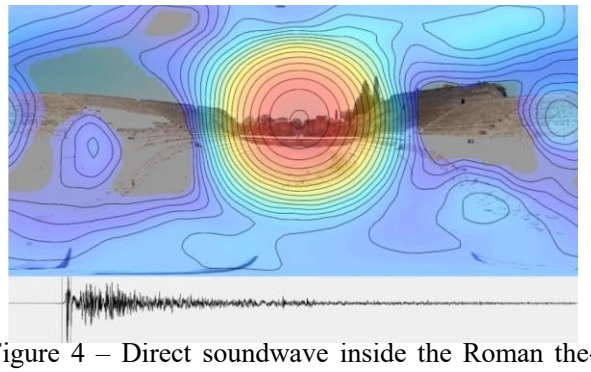

Figure 4 – Direct soundwave inside the Roman theatre of Pompei.

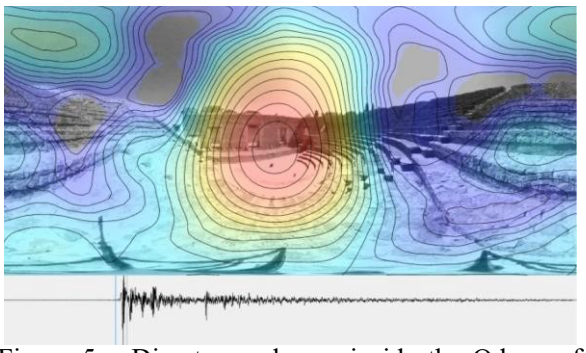

Figure 5 – Direct soundwave inside the Odeon of Pompei.

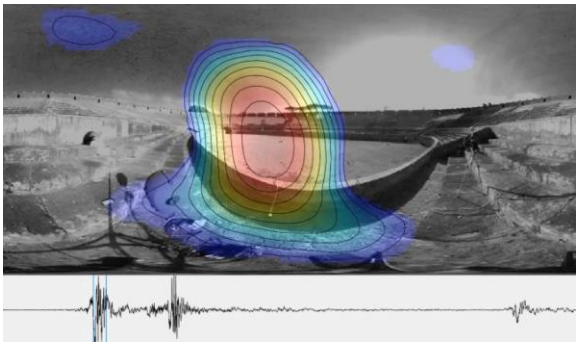

Figure 6 – Direct soundwave inside the amphitheatre of Pompei.

The sound intensity has been processed as contour levels based on a range of colours comprised between red and blue shades, representing a high and a poor sound energy, respectively.

Figure 7 to 9 show the reflection of the soundwaves, bouncing on the marble steps of the *cavea*.

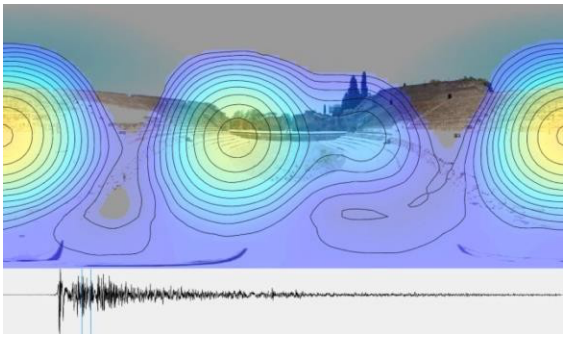

Figure 7 – Reflections inside the Roman theatre of Pompei.

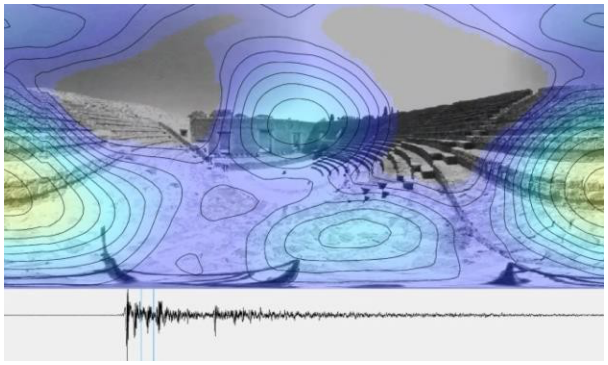

Figure 8 – Reflections inside the Odeon of Pompei.

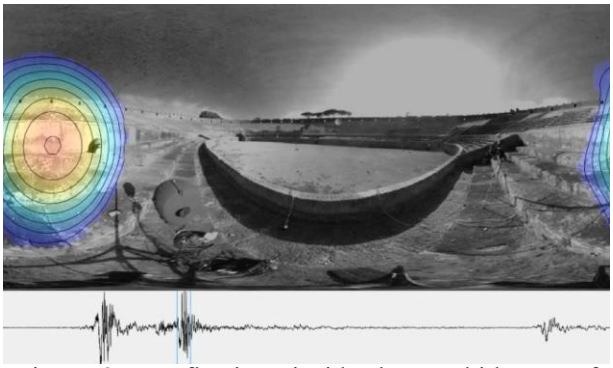

Figure 9 – Reflections inside the amphitheatre of Pompei.

4. CONCLUSIONS

This paper has shown that the innovative technology can help in deeply understanding the acoustics of spaces. The cases indicated in this manuscript are related to open-air performing arts spaces, located in the ancient city of Pompeii. Based on the position of the receiver across the *cavea*, it has been shown that specific architectural components of the room volume can contribute to detect the directivity of the soundwaves due to the uniform distribution of the capsules on the spherical front of the microphone [8].

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