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ARCHITECTURAL ELEMENTS TO DESIGN A SPACE EVOCATIVE OF ETRUSCAN TOMBS CHARACTERIZED BY A CONTEMPORARY ACOUSTIC RESPONSE FOR MULTIPURPOSE USES

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ABSTRACT

The new multipurpose space is located inside a concrete parallelepiped building. The internal perimeter partition walls create shapes and geometries typical of Etruscan tombs. They consist of a circular structure in plan built in squared blocks, surmounted by a pseudo-dome in slabs arranged in concentric circles with decreasing diameters to form a domed envelope.

In this paper the acoustic phenomena depending on the concave surfaces that characterize this space are presented, mainly focusing and whispering. Acoustic architectural elements are used to inhibit them against the architectural image and controlling the other main acoustics parameters such as the Reverberation Time.

The suggested construction solutions mainly refer to the chosen materials to realize the tumuli envelope.

1. INTRODUCTION

The project was based as a wish of the Luigi Rovati Foundation to create a place where to expose art collections, first of all their own collection of Etruscan vases.

The project takes shape starting from three macro interventions. The most important is the construction and realization of an underground space to house a museum for the important collection of Etruscan vases, a space even possibly used for multipurpose functions.

The design is inspired by the Etruscan oval burial mounds of Cerveteri but also by the treasure museum of the San Lorenzo cathedral in Genoa.

The space will host more than 300 pieces, a tribute to a folk, the Etruscans, who always had a lively relationship with the afterlife, as it is proved by the precious vases, jewels, sculptures and memorial stones, collected for the permanent exhibition.

As in Cerveteri where a large tumulus is surrounded by other smaller tumuli (suggesting that Etruscan society at that time was hierarchical and was governed by aristocrats), in the museum there are three different domes, with light and shadow effects, a metaphor for a civilization in a wise balance between earthly and non-earthly life.

A suspended atmosphere is present and the acoustics contributes to transform the visit to the museum into an emotional experience.

2. PROJECT DESCRIPTION

The project is designed by the architect Mario Cucinella and it includes a hypogeum space dedicated specifically to the Etruscan folk and a ground floor occupied by services. Near the museum, a restaurant and a bookshop offer services to the museum.

In the project, the Etruscan culture is innovatively presented, through a highly stimulating visual approach, offering a new way to visit the museum.

The new multipurpose space is located inside a concrete building. The internal perimeter partitions are fitted onto a metal structure to recreate shapes and geometries typical of Etruscan tombs.

There are three rooms, the tumuli, with its oval section, maximum 4 m high. They are circular in plan with radii of curvature accounting for 3.5 m, 4.25 m and 4.85 m respectively. The three rooms are connected to each other and to a large elliptical-shaped foyer whose main axes are respectively 16.5 and 8.5 m long. The housing forming the shape of the three rooms and the large foyer is made of overlapping elements intending to look like stones resting on each other and hung behind to a metal structure.

The large foyer aims at transforming the archeology in a common interest through educational activities, cultural studies and researches.

The whole project was developing by a team of interdisciplinary experts, to create not only a museum but a hub for the Etruscan world in Milan.

Moreover, the team requested the acoustic expert to provide for a sound quality supporting didactic activities, dossier film projections, with no unwanted sound effects (echoes, whispering, focusing) and a controlled reverberation, avoiding a too “dry” acoustic atmosphere and respecting the embracing image created by the stones.
3. GEOMETRICAL ACOUSTIC ANALYSIS

To control the acoustic field in the project, a geometrical acoustic analysis is considered where the concept of a wave is replaced by the concept of a sound ray and the main acoustic phenomena are studied, coming from the tumuli, circular in plan, and the surfaces, concave in section.

When a bundle of rays originating from a point S is reflected on a curved surface with radius R, they can be focused into the point P from which they diverge. This focusing occurs when the distance of the source from the concave surface is larger than R/2. If the incident bundle is parallel the focus is at a R/2 distance.

If the source is closer to the concave surface than R/2, the reflected ray bundle is divergent (although less divergent than the incident bundle) and it seems to originate from a point beyond the curved surface [1].

In section the tumuli shape is very similar to an ellipse or to an ellipsoid with two foci F1 and F2. If a sound source S is placed in one of them, all the rays emitted are collected in the other source.

For this reason, enclosures with elliptical floor are plagued by quite unequal sound distribution even if neither the sound source nor the listener are in a geometrical focus.

If the wall is smooth and uninterrupted by pillars, niches, etc., the rays remain confined within a narrow band: in other words, the wall conducts the sound along its perimeter.

Generally, a whispering gallery is an interesting curiosity, but if the hall is used for performances or for a museum with multipurpose functions, as in this case study, the acoustical effects conveyed are rather disturbing. This is the reason why focusing and whispering were checked in the project (see figure below).

4. ACOUSTIC ARCHITECTURAL SOLUTIONS

To avoid the disturbing effects of focusing and whispering and to control the acoustic field aiming at reaching the acoustic goals without changing the housing shape and the tumuli plan, some acoustic architectural solutions to reduce the sound reflections intensity and/or their path length and direction were investigated [3].

The acoustic architectural solutions had to allow to control the reverberation time in a range between 0.9 and 1.1 sec and within the Intelligibility index STI.

Porous materials, cavity resonators such as perforated panels or milled panels with air gap and sound absorbing material behind, membranes, diffusing and scattering surfaces were suggested.

To interrupt the rays, some horizontal protruding shelves were also considered. They are made of stones and covered by absorption material on the side facing the floor.
Deciding to respect the image of the tumuli made of smooth stones, many of the suggested acoustic architectural solutions were excluded [4] [5]. Just two were chosen to recreate the image of the stones: a fiberboard absorbing panel covered with concrete powder on one side and glued on a gypsum board to the other side to be anchored to the metal structure of the tumuli; and a cavity resonator made by the different stones rows of the tumuli spaced by air gaps with an absorbing panel fitted behind.

At first these solutions were tested in a reverberant room, the sound absorption evaluated in compliance with the standard UNI EN ISO 354 [6] and the rating of sound absorption was compliant with the standard UNI EN ISO 11654 [7].

A tested solution is the fiberboard panel, density 60 kg/m³, thickness 4 cm, covered with concrete powder.

Another tested solution is a cavity resonator made of stone rows, 5 cm wide with an air gap in between, 6 mm wide, supported by the fiberboard panels fitted to the floor.

The third solution is similar to the second, supplementing an air gap, 5.5 cm wide, between the stones and the fiberboard panels.

5. CONCLUSIONS

Some acoustic technical solutions were designed to reduce the sound reflections intensity, as to avoid the audible whispering and focusing effects, initially forecasting their fitting inside the housing.

The optimization of their position to reach the goals asked for a prediction analysis with a dedicated software and it is still in progress e, but a distribution still to be checked is provided in the figure below:

From 0 to 2 m high, resonators are introduced: in between a horizontal stone row and the other, an air gap, 6 mm wide is fitted. Behind the rows, parallel to them, an absorption panel is fitted to a gypsum board with an air gap in between, 5.5 cm wide. A random distribution of the absorption panel is forecast on 80% of the stone surface.

From 2 m to 3.5 m high, the same resonators are used but with a random 40% distribution.

From 3.5 m to the top, absorption panels covered with concrete powder are forecast.

Some few horizontal protruding shelves could be also considered according to the museum layout.

6. REFERENCES


