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# Observational Results of the Normal Evacuation of Aspendos Ancient Theater After Concert Event

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**Abstract**

One of the important criteria of the safety of the structures is to ensure safe evacuation. In buildings with high occupant density, the number of factors affecting the evacuation increases. In heritage buildings such as the ancient theater, there may be different problems in evacuation, such as late egress, due to what insufficient egress etc. In this study, the results of the observational evacuation measurement of the normal evacuation after the concert of the Aspendos theater in Turkey, which is the ancient theater of the Roman Period, are presented. The evacuation time of the crowd from the building and the walking speed on the stairs were observed. Obtained results were compared with studies in literature. It is seen that the walking speed is slower than expected due to the architectural features of the theatre such as inappropriate stairs. To ensure safe evacuation in cultural heritage structures without damaging the structure, improvement suggestions can be made regarding guidance for route selection. There is not enough study exist in the literature about the evacuation of ancient theaters. Evacuation works to be carried out in these structures, which are actively used in cultural activities, are important for safe use.

## 1. INTRODUCTION

One of the most important factors in building safety is to provide safe evacuation in situations that require emergency intervention such as fire, attack, explosion, or chemical substance spillage that may occur in buildings. As the number of factors affecting the evacuation such as crowded user groups, simultaneous exits, bottlenecks, audience seats and complex building designs increases in structures such as concert halls, theaters, sports halls, and arenas, evacuation becomes more difficult [1]. The simultaneous exit of crowded groups in these structures may cause congestion and crowding during evacuation. Evacuation in buildings can be measured with drill and simulation models. However, it can be said whether the structures are safe or not according to the evacuation time estimation [2,3].

Historical buildings also contain different problems in terms of evacuation safety. [4] The structural features of historical buildings differ from modern ones. For example, riser heights and door widths may not be in standard sizes. This creates confusion for the evacuated people and slows the evacuation. Measures that can be taken to increase evacuation safety in these structures may conflict with preserving the features of the structures. Irreversible interventions may be required to comply with codes and regulations [5, 6].

In the study, the results of the observational evacuation measurement of the normal evacuation after the concert that took place at the Aspendos Theater, which is the ancient theater of the Roman Period, will be presented. The reason for choosing this building is that it is one of the best-preserved ancient theaters with the structural features of the ancient Roman period. The other reason is that the building, which was built in the A.C. 2nd century, is still used for cultural events today.

Structural and acoustic analysis studies were carried out at the theater in Aspendos, but no study on evacuation was found. In addition, there is no evacuation study related to ancient theaters in the literature.

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The theater is a typical Roman theater reflecting the Roman period. The Ancient Roman Civilization was founded in the 9th century BC and lasted for 1200 years. The civilization, which reached wide borders around the Mediterranean, developed socially, politically, and economically [7]. Various assembly structures such as a theatre, an amphitheater, an odeum, a hippodrome, and a parliament building were built in these ancient Roman cities.

Vitruvius described the plan of a theater structure in detail in his book De Architectura, which he wrote in the 1st century BC. The theaters are planned by drawing four equilateral triangles to the center after their location and the center is chosen. The vertices of these triangles determine the direction of the steps. The measurements of the seats should not be less than a foot and a palm, and not more than a foot and six fingers. Their depth should not be more than two and a half feet and not less than two feet. He also stated in the book that the entrances should be made in large numbers and wide so that the theater can be evacuated without a stampede [8].

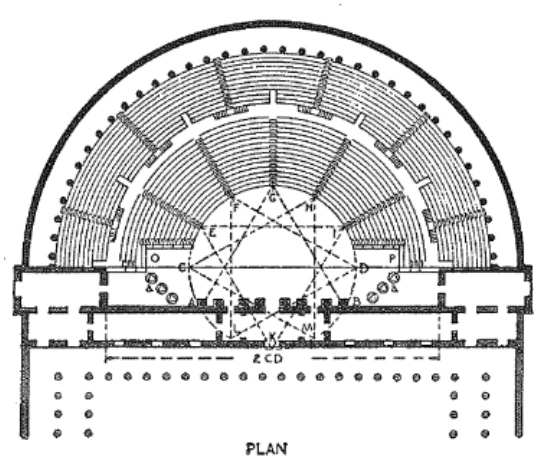



***Figure 1.*** *Roman Theater Plan According to Vitruvius [8]*

No permanent theater was built in Rome until 55 BC. Temporary wooden theaters were used for the shows until this date. The first stone theater was built by Pompeus in BC. It was built in 55. Roman theaters are characterized as the more advanced and state of Greek theaters, which were built according to geography and natural conditions. [9]

The main differences between Roman and Greek theaters are the differences stemming from the cultures and levels of development of the two communities. But this is not a sharp distinction. One of the most distinctive features of the Roman period is that the orchestra and cavea sections are semicircular. Another feature is that the theater can be built on arches and columns on a flat land without the need for a slope [9].

## 2. FEATURES OF ASPENDOS ANTIQUE THEATER

Aspendos is an ancient city in the Province of Lycia-Pamphylia, which was included in the borders of the Roman Empire in 43 AD [10]. It is in the Serik district of today's Antalya province. The theater in the city is one of the best-preserved examples of ancient Roman theaters in the world. The architect of the theater, which was built during the reign of Marcus Aurelius (161-180 AD), is Xenon. The theater, which was used throughout the Roman period, was restored, and used as a caravanserai in the 13th century when the city came under the rule of the Seljuks. The traces of repairs made during the Seljuk period can be seen on the monumental door and facade plasters made on the exterior of the stage building [11].

***Figure 2.*** *Outside view of Aspendos Antique Theatre, photographic date is uncertain.* [12]

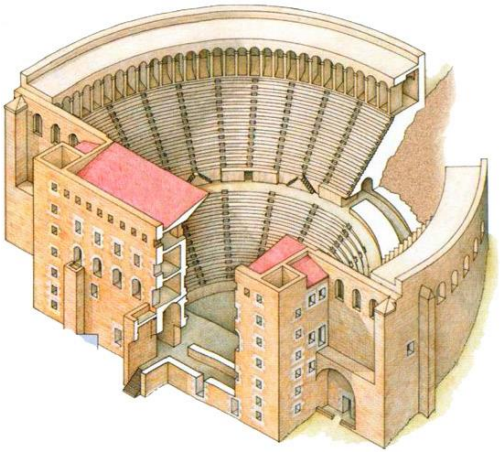


***Figure 3.*** *Aspendos Theater Partial Section Perspective [13]*

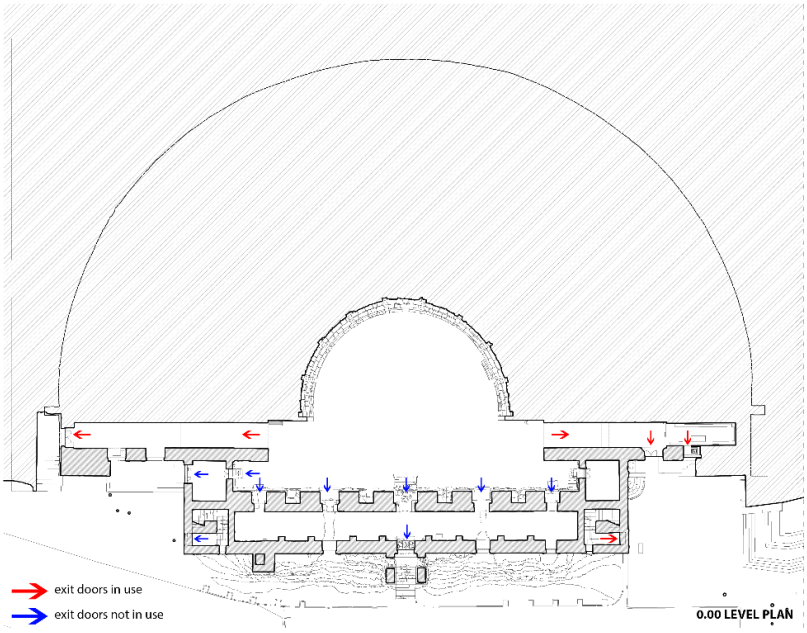
The theater shows the typical features of Roman theatres. The cavea (seating places) and the stage building is a closed theater built as a whole. With this feature, it is unique among the examples that have survived to the present day in Turkey. There is a vaulted gallery at the top of the cavea [14]. The theater leans on a hillside, but there is a vaulted passage under the cavea.

The diameter of the cavea section of the theater is 96 m. 20 rows of seats in the lower cavea and 19 rows in the upper cavea are separated by a corridor (diazoma). There are 10 rows of stairs in the lower part of the cavea and 21 rows of stairs in the upper part. The upper cavea is reached by six double stairs from the diazoma [15]. The height of the sitting rows is 43 cm on average, and the width is 60 cm on average. Cavea stairs were built by dividing the row of seats into two, with one step per seat. Above the cavea, there is a vaulted gallery in line with the height of the stage building. In a previous study, 0.50 $m^2$ area was allocated for each audience and the audience capacity of the seating areas was calculated as 7000 people [11].

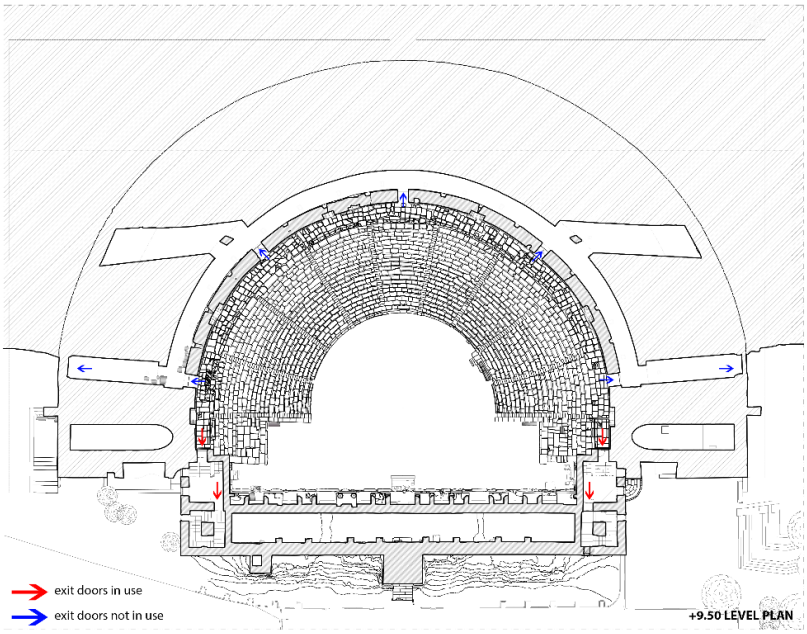
The stage building is 62.48 m long and 4.10 m wide. At both ends of the stage building, there are stairs connecting the diazoma and the vaulted gallery. There are five doors used as stage entrances. The door in the middle is the largest and a monumental addition was made in front of it during the Seljuk period. At the top of the stage building, there is a floor with 17 windows corresponding to the vaulted gallery in the cavea [11].

## 3. OBSERVATIONAL EVACUATION STATUS OF ASPENDOS ANTIQUE THEATER

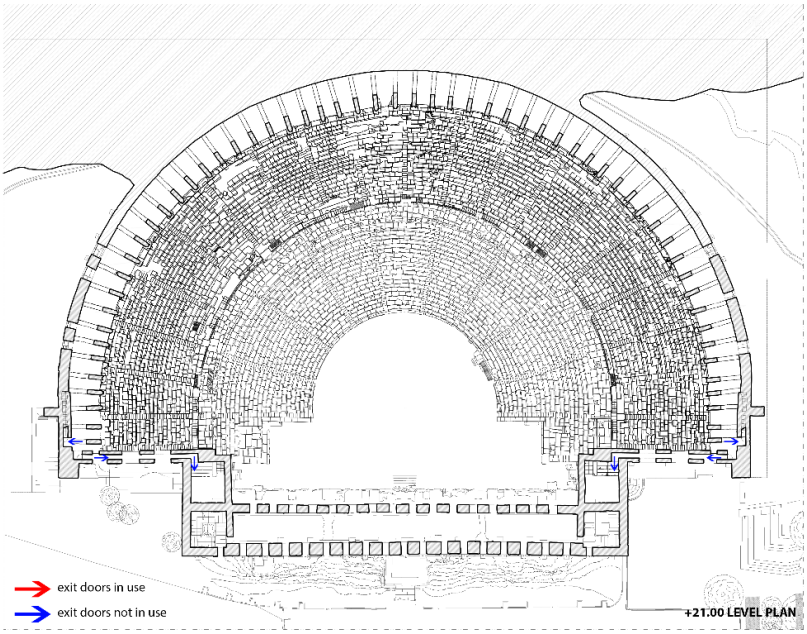
Aspendos Antique Theater is used in various shows and concerts today. To observe the crowd evacuation during the concert, observations were made by going to the Gala Concert event, the closing concert of the 28th International Aspendos Opera and Ballet Festival.
The survey drawings of the building were obtained by interviewing the company that prepared the final restoration project of the Aspendos Antique Theater in 2010. Exit doors that are in use and not in use during the event are marked on the plans below. Exits from the building are provided from 0.00 level. There are 4 doors used for exit. Currently, there are 5 doors that can be accessed behind the stage in the stage building and 2 doors that provide an exit from the building. Since these doors were closed, they could not be used for exits during the event. The exit from the upper levels is provided by the stairs on both sides of the stage building. With these stairs, it is possible to exit through the doors in the corridor between the caveas at +9.50 level. However, since the exits at +21.00 level are closed, only the stairs in the cavea can be exited from this level.




***Plan -1***




***Plan -2***




***Plan-3***

During the observation, the duration of the evacuation was measured by using a stopwatch. In the event where 1233 people were present, it took 16 minutes for all the spectators to leave, except for the security and concert staff, from the moment the concert ended. According to the information obtained from the General Directorate of State Opera and Ballet, the statistics of the audience at the concert event are given in the Table 1. According to these data obtained from event ticket sales, the number of seats is given as 1944. 63.43% of these seats were sold and a total of 1233 people attended the event.

***Table 1.*** *Number of Attendees and Occupancy Rate of the 28th International Aspendos Opera and Ballet Festival Gala Concert Event*

| Protocol | 52 |
|---|---|
| full price | 714 |
| off-price | 467 |
| Total Attendance | 1233 |
| Number of Seats | 1944 |
| Overall Audience Percentage | 63,43% |


***Photo-1***
*Time: 01.01*


***Photo-2***
*Time: 01.47*


***Photo-3***
*Time: 02.01*


***Photo-4***
*Time: 02.29*

During the evacuation, one person from the audience was selected and the evacuation behavior was observed and documented with video and photo shoots. In the images taken from the video, the time of the selected person to descend the stairs in the lower cavea is seen in the minutes of the video. The person descended the 40 stairs in the lower cavea in a total of 88 seconds. The descending speed of the person whose horizontal distance and descent time is known was calculated as 0.13 m/s. The results obtained in the study in which the relationship between the stair riser height and the angle made by the step width and the walking speed were measured are given in Table 2. According to these results, walking speed increases as the stair angle decreases [16]. The observed person is male over 50 years of age. In the measurements made in the cavea section on Figure 4, it is seen that the angle is 35 degrees on average. With these results, the speed of the selected person is expected to be 0.50 m/s. When compared to the walking speed seen because of the observation, it can be said that the walking speed during the evacuation in the ancient theater of Aspendos was slower than expected.

***Table 2.***
*Relationship between stair angle and walking speed*

| **Stair Gradient** | Elderly | | Young | |
|---|---|---|---|---|
| | **male** | **female** | **male** | **female** |
| 38,8 | 0.41 | 0.46 | 0.50 | 0.47 |
| 35,0 | 0.50 | 0.53 | 0.57 | 0.56 |
| 30,5 | 0.56 | 0.60 | 0.65 | 0.62 |
| 24,6 | 0.68 | 0.76 | 0.77 | 0.75 |

Horizontal walking speeds: (m/s)
Stair-gradient: (degree)
Data of pedestrians aged more than 50 is applied into "Elderly"
Data of pedestrians aged from 30 to 50 is applied into "Young"
*Note:* [16]

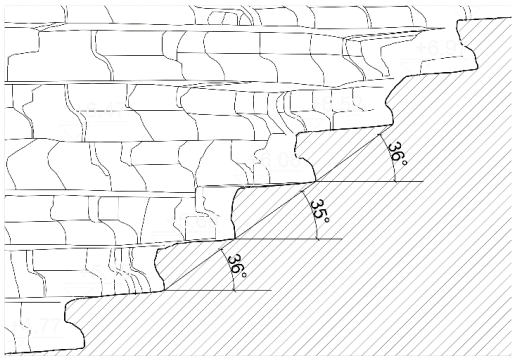


***Figure 4.*** *Cavea angle in Aspendos*

## 5. CONCLUSION

A negative situation in cultural heritage structures can cause great damage to the structure and users and visitors. Due to the non-standard features of these structures, the evacuation process may be different than expected. In this study, the observational results of the crowd evacuation of the Aspendos Antique Theater, which is a cultural heritage, are presented. With the observations made after the concert attended by 1233 people, it was seen that the crowd emptied the building in 16 minutes. During the evacuation, the spectators descending the cavea stairs created a blockage. This is due to the pier heights and step widths of the steps. The pier height of the stairs in the theater varies between 21 cm and the width of the steps between 22 cm and 38 cm. The walking time on these stairs was measured as 1.28 minutes on 40 steps for the male audience over 60 years old. Due to this slowness, accumulations occurred on the stairs. Another blockage was seen

at the +9.50 level, at the exit door with the stairs of the stage building. It can be said that the reason for this obstruction is the differences in the dimensions of the stairs, as in the cavea.
Entrances to the concert were made through a single door facing north due to ticket control. After the concert, it was observed that most of the audience preferred the same door for exit. The choice of the customary and known route during the evacuation is expected from human behavior. However, this situation caused a crowd in a single door. It was observed that there was a lack of directing the spectators to evacuate by the personnel assigned here.
In future studies, evacuation safety can be measured by comparing the evacuation simulation with the actual evacuation time. To ensure safe evacuation in historical buildings without damaging the structure, improvement suggestions can be made regarding routing and route selection.

## CONFLICTS OF INTEREST

Thanks to the Strategy Development Directorate of the State Opera and Ballet General Directorate of the Ministry of Culture and Tourism of the Republic of Turkey for sharing the event data, and Okyanus Engineering Inc. for sharing the survey drawings of the Aspendos Antique Theater.

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