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Contribution of architectural design of ancient city Dara's water cisterns to the water efficiency of the city

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Abstract

Drought and difficulty in accessing to water is one of the problems encountered by Mesopotamia region for centuries. Insufficiency of the water resources has brought forth the need of storing water and necessitated the construction of the cisterns in this region in the past. Application of the correct design techniques in the architectural design of the cisterns shall provide saving in storing, transporting and transferring the water. Within this context, starting with the fact that the cisterns have a significant place within the immovable culture heritage of Mesopotamia region, the aim of this study to determine the contribution of architectural and technical design of water cisterns of ancient city Dara to the water efficiency of the city in the past. Within the scope of the study, it is adopted to conduct literature review, to identify the cisterns on-site, and to document the current statuses of them via photographs as method. Within the scope of the study, it is seen that the design of the cisterns is shaped according to the topography and the working principle is coincided with the principle of computational fluid exactly. It is determined that this system provided great saving in storing, transporting and transferring the water in Mesopotamia region, where it is necessary to use the water in the most efficient manner.

Introduction

People have designed various architectural elements in order to access water easily. Cisterns are the architectural designs designed as open or closed, where the fresh water is stored. Stored water is transported to the place in need of water in the city via the watercourses. Water and water supply is in the lead of the most important problems for Mesopotamia regions, which is located on the south, for centuries. Construction of the cisterns was commenced in order to store the fresh water resource and to bring it to the city through a watercourse. When the design of the cisterns is made in a true manner, a significant amount of water shall be saved in storing, transporting and transferring the water. The cisterns of the ancient city of Dara, which is the subject of our article, are among the unique examples of Roman and Byzantium architecture world in the world's architecture history in terms of both technic and design. Within this context, the aim of this study is to investigate the architectural design of ancient city of Dara's water cisterns in terms of technic and design, and to research the contribution of the system established to the water efficiency of the city in the past. As a result of the study, it shall be revealed whether the correct design techniques have been used and to what extent the water has been used efficiently.

Location and History of the Building

Ancient city of Dara, where the subject of the article takes place, is located on 30 km southeast of Mardin Province, and is an ancient border settlement in Oğuz village. It is located on approximately 8 km north of Nusaybin highway and at the point, where the Mesopotamia plain and Mountains of Tur combine [1, 2].

Dara has been established in A.D. 505-507 by Roman Emperor Anastasius (A.D. 491-518) as a garrison city in order to protect the east border of the empire from the Sasanians. The city is being referred as "Dara-Anastasiopolis" with the name of the founder emperor. The fortification walls of the city, which have been built by the 1st Anastasius, have been repaired in the period of the emperor Justinianus (527–565), and the cisterns have been built within this period [3].

Dara city has large water systems. The city is meshed with the defence structures such as its fortification walls, internal castle, bastions, and gutters. The existence of these water systems has been effective in the resistance of the army, which has taken refuge in the city for longer periods during the long-lasting envelopment periods. Most of the ruins, which have reached from the ancient city of to present, belong to the early Byzantine period. However, the structures of late Roman, Byzantine, Seljuk and Ottoman are seen together in the city. These structures are consisted of agora, columned avenue, big church, building with mosaics, baldachin planned structure, bridges, cisterns, sets, necropolis area, city's fortification walls, and doors, and tombs, sepulchral monuments and the mosque, which are the ruins of Islamic period. Dara's most remarkable characteristic is having large water systems. Water systems have been built as part of the defence strategy, except the daily use. The existence of these water systems has been effective in the resistance of the army, which has taken refuge in the city for longer periods during the long-lasting envelopment periods. The water systems, which are stored through flowing from the high mountains and distributed to the entire city via the channels in order to meet the water need, had an important place also in the defence of the city. The city has resisted for a while thanks to these water resources particularly within the periods of envelopment by Sasanians, when it did not have contact with the outside [4] ("Fig. 1").

Architectural design of a cultural heritage has been frequently performed using photogrammetry and point clouds in the last decade [5-16].

Figure 1. Images of the water cisterns of ancient city of Mardin-Dara

Material and Method

Within the scope of the study, it is adopted to conduct literature review, to identify the cisterns on-site, and to document the current statuses of them via photographs as method. Plan diagrams were drawn by taking the current measures, and the findings are presented below.

Results

A rectangular plan diagram is seen as the venue layout of Mardin Dara city. Topographic structure of the settlement has determined the design of the water cisterns, and the cisterns have been shaped so as to comply with the sloping land. Cistern is consisted of eleven venues. It is formed completely from the main rock on the ground. It has been completed with the small stones on the upper part and the upper cover has been created for the cells. There are small cavities on the points corresponding to the upper parts of the walls creating the cells. Water coming from the upper cell can pass to the other cell by means of these small cavities. Upper part is covered with barrel vault. The walls and the upper cover have been built with the masonry system, in the manner usual in the traditional Mardin architecture. Construction elements have been created with the stone materials. There is a round arch on the part covering the retaining walls, over the cisterns.

The stones in the arch have been bonded according to the reverse potential technique. Key block is located on the exact crown. The height of the retaining walls is seven – seven and a half meters. Barrel vault, of which the top is covered, is at an elevation of 9.35 meters. The principle of water flow has been adjusted so as to coincide with the **principle of computational fluid** exactly (Fig. 3). The rainwater falling onto the vault flows into the cisterns through the filling holes located on the point, where the wall and the vault joints. Thus, the cells, which have elevation difference, fill each other with the help of filling holes. There are chimneys on the part, where the upper cover is located, for treatment. After the water passes into the cells, it is subjected to treatment, afterwards the water is stored in the underground cistern and it is distributed.

Conclusion

In the study, the architectural and technical designs of ancient city of Dara's water cisterns have been investigated and the contribution of the system to the water efficiency of the city in the past was searched. As a result of the study, it is seen that the design of the cisterns is shaped according to the topography and the working

principle is coincided with the principle of computational fluid exactly. It is determined that this system provided great saving in storing, transporting and transferring the water in Mesopotamia region, where it is necessary to use the water in the most efficient manner.

As a result of the investigations made under the study, it was concluded that Dara's cisterns must undergone a general maintenance and repair process as soon as possible. In the selection of the materials and methods to be applied in cleaning, strengthening and conservation, not damaging the current structure must be essential. For this, the necessary analyses must be conducted on the original materials before the application.

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