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Urban Planning and Engineering in Southwest Asia during the Ancient Era

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Abstract: There is very little information available about the pre-Achaemenid state formations in Central Asia and Eastern Iran. Based on the study of ancient sources, historians have concluded that in the first half of the first millennium BC, the Central Asian ethnic community of the southern regions of Central Asia and Eastern Iran formed the earliest state formations, which can be attributed to the state of Khwarazm and the Bactrian kingdom. The Bactrian kingdom was the largest formation in the 7th century BC, centered in Bactria (or the ancient city of Balkh). More reliable information about the history of the people of Central Asia is only available after the entry of Central Asian lands into the territory of the Achaemenid state, which was one of the most powerful empires of the ancient world (mid-6th to early 5th centuries BC).

Keywords: Building culture, gadur and foundation system, earthquake, building technology

Introduction

Based on the study of historical sources such as the Avesta and the reports of ancient authors, it has been concluded that in the first half of the first millennium BC, the Central Asian ethnic community consisted of the southern regions of Central Asia and Eastern Iran formed.This planning, which includes countries such as Iran, Iraq, Oman, Qatar, Kuwait, the United Arab Emirates, and other countries in the region, is a critical and challenging task. Due to its large population, increasing urbanization, environmental pressures, and complex economic and social transformations, the region requires effective and sustainable planning. By examining the history of these regions, it can be observed that the cities of Southwest Asia have always played an important role in the history of the region as cultural, economic, and political centers. Therefore, urban planning and engineering in these areas have become one of the main factors in social and economic development and progress. Given the many contemporary challenges of the region, today's planners and engineers need a dynamic and comprehensive perspective to design sustainable, smart, and human-centered cities using past experiences and modern technologies.

Urban Planning and Engineering in Southwest Asia during the Ancient Era

The vast grasslands located on the Iranian plateau between the agricultural regions of Mesopotamia and India provided favorable conditions for the development of animal husbandry. The ancient Iranians who inhabited these regions had their own specific traditions and customs in agriculture and art, which were based on a nomadic lifestyle. They had portable and lightweight houses, wheeled vehicles, and household utensils. The strictness and discipline of the highly organized Parthian groups ensured their military success in wars. Cyrus the Great, the Persian king, conquered the weak states of Mesopotamia and the Eastern Mediterranean one after another in the middle of the 6th century BC. Thus, he created a centralized state, the Achaemenid dynasty.

Historical sources mention the first Achaemenid king from a small mountainous region in southwestern Iran, which was part of the Median kingdom, which led to the creation of a great power that later claimed to have unlimited without any conditions on the eastern and western countries. These people were Cyrus II, son of Cambyses, and Darius I (a total of 15 Achaemenid rulers ruled).

Darius I, during his reign of over 35 years (522-486 BC), after taking power, began to reorganize his governing system. He abolished the borders between the conquered countries and divided his state into 20 satrapies (provinces), merged the territories of different states, and began to build roads and organize trade and cultural relations along the built roads. He also started minting gold coins throughout the empire - the Daric and others. This period is considered the peak of the prosperity and power of the Achaemenid state. Among the countries under the control of Darius and his successor Xerxes, there were 30 different regions, including the Parthians, Bactrians, Sogdians, Khorezmians and other tribes. All of Central Asia was completely part of the Achaemenid state before the defeat of the Persian armies by the Greeks in 480-779 BC. Only present-day Fergana and the Tashkent oasis remained outside its borders. The capital of the Achaemenids was first Pasargadae and then Susa. The formation of a single centralized state greatly contributed to the spread of cultural traditions, including architecture and art, throughout the empire, which stretched from Egypt in the west to the western borders of China in the east. The architecture of Iran during the Achaemenid period was greatly influenced by the culture of house building of the Medes and the neighboring regions of northern Iran. This connection can be seen in the construction of cities, types of buildings, and even in the construction techniques of buildings. Of course, this does not mean that these traditions were created by the Central Asian countries. It is more likely that there was a mutual influence and adoption of traditions and cultures in these regions. Previously, in the Bronze Age and early Iron Age, in the territory where the Iranian tribes lived, namely in the regions of Central Asia, methods of building urban settlements, namely housing for permanent residence, methods of agriculture and artificial irrigation were developed and improved. Despite the fact that the first urban settlements in ancient Bactria, Sogdia, Margiana and other regions of southwestern and Central Asia had existed long before they were included in the Achaemenid state, the urban planning and defensive fortification culture of the Iranians and their western and northern neighbors had more advanced traditions.

The first capital of Iran, Pasargadae, was built by Cyrus in 550 BC in the style of the Median capital, Ecbatana (present-day Hamadan, Hagmatana). This location is located on a plateau surrounded by mountains. The city was not surrounded by fortress walls, but it had a strong citadel, which was protected by a large square with palace-like buildings, and residential houses were located in one period. The citadel was located on a stepped platform (78x79) made of massive regular blocks on one of the hills northeast of the palace. Persepolis had a different structure (the Persians called it Parsa), which became the political center of the empire during the reign of Darius I, who began its construction from 520 to 460 BC. According to researchers, the engineering plan of the city was prepared before its construction. Here, the palace complex was built in the form of a strong fortress with inaccessible balconies along with developed defensive fortifications. The houses of the townspeople were located outside the walls in one period. Susa was also built on the same principles, but here a strong citadel was also provided in the upper part of the palace complex.The defensive systems of Persepolis and Susa provide an idea of the fortification system of the Achaemenid state. The first fortifications of Persepolis consist of several lines. The upper defensive line is located on the mountain passes in the east and southeast of the palace balconies. The walls are fortified at regular intervals with square towers with protrusions from the outside and inside, of which only mounds remain. The second line of defense runs parallel to it on the eastern edge of the balconies. It is made of the same type of wall and towers and its end is connected to the first line of defense. In the same way, the most tactically vulnerable point of the city is protected by another fence. As archaeologists have proven, the third part of the defensive fortification system was in the form of a wall that surrounded the terrace from the west, north, and south surrounded the terrace from the west, north, and south, which was as strong, wide, and high as the eastern fortifications. Behind the mound of stone and in front of the foundation of baked bricks was a deep ditch, behind which the fortress wall with niches was built of

baked bricks. The moat was not filled with water and its depth only served as an obstacle against enemy attacks. In fact, this moat protected the defensive walls and terraces from the floods of Mount Rahmat. The height of the defensive walls in the east was more than 11.5 meters and in the west about 15 meters. The foundations are made of massive stone blocks and the walls and towers are made of adobe (33cm*33cm*12cm) which are plastered with very strong clay and the floors of the buildings are made of stone slabs. From the inside, a garrison is located next to the fortress walls. During the excavation of Persepolis, archaeologists discovered an advanced sewage system with underground tunnels for draining water that could enter the building and the terraces themselves. The city was supplied with water through a canal that was located on the mountain slopes at a higher altitude than the plain from the Pulvar River. The defensive system of Susa was somewhat similar to the fortifications of the Hittites and Assyrians and consisted of three lines of defense that were arranged in a stepped manner on a terrace and surrounded by a moat filled with water from the outside. Behind it was a 18-meter high terrace retaining wall, in the middle of which, 9 meters from the edge of the wall, there was a row of loopholes and branches at the top. Another earthen rampart was built on the terrace, which was

surrounded by a stone wall from the outside. The gap between these two walls looks like a dry moat that prevents collapse. In each of the three lines of defense, there are strong rectangular towers that protrude from the surface of the wall. In Pasargadae, the initial capital of the Achaemenid state (founded in 50 BC by Cyrus II, 60 km from Persepolis), the palace square enclosed a large area with a 4-meter thick stone wall. Inside this vast artificial park were the ceremonial and residential palaces of Cyrus and the building of small kiosk-like structures. These buildings formed a single complex with a completely rational design.The culture of urban public design and fortifications of the central cities of Iran during the Achaemenid period was influenced by the traditions of the Medes, Assyrians, Urartu and other neighboring countries. This is especially noticeable in the architecture of Susa, which was located near Babylon. In the eastern provinces of the Achaemenid state, such as Bactria, Margiana, Sogdia, Khorezm and other countries, in the 4th-6th centuries BC, along with small rural settlements, there were also large urban-type settlements. Almost all of these settlements (urban and rural) were built with strong adobe walls. Fortresses were often located on natural rocky heights or artificial earthen mounds. Thus, in Khorezm, the cities of the Achaemenid period were located on hills and occupied large areas (for example, Guzly-Gir, Kalaly-Gir, etc.). One of the characteristic features of the fortifications of ancient Khorezm is that oval towers appeared here earlier than in other regions of Central Asia. Residential and administrative buildings were built close to the defensive walls, and sometimes residential areas were located between two rows of defensive walls. Inside the fortress, a large area was naturally allocated, which was often used to protect livestock during the war.

Principles of Architectural Construction in the Achaemenid Period

Materials and Execution

The Achaemenid building culture is not unique only in terms of its final products: the process of architectural formation, construction methods and techniques used in the application of materials also show interesting points. The use of materials that best meet the functional needs of the building was the most important pillar that guided Achaemenid architecture in the selection and combination of different materials. For example, while the geographical conditions of Iran provided access to a variety of building stones, the Achaemenid architects used limestone in the construction of Persepolis, the largest construction project in the entire empire. These stones are in the middle of the range in terms of ease of processing and durability (Hunt 2008). Compared to the massive structures previously built in Egypt (sandstone and granite) and contemporary examples from Greece (marble), the Achaemenids' use of limestone demonstrates the use of materials that, in addition to having the required strength and hardness, were easy to carve, finish, and thus facilitated the construction of the building. An examination of the numerous ancient quarries that were used to extract stone shows that the builders paid particular attention to extracting the best veins of stone, and even in some of these quarries that were used in the construction of Persepolis, there are up to eleven different exploratory pits for quarrying stone (Zare 1382). The Persepolis complex is made of two different types of stone: while the main part of the terrace and the load-bearing elements of the palaces are made of relatively light and gray limestone, which was quarried near the complex, darker and softer stones from the Majdabad quarry, which was located forty kilometers away from the construction site, were used to build the components that were to be carved (Tilia 1968). There are also subtleties in how and why different materials were used together, as well as in the techniques used for the joints. The stone elements of the Achaemenid palaces were made as monolithic as possible and from massive pieces. To the extent that Krefter (1971, 32) has found the term "rock carving" to be more appropriate for this particular type of architecture. It is as if even in the construction of building components such as stairs, door frames, and windows, sculpture has been used.The use of this method (which of course had difficulties in the transportation and implementation stages) had a great impact on the monolithic behavior of the building in the event of an earthquake. A significant portion of the load-bearing walls around the palaces were made of brick or adobe, which, due to the inherent properties of soil (weakness in tension), did not show much resistance to destructive forces and dynamic natural loads.The weakness of adobe buildings is generally manifested at the joints and openings, where tensile stresses are unavoidable, and causes the building components to disintegrate. Therefore, the monolithic stone pieces that were placed in the brick walls of most Achaemenid palaces (Figure 1), regardless of their role as openings and decorative elements of the building, effectively took over the transfer of tensile stresses and prevented the occurrence of cracks or serious damage to the building. These large stone pieces are hollowed out from the inside at the point of connection with the bricks so that, in addition to reducing the dead load of the building and making it easier to transport materials to the construction site, the connection of different materials to each other is also more effective.

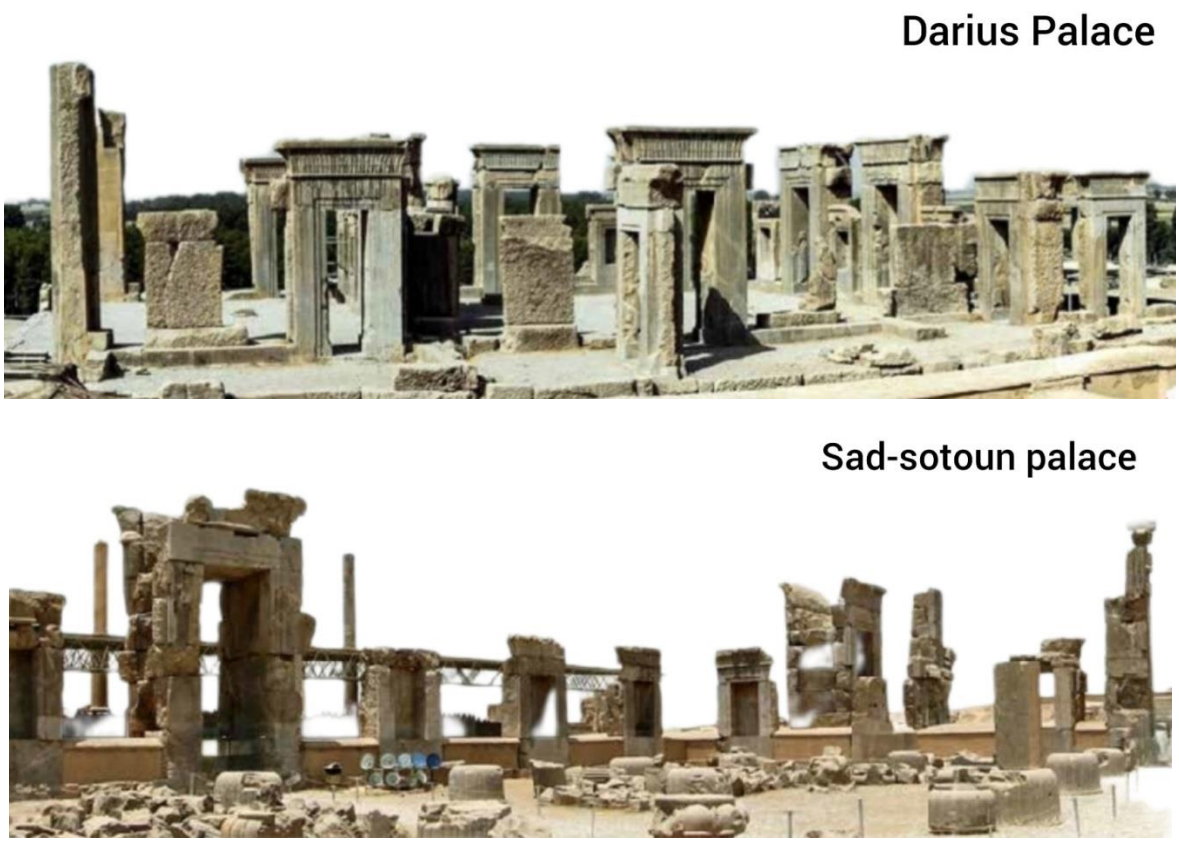

Figure 1. Stone elements forming the openings in the middle of the brick walls and the bricks in place

The method of carving and the way the stone components are connected are noteworthy.

The first method requires a lot of time and money to implement.

The second technique is prone to structural weaknesses due to the poor placement of materials next to each other, which allows free movement of the pieces in the event of a horizontal earthquake force. Finally, it is the third method that strikes a good balance between the load-bearing requirements of the building and the costs of construction.In the Anathyrosis method, the edges of the stone pieces are cut in a way that they fit perfectly into each other, creating a tongue-and-groove joint. The Anathyrosis method was used extensively in the construction of Persepolis. The stone pieces were carefully cut and fitted together, creating a strong and durable structure that has withstood the test of time creates a strong connection that resists horizontal forces such as earthquakes (Figure 2). The second pattern is easy to achieve and examples of it can be seen in abundance in the architecture of other ancient civilizations. However, it seems that the Achaemenids, aware of the structural weakness inherent in this method, were reluctant to use it. In Anathyrosis joints, the central part of the pieces that come into contact with each other is left rough and below the natural surface of the stone (at a lower level than the point of contact of the two pieces). Only around this central core are the surfaces smoothed and polished.

This way, by eliminating the time spent finishing the stone in areas where it is not visually necessary, the speed of execution is significantly increased.On the other hand, this pattern of stone carving helps to minimize the joint gap and create visual uniformity between the pieces.The Anathyrosis technique was used in Greece since the Old Testament, but outside of Greece, it was first used in Achaemenid Iran and then gradually became widespread in other parts of the Near East (ibid., 61). Despite the advantages mentioned above, due to the reduction of the effective cross-section area for load transfer in this case, the materials are not used optimally.

The Achaemenid builders were aware of this shortcoming and therefore the Anathyrosis technique was not used in parts of the building where load-bearing requirements were a priority (Figure 3).

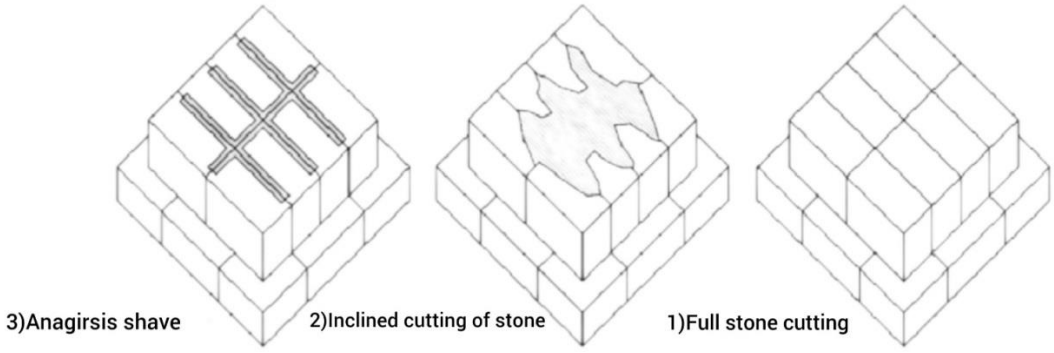

Figure 2. Different forms of connecting stone pieces together

In Achaemenid architecture, stones were tightly fixed next to each other without using any materials and only with the use of iron ties These ties not only prevented the excessive or individual movement of the stone pieces, but also increased the integrity of the structure and provided better resistance to tensile forces and shear stresses that could unexpectedly occur in the structure (Wright 2005). In general, there are two different types of ties in the architecture of the ancient world: horizontal and vertical ties. The use of ties first began in the kingdom of Egypt and later continued to a limited extent in Asia Minor and Mesopotamia during the Bronze Age (Nylander 1966). However, this technique was used extensively in Achaemenid buildings. This shows the special attention of the architects of this empire to the strength of the buildings they built. The evolution of ties in Achaemenid architecture shows a transition from simple dovetail ties (stone, wood, copper and bronze) in the early Achaemenid period to the use of linear ties with vertical protrusions at both ends. These protrusions were embedded in the stone to provide better and deeper connections (ibid., 137-141). The outer surface of these iron hooks was finally covered with molten lead. The striking difference in the shape and function of ties in early (Pasargadae) and later (Persepolis) buildings shows the increasing understanding of the builders of the structural behavior of connections and their efforts to improve the efficiency of materials. This is because in the course of the development of ties, ultimately more effective connections were created using less material. While horizontal ties are abundant and found almost everywhere, vertical ties (which are more difficult and complex to implement in comparison) were only used in parts of the building (such as columns, parapets, and fortifications) where there was a possibility of the structure disintegrating due to specific stresses (Nylander 1970, 45). To connect the components of the columns, wooden ties were generally used in a tongue-and-groove pattern. This change in the pattern and material of the connecting elements could be due to the elastic and flexible behavior of wood, which in an earthquake-prone country like Iran, allows for limited horizontal movements at the connection point of the individual parts of the structure. For the same reason, in some cases the vertical connection of the piece. was made possible by the metal tin (Farshad 1384, 59).

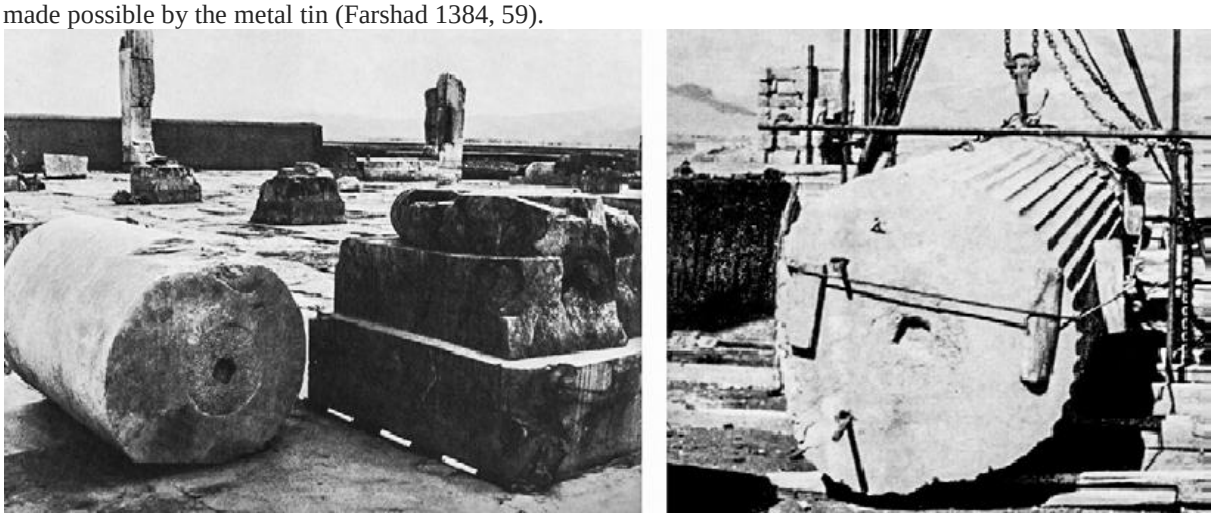

Figure 3. Use of the Anathyrosis technique in the construction of columns in Pasargadae (left) and Persepolis (right) (Stronach 1978; Tilia 1972)

Conclusion

In ancient times, the cities of Southwest Asia, including Babylon, Nineveh, Persepolis, and others, were built with special planning and engineering that are symbols of human ingenuity and intelligence in that era. These cities were built with complex, regular and high-precision structures at a time when more advanced engineering techniques were not available. There is very little information about the pre-Achaemenid government organization in Central Asia and Eastern Iran. Based on the study of ancient sources, historians have concluded that in the first half of the first millennium BC, the Central Asian ethnic community of the southern regions of Central Asia and Eastern Iran established the oldest state formations. These include the state of Khorezm and the Bactrian kingdom. The Bactrian kingdom was the largest formation in the 7th century BC with its center in Bactria or (the ancient city of Balkh). More reliable information about the historical fate of the people of Central Asia exists only after the entry of Central Asian lands into the territory of the Achaemenid state, which was one of the most powerful empires of the ancient world (mid-6th to early 5th centuries BC).

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