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An Evaluation of the Architecture and Urban Positioning of the Phaselis Aqueduct

Phaselis Su Kemeri'nin Mimarisi ve Kentteki Konumu Üzerine Değerlendirme

Kibar CESUR* Leyla KADERLİ**

Abstract: The Phaselis Aqueduct, constructed in the IInd century AD to address the increaing population and water demands, stands as an advanced example of Roman engineering, contributing significantly to the social, economic, and public life of Phaselis. Designed to align with the city's topography, the aqueduct transported water from distant sources, to the city, delivering it through two directional shifts to baths, fountains, an other public spaces. In the Late Antique Period, the aqueduct was adopted to the city's evolving urban plan through various repairs and reinforcements, enabling its contiuned use. However, it gradually deteriorated due to eartquakes and changes in sea levels. The structural features of the Phaselis aqueduct, its technical details and its contribution to the city's water transmission system have not been comprehensively documented due to partial investigations in the past. For this reason, a detailed documentation process was initiated and the relationship of its system to the structures in different parts of the city was examined through the provision of architectural and engineering documentation. Only limited sections of the aqueduct have survived to the present day, and the non-existing sections of the aqueduct have been reconstructed with their possible locations according to the data obtained.

Keywords: Phaselis Aqueduct, Laser Scanning, Mobile Lidar, Archeological Areas, Documentation

Öz: Phaselis Su Kemeri, MS II. yüzyılda, artan nüfus ve su ihtiyacını karşılamak üzere inşa edilmiş, Roma Dönem'i mühendisliğinin gelişmiş bir örneği olarak Phaselis'in sosyal, ekonomik ve kamusal hayatına katkıda bulunmuştur. Kentin topografyasına uyumlu tasarlanan yapı, suyu uzak mesafelerden kente iki açı değişikliğiyle hamamlar, çeşmeler ve diğer kamusal alanlara ulaştırmıştır. Geç Antik Çağ'da kentin değişen yerleşim planına uyum sağlamak amacıyla kemer çeşitli onarımlar ve güçlendirmelerden geçirilerek kullanılmaya devam etmiş ancak son depremler ve deniz seviyesindeki değişimler ile zamanla işlevini yitirmiştir. Phaselis su kemerinin yapısal özellikleri, teknik detayları ve kentin su iletim sistemine katkısı, geçmişte yapılan kısmi incelemeler nedeniyle kapsamlı bir şekilde belgelenememiştir. Bu nedenle detaylı bir belgeleme süreci başlatılmış ve sistemin kentin farklı bölgelerindeki yapılarla olan ilişkisi mimari ve mühendislik belgeleri temin edilerek incelenmiştir. Su kemerinin sadece kısıtlı bölümleri günümüze ulaşabilmiş, mevcut olmayan bölümleri ise elde edilen verilere göre olası konumları ile birlikte yeniden inşa edilmiştir.

Anahtar Sözcükler: Phaselis Su Kemeri, Lazer Tarama, Mobil Lidar, Arkeolojik Alanlar, Belgeleme

This study has been developed and produced from the thesis titled "Architectural Assessment and Conservation Proposal for the Phaselis Ancient City Aqueduct" It was conducted by Kibar Cesur under the supervision of Leyla Kaderli at the Graduate School of Natural and Applied Sciences of Erciyes University. The research was supported by the Scientific Research Unit of Erciyes University, unit number FYL 12002 (BAP).

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Water, one of the fundamental elements in the transition to settled life in human history, has always played a vital role in the development of civilizations. From ancient times to the present, many civilizations have been established near water sources, particularly in areas such as riverbanks and deltas. These settlement preferences reflect the impact of water on societies and its strategic importance in the evolution of civilizations. Water has not only been a basic necessity for life but has also been a decisive factor in the economic and social structures of civilizations, influencing agriculture, trade, transportation, and industry. However, societies living in areas far from water sources have required advanced engineering structures for the procurement and storage of water. In this context, various constructions such as aqueducts, canals, and cisterns have been built along routes suitable for transporting water according to geographical conditions. These engineering structures have facilitated the effective transportation and storage of water, thereby enhancing the quality of life for communities and contributing to the sustainable development of civilizations.

In antiquity, Mediterranean port cities recognized the vital importance of water and sought to shape their settlement plans and infrastructure around water sources. Many of these cities, while strategically positioned for maritime trade, were also heavily dependent on freshwater resources for the sustainability of agriculture, commerce, and military activities. The engineering structures built to meet the water needs of port cities were crucial for maintaining daily life and preserving the economic strength of the city. In particular, aqueducts played a critical role in the development and prosperity of these cities by facilitating the transportation of water over long distances. These constructions not only supported the immediate water supply but also contributed to the overall growth and resilience of the urban environment.

The Phaselis Aqueduct is an engineering structure built during the Roman Period to meet the water needs of the city. It played a significant role in the historical development of Phaselis and served as one of the essential infrastructure elements feeding various settlement areas and public buildings within the city’s urban plan. Since its construction, the aqueduct has withstood numerous challenges, including natural disasters such as earthquakes[1] and tsunamis, as well as human-made calamities like warfare, fires, and epidemics[2], undergoing many repairs and modifications over time.

Throughout the historical process, the structure has suffered significant damage; however, a portion of the aqueduct located in the Central Harbor area has been preserved and has reached the present day. The findings from excavation work conducted in 2022 and 2023 have led to both digital and manual documentation of the aqueduct and its surroundings[3]. As part of these efforts, the architectural features of the aqueduct and its current state of deterioration have been examined in detail, and proposals for the restitution of the structure have been developed.

The cultural heritage value of the Phaselis Water Aqueduct is of great importance for the holistic preservation of the city's historical geography. In the processes of conserving and documenting historical structures, traditional methods are being complemented by digital technologies, allowing for the creation of more comprehensive and detailed documents and the development of effective preservation strategies.

Water Management in the Antiquity

Aqueducts and water conduits were crucial infrastructure facilities used for water supply in ancient and medieval cities. These structures facilitated the transportation of water over long distances and its distribution to populated areas. In antiquity, water channels were typically constructed as underground closed conduits or open channels on the surface, allowing water to flow downhill

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1 See Brandes 1989, 176-181. Notably, the major earthquake that occurred in 529 caused significant damage to Lycia. Io. Mal. 376; Brandes 1989, 97; Foss 1994, 23; Duggan 2017, 31.

2 Hellenkemper & Hild 2004, 115 dp. 235 ve 236.

3 Butler 1901, 175-199; Smith 1978, 154; Bruun 2009, 1-17; Özbay 2018, 13-35; Arslan & Tüner-Önen 2022, 255-260; Tüner-Önen 2023, 123-124; Cesur 2024, 80- 91.

under the influence of gravity. These channels were usually built with a natural slope, enabling water to reach cities over a specific distance[4]. The water supply system of the Roman Period is regarded as one of the greatest engineering achievements of antiquity. Indeed, despite the long distances and numerous obstacles, the water storage, transportation, and distribution systems they built remained unmatched for approximately 1,500 years following the collapse of the empire[5]. During this period, water systems utilized two primary methods to traverse valleys with different geographical features: aqueducts and the inverted siphon method[6]. The first method, aqueducts, were monumental structures designed to transport water in accordance with the slope of the transmission system, and they were costly to construct, requiring a considerable amount of time for their completion. The second method, the inverted siphon, was used to cross valleys that were too deep for aqueducts to be built. The best-known example of this method is the Aspendos inverted siphon[7]. In the Hellenistic Period, the 65 km long Madradağ waterway, which supplied water to Pergamon, is one of the earliest inverted siphon systems in history[8]. In this waterway, the inverted siphon spans 3.2 km and reaches a depth of approximately 200 m[9].

During the Roman Period, advancements in architecture inherited from the Greek world were significantly enhanced by the innovative techniques of Roman engineers, leading to revolutionary progress in construction. One of the most important developments was the discovery of concrete (opus caementicium). The use of concrete, combined with the arch construction techniques employed during the Hellenistic Period, facilitated significant advancements, particularly in the construction of aqueducts. These water bridges were typically constructed using semicircular arches, often built from cut stone walls or faced with slab stone, filled with Roman concrete[10]. Roman emperors viewed the provision of water as an imperial investment in public service. Water systems were costly projects that required extensive time for construction, and once completed, they necessitated regular maintenance and sustainability. The earliest example of such a system is the Ponte Lupa aqueduct, built in the II[nd] century BCE to convey water to the city of Rome[11]. As the city expanded and the demand for water increased, the construction of aqueducts continued, resulting in the building of 11 aqueducts over a period of 500 years[12].

Before the Roman Period, the water needs of cities were primarily limited to the essential requirements of daily life. However, during the Roman Empire, the increasing population and the need for sanitation made the construction of water systems essential, as monumental structures such as fountains, baths, gymnasiums, and latrines became prominent. Baths, which served as propaganda tools for emperors, evolved over time from mere facilities for bathing into social gathering spaces, leading to an increase in their number[13]. As urban water consumption rose during this process, new water sources were incorporated into the aqueducts, resulting in a proliferation of water conveyance structures. Additionally, water usage extended beyond monumental buildings and basic needs; it became crucial for industrial production as well. The use of water was significant in various industries that contributed substantially to the urban economy, including ceramic production, dyeing and cleaning textile products, washing ore, and tanning leather[14].

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4 Kretzschmer 2000, 91.
5 Smith 1978, 154-161.
6 Kütükçüoğlu 1962, 56-57.
7 Kessener& Piras 1999, 149-168.
8 Garbrecht 1987, 24; Hodge 2002, 106-115; Özbay 2018, 105.
9 Özbay 2018, 22.
10 Özbay 2018, 23.
11 Butler 1901, 175-199; Smith 1978, 154; Bruun 2008, 1-17; Özbay 2018, 13-35.
12 Mays, Koutsoyiannis & Angelakis 2007, 8.
13 Yegül 2006, 22; Özbay 2018, 31.
14 Wilson 2000, 127-149; Weiss 2011, 134; Özbay 2018, 32.

Water Supply and Aqueducts of the Ancient City of Phaselis

In the early periods of city establishment, the availability of water sources was crucial. Cisterns built to preserve these resources were also vital for early cities. It is believed that the first inhabitants of Phaselis met their water needs not through aqueducts, but rather through cisterns, lakes, streams, and other nearby sources. This reliance on local water sources was essential for the survival and development of the settlement[15]. In the Archaic and Classical periods, the water needs of the city dwellers settled on the Acropolis were likely met by clean water collected in cisterns and sourced from nearby resources[16]. In investigations conducted in 2015 aimed at discovering hydraulic structures on the Acropolis and as part of hydrographic studies, a total of 36 cisterns were identified and documented, with 27 found in 2015 and 9 in 2016[17]. Today, some of these cisterns can be observed in the fractured cliffs of the Acropolis due to natural disasters such as earthquakes, erosion, and massive waves (fig.1).

Fig. 1. Section of the Ruined Cistern at the Acropolis (Kürkçü 2016, 118)

Fig.2. Cistern 1.S.2. (Kürkçü 2015, 76)

During the Hellenistic Period, as the population of Phaselis increased and the city boundaries expanded to the north and west, the existing cisterns must have been insufficient for water supply. Therefore, water sources located at the foothills of Tahtalı Mountain were conveyed to the city center through open channels, pipes, water walls, and arches from the Northern Settlement[18].

Since the initial surface investigations on the hydrology and water supply of the city of Phaselis, numerous studies have been conducted[19]. F. Beaufort included sections of the waterway within the city and the aqueduct in his work "Karamania"[20]. G.E. Bean noted a spring that fed the aqueduct in the northeast of the settlement[21] (fig 5). In his study titled "The Harbors of Phaselis" D. J. Blackman reported that a portion of the waterway located on the city wall carried water from a 'spring' at the top to the city center[22]. The team led by Schäfer, which initiated the first scientific studies related to the city, expressed that the city’s water needs must have been met at all times by fresh water supplied through both cisterns and water channels[23]. Generally, researchers indicate that the city's water supply came from springs near the Tamtır Area at the foothills of Tahtalı Mountain and from the Source Cave (Kaynak Mağarası) located in the Northern Settlement. Schäfer described the water source known as the Source Cave as being hidden beneath the soil layer of the slope, approximately

15 Kürkçü 2015, 70. Additionally, G. Bean suggests that in earlier periods, the city may have relied on cisterns for rainwater collection in the event that the lake could not be utilized for water supply (Bean 1968, 146).

16 Tüner-Önen 2008, 79-83; Tüner-Önen & Akçay 2014, 280.

17 Kürkçü, 2016: 118.

18 Tüner-Önen 2008, 79-83; Tüner-Önen & Akçay 2014, 280; Cesur 2024, 62.

19 For more detailed information, see Tüner-Önen & Akçay 2014; Kürkçü 2015, 69-79; 2016, 103-121.

20 Beaufort 1818, 60-61.

21 Bean 1998, 155-157.

22 Blackman 1973, 358.

23 Schäfer 1981, 42.

4 km southwest of the city, along the Kumluca-Finike road in Tekirova. The researcher noted that the Source Cave, situated between two rock layers with different permeabilities, formed a cave system branching out from easily soluble limestone, suggesting the presence of a small river that could flow underground over long distances[24]. Another water source examined by Schäfer and his team is a reservoir structure located about 680 m northeast of the northern starting point of the Water Bridge, shaped by the carving of the bedrock[25]. In 2014, it was determined that the reservoir structure, which had been preserved in-situ, has an opening with a diameter of 2.65 m and a depth of 17.67 m[26]. During Schäfer's research in 1969-70, the depth of the structure was measured at 25.7 m[27]. However, examinations revealed that the bottom of the water structure was filled with collapse, sedimentation, and debris. The structure features three rows of rock stairs, approximately 60 cm wide, carved into the rock and descending in a north-south direction[28]. It is believed that the partially natural, partially human-made water reservoir structure may have been used for collecting water from the valley[29] (fig. 3-4).

Fig. 3. Source Cave (Kaynak Mağarası)

Fig. 4. Reservoir Structure- Rock Staircases (Kürkçü 2015, 70-71)

Between 1982 and 1984, observations related to water management in the city center were made during excavation and restoration works led by C. Bayburtluoğlu (fig. 6-7). In his excavation reports, Bayburtluoğlu noted that some of the waters reaching the city center via arches descended to the level of the agora through pipes placed in the recesses of the southern wall of the agora, continuing northward parallel to the agora wall. He also mentioned that these pipes were found preserved in front of the agora's entrance[30]. Only the recesses in the wall have survived from the described arrangement to the present day[31]. The water conveyed through the pipes opened on the façade of the Tetragonal Agora was distributed to the Nymphaion located adjacent to the agora, from there to the Small Bath, the Latrina structure, and the Great Bath[32].

24 Schäfer 1981, 30.
25 Schäfer 1981, 43.
26 Tüner-Önen & Akçay 2014, 281.
27 Schäfer 1981, 43.
28 Tüner-Önen & Akçay 2014, 281.
29 Tüner-Önen & Akçay 2014, 282.
30 Bayburtluoğlu 1983, 183-184.
31 Kürkçü 2015, 71.
32 Schäfer 1981, 42; Bayburtluoğlu 2004, 89; Karahan 2019, 78.

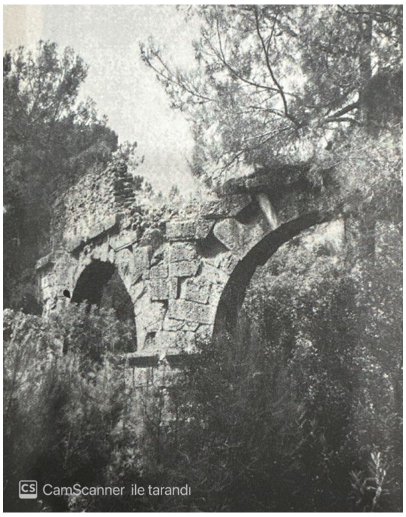

Fig. 5. Phaselis Aqueduct, G. Bean 1968

Fig. 6. Phaselis Aqueduct, Bayburtluoğlu 1982

Fig. 7. Phaselis Aqueduct, Bayburtluoğlu 1982

In 2014, research conducted on the eastern and northeastern slopes of the Northern Settlement revealed that water was conveyed to the city center not only through a single pipe system but also via a water distribution system made up of pipes extending in various directions[33]. This indicates that the water for the Phaselis Aqueduct was sourced not only from Tahtalı Mountain but also from the caves in the northeastern and southeastern slopes of the Northern Settlement, particularly from the Alacasu water reservoir[34]. In this context, observations and studies conducted on Tahtalı Mountain identified the primary sources feeding the city's hydrology and waterway as the Sıtma Spring and the Tamtır Kavaklı Spring[35]. The route of the waterway used to supply water from the sources on Tahtalı Mountain to the city center has been mapped based on the remains obtained during fieldwork. As a result of these studies, it was determined that the spring near Mağara Deliği feeds water through pipes from Tamtır Area towards Yerleştir Ridge. Along the route, it was observed that in some areas, the waterway continued in open channels above walls constructed without mortar in a dry-stone technique, while in other areas, it proceeded through pipes atop structures made of polygonal stones reaching heights of 3.5 m[36]. It is believed that three different springs on Tamtır Hill and Atamak Ridge constitute the main water source for the city[37].

In surface surveys conducted in the region in 2015, new water sources, hydraulic structures, and material cultural remains were identified, and the coordinates and architectural features of the in-situ sections of the water sources and waterway were recorded[38]. There is an approximate elevation difference of 1020 m between the point where the waterway surfaces at the Sıtma Spring location and the sections where it passes into the city via arches, with a straight-line distance of about 8 km calculated between the two areas[39]. In this context, it is believed that it would not be technically or architecturally feasible for the waterway to reach the city in a straight line without consideration of these factors. The sources of the Phaselis city waterway are thought to be ranked as follows, descending from the highest elevation: Sıtma Spring (1029 m), Köy Spring (1013 m), Tamtır Kavaklıpınar (980 m), Oluksuz Spring (843 m), Çatak Sugözü (816 m), Molla Deliği Cave, Yardımtepe

33 See Tüner-Önen & Akçay 2014, 279-292.

34 Reservoir: A natural or artificially created body of water used for the storage, regulation, and control of water resources (DSI Hydrology Terminology Dictionary).
Tüner-Önen & Akçay 2014, 281.

35 Tüner-Önen & Akçay 2014, 287; Kürkçü 2016, 107.

36 Tüner-Önen & Akçay 2014, 287.

37 Büyükyıldırım 1994b, 80.

38 Kürkçü 2016, 103- 121.

39 Kürkçü 2016, 104.

Location/Demiroluk (771 m), and Akboyun (731 m). dditionally, arrangements have only been found at the sites where water surfaces, except for Çatak Sugözü. For example, at Sıtma Spring and Tamtır Kavaklıpınar, spring collection structures made with cut stones have been identified, as well as channels carved into the bedrock at Akboyun and remnants of walls through which the water channel passed. On the route, pieces of baked clay pipes were observed at Oluksuz Spring. The average slope between Sıtma Spring and the waterway remnants within the city has been calculated at 127.18 m/km (12.72%)[40]. In the hydrographic studies conducted in 2015, remnants known as the waterway by the local population were also examined in the southwest of the city, in the Cumayeri neighborhood. Wall remnants built with rubble stones and mortar, descending from the slope in a southwest-northeast direction, were identified in the area[41].

Phaselis Aqueduct

In the regions of Lycia, Pamphylia, and Cilicia, there are numerous aqueducts built during the Roman Period that utilized atmospheric pressure to convey water across valleys. The aqueduct located in the ancient city of Phaselis is one of the water structures constructed during the Roman Period, similar to those in other Pamphylian and Lycian cities, due to the increasing water needs of the cities and the inadequacy of cisterns during the Hellenistic Period. However, it can be stated that the Phaselis aqueduct is relatively simpler in comparison to the water systems in Aspendos, Side, and Patara[42]. To better understand the architecture of the Phaselis aqueduct, digital documentation was carried out as part of studies in 2022. The aqueduct was meticulously documented using photogrammetry, terrestrial laser scanning, and mobile LIDAR scanning techniques[43]. The data obtained were combined with on-site inspections to provide comprehensive documentation that will serve as a foundation for the current status, restitution, and restoration projects of the aqueduct[44].

In this context, the holistic architecture of the structure and its relationship with the city have been elaborately revealed. The water conveyance system, which starts from the city center, progresses towards the strong fortification structure located in the area known as the Northern Settlement of Phaselis, or Hellenistic Settlement. This system can be traced through ceramic finds related to water pipes identified in the terrain, beginning from the remnants that terminate on the slope in the Northeastern Necropolis area[45]. It has been stated that the water conveyance system continues as a water wall from a height of +13 m on the southern slope of the Northern Settlement area, with Schäfer noting that the end of the water wall leading into the city breaks at the North

[40] Kürkçü 2016, 104-109.

[41] Kürkçü 2016, 114.

[42] For example, along the aqueducts that supplied water to Perge, there are the Saklısı Aqueduct, Eğridere Aqueduct, and Ahmetali Aqueduct (Albek 1972, 290; Büyükyıldırım 1994a, 1056; Büyükyıldırım 1994b, 130; Özbay 2018, 89). Numerous aqueducts are also found along the water routes of Side. Some of the Side aqueducts include Gözyanı, Tırşaklar, Kırkgöz, Mezarönü, Alçakkemer, Akçeşme, Kemerderesi, Akçay, Naras, Delikgözler, and Çakalderesi. The Akçay and Kemerderesi aqueducts are two-storied, while the others are single-storied (İzmirligil 1976, 469; Mansel 1978, 82-85; Özsoy 2018, 91). In the Aspendos water system, there is the Kısık Aqueduct, which has a height of approximately 20 m, aside from the inverted siphon water structure (Büyükyıldırım 1994b, 156; Özsoy 2018, 92). At the ancient city of Patara, there are five aqueducts along the water routes: İncesu, Akbel, Delikkemer, Tavas, and İbrikdere (Baykan, Kocakaya & Alkaya 1994, 1072; Baykan & İşkan 2011, 69-70).

[43] Arslan & Tüner-Önen 2022, 255-260; Cesur 2024, 80-91; Cesur 2024, 686-695.

[44] Cesur 2024, 80-129.

[45] See, Tüner-Önen & Akçay 2014, 281. The channels on top of the aqueducts vary from system to system. In some aqueducts, baked clay, lead, or stone pipes are used, while in others, open concrete or stone channels are preferred. For example, in Side, water is conveyed through the open channels of the Gözyanı Aqueduct at a gradient of 2%. In the Delikkemer inverted siphon of the Patara water system, water transport is provided within a closed channel using stone pipes, and at the end of the siphon, it is directed into open channels (Baykan, Kocakaya & Alkaya 1994, 1073-7074; Baykan & İşkan 2011, 70-71; Büyükyıldırım 1994b, 51; Coulton 1987, 72-84). The water transport system of Pergamon consists of baked clay pipes and lead pipes secured to stone sockets along the Madradağ aqueduct (Garbrecht 1987, 24; Hodge 2002, 106-115; Özbay 2018, 22).

Harbor shoreline; however, this has not been transferred to the map he created[46]. The length of the water wall is assumed to be around 12-13 m above the base of the slope. The water wall consists of a neatly cut ashlar stone wall up to a certain height, above which is a rubble stone wall that supports the water pipes and provides the flow gradient. Local limestone breccia blocks were used in the construction of the ashlar wall, and the rubble masonry above likely utilized crushed and reused materials obtained from the excavation of this area. Schäfer mentions that a passage was constructed at the southern end of this wall towards the coast, consisting of two horizontally positioned sarcophagus blocks forming the threshold of the passage. This passage has been closed off with later repairs (fig. 8)[47]

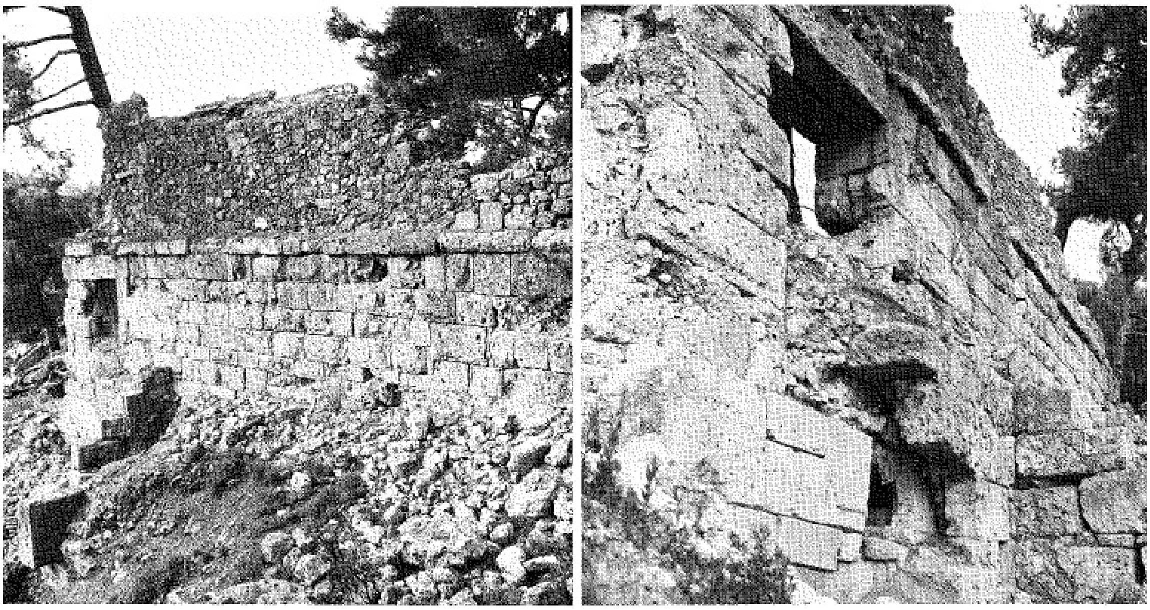

Fig. 8. Aqueduct over the Northern Gulf; Left Front: Roman Tomb Wall; Left Passage, Dock Holes, Mortar Traces of Both Lines; Control Path on Flat Layer (Schäfer, 1981, Tafel 7)

Additionally, there are partially preserved structural walls of a monumental tomb on the eastern side of the wall. Although the aforementioned passage has not survived to the present day, the vaulted tomb structure and the sarcophagus blocks remain preserved in situ. The aqueduct constructed in the Roman Period in the Necropolis area was built without regard for the existing burial sites and later integrated with the tomb structures (fig. 9). At the end of the Necropolis area, the aqueduct descends along the slope with a height difference of approximately 4 m, passing over arches to cross the North Harbor quay and then connecting to the Central Harbor basin, turning southwest towards the center of the city. Schäfer, who conducted the most comprehensive study on this topic, noted that the degradation of the water wall here was not solely due to the sea and waves; it is likely that in later periods, the building stones were dismantled for use in other constructions, although part of the wall's foundation stones can still be traced underwater. However, these have completely disappeared in modern times[48].

[46] Schäfer 1981, 42.
[47] Schäfer 1981, 43, Tafel 7.
[48] Schäfer 1981, 42.

Fig. 9. Water Route Found in the Northern Necropolis Area (Cesur 2024, 71)

Fig. 10. West Elevation Drawing (Cesur 2024, 112)

In his study, Schäfer documented the water conveyance system by numbering the arch supports from the direction in which water was delivered to the city towards the water distribution area. He noted that the wall descending along the North Necropolis slope gently curves westward and transforms into a sequence of 31 arches. He also expressed that the traces of 9 arch supports, which should have originally existed at the North Harbor, have completely disappeared. However, in the southern section of the North Harbor, traces of 3 arches can be followed underwater, with an additional 3 traces identifiable on land[49].

Currently, there are no visible traces of the water wall that reaches the quay of the North Harbor, and the supports in the southern section of the quay, which remain underwater, are difficult to discern. These remnants, particularly exposed to harsh winter waves, are rapidly deteriorating. However, researcher J. Schäfer noted that the aqueduct presents a typical Roman aqueduct appearance with its supports and arches, stating that 15 of the supports are still preserved, while from the 22nd support onward, the aqueduct gently curves westward. At the termination point of the aqueduct, it is indicated that the waterway, fitted with pipes, conveyed water to a height of +15 m to the hilltop, suggesting that there should be a water distribution structure in this area[50].

The exact structures present around the North Harbor quay and the Central Harbor basin at the time the aqueduct was originally constructed are not fully known. However, remnants of a Hellenistic Period maritime fortification wall can be encountered between the 16th and 17th supports. J. Schäfer commented that these fortification wall remnants represent a wall that was no longer standing at the time of the aqueduct's construction or that the fortification wall might have been passed beneath by the aqueduct[51]. This question is expected to be clarified in future excavations in the area, which will shed light on the relationship between the fortification and the aqueduct.

49 Cesur 2024, 74.

50 Schäfer 1981, 42-47.

51 Schäfer 1981, 42-47.

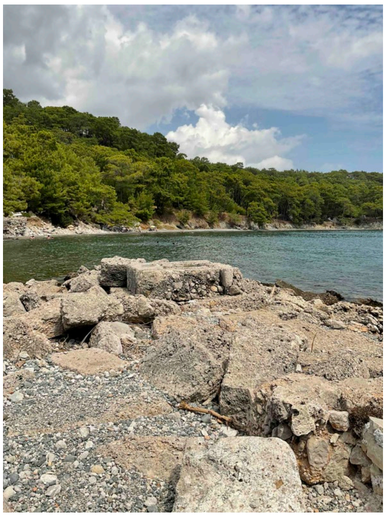

Fig. 11.

Fig. 12.

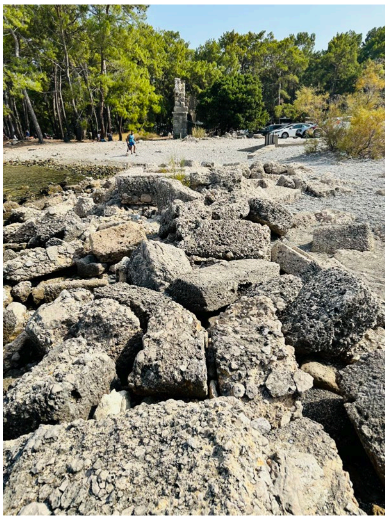

Fig. 13.

Fig. 14. Aerial Photograph Showing the Excavation and Conservation of the Aqueduct Supports (Arslan & Tüner-Önen 2023, 124)

As a result of the documentation conducted in 2023, it has been decided to designate the in-situ wall section of the aqueduct within the city as "A1". This decision was made because the location of the first arch support has not been identified west of the North Harbor. Accordingly, starting from the first arch support (A1) to the seventeenth arch support (A17), the aqueduct has largely been preserved without interruption, while the 18th, 19th, and 20th arch supports (A18, A19, A20) are completely buried beneath coastal pebbles. However, the foundational remains of the 21st, 22nd, and 23rd supports (A21, A22, A23) and structural elements presumed to belong to the arches have been observed in situ along the North Harbor shoreline (fig. 11-12-13). The arches and supports A1, A2, A3, A4, and A5 located in the southern section of the Phaselis Aqueduct have been well preserved. The arch between A6 and A7 has collapsed, while the supports for A6 and A7 have been partially preserved. The arches and supports between A8 and A14 are in good condition, while the arch between A14 and A15 has collapsed; the two arches between A15 and A17 have been partially preserved, along with their supports. None of the arches continuing after the A17 support have survived to the present day[52] (fig. 14).

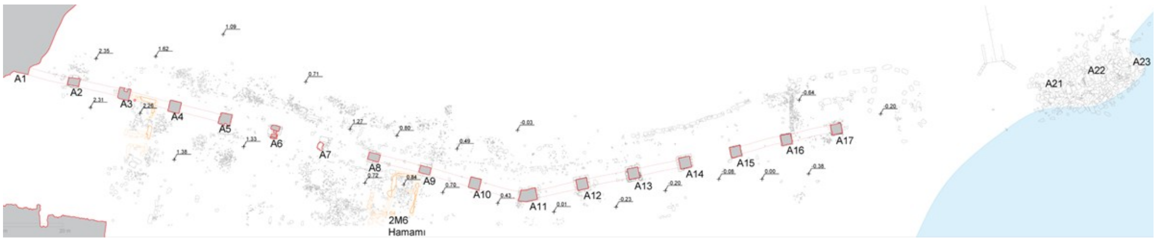

Fig. 15. Plan of the Aqueduct Supports (Cesur 2024, 149)

[52] Cesur 2024, 68-79.

The general architectural arrangement of the Aqueduct consists of repeating arches and arch supports. The arch supports are set on pedestals and are finished with sloped profiles at the springing level, giving them a base-like appearance. Above the arch stones, there is a row of impost stones that protrude in both directions, on top of which stands a rubble masonry wall leaning against the western face. Within this wall, there are two drainage pipes of varying heights (fig. 14). Today, some examples of these pipes can be seen in the wall section of the waterway located in the Northern Necropolis. Additionally, drainage pipes were discovered in the arch supports during excavations conducted in 2023. The drainage pipes found in arch support A8 have diameters of approximately 17 cm and lengths of 24 cm (fig. 16).

Fig.16. Water Pipes Found During Excavation Work at the A8 Aqueduct Support in 2023 (Cesur 2024, 78).

The average distance between the arch supports of the aqueduct is approximately 6.50 m, with the narrowest distance measured at 6.30 m between supports A5 and A6, and the widest distance at 6.65 m between supports A13 and A14. The heights of the arches have been calculated to be an average of 5.40 m from the ground level and approximately 5.90 m from the pedestal level. However, these heights vary depending on the topography and the heights of the arch supports. The arch supports, which measure approximately 1.75 x 1.75 m and about 2.30 m in height, rest on pedestals that protrude 0.30 m on all sides from the ground. The distance or height between the pedestal and the springing level can vary for each support in relation to the ground level. Immediately above the arches, there is a row of impost stones that project outward in both directions by 0.10-0.20 m, featuring a flat profile. This row of stones has balanced the level of the arch top and serves as a support for the rubble wall that carries the drainage pipes above it (fig. 17).

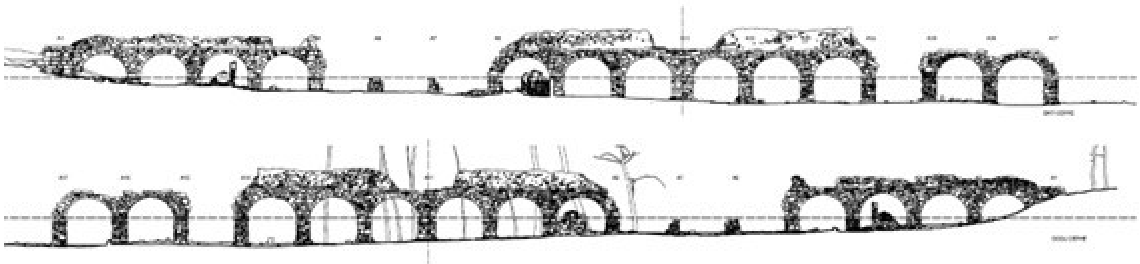

Fig. 17. East and West Elevations of the Central Harbor Aqueduct

In Turkey, ancient water conveyance systems feature aqueducts reaching heights of 40 m, water tunnels with diameters exceeding 2 m, and siphons made of lead and stone operating under water pressures of 190 ms and 155 m, respectively[53]. There are also various diameters of terracotta, stone, and lead pipes. Among these, the lead pipe siphon in Bergama, as well as the stone pipe siphons in İzmir, Patara, Laodicea, and Aspendos, are significant[54]. Additionally, terracotta pipes have been found in Phaselis, while remnants have also been discovered in Side, Bergama Madradağ, Ephesus, and Perge[55].

On the eastern side of the Phaselis Aqueduct, there is a control passage that is 0.49 m wide, with the highest point of the wall reaching a height of 2.8 m and a wall thickness of approximately 0.62 m. The height of the water wall above arches A1 to A4 is about 1.5 m, although a section approximately 3.8 m long between arches A4 and A5 has collapsed. Above arch A5, the wall rises

53 Garbrecht 1991, 34; Öziş 2002, 18; Çağlayan 2009, 2.

54 Büyükyıldırım 1994b, 156; Baykan &İşkan 2011, 70-71; Kessener 2014, 269; Özbay 2018, 92.

55 İzmirligil 1979, 1-5; Garbrecht 1987, 24; Hodge 2002, 106-115; Çağlayan 2009, 2; Özbay 2018, 22.

again to a height of 1.5 m over a length of 1.5 m (fig. 18).

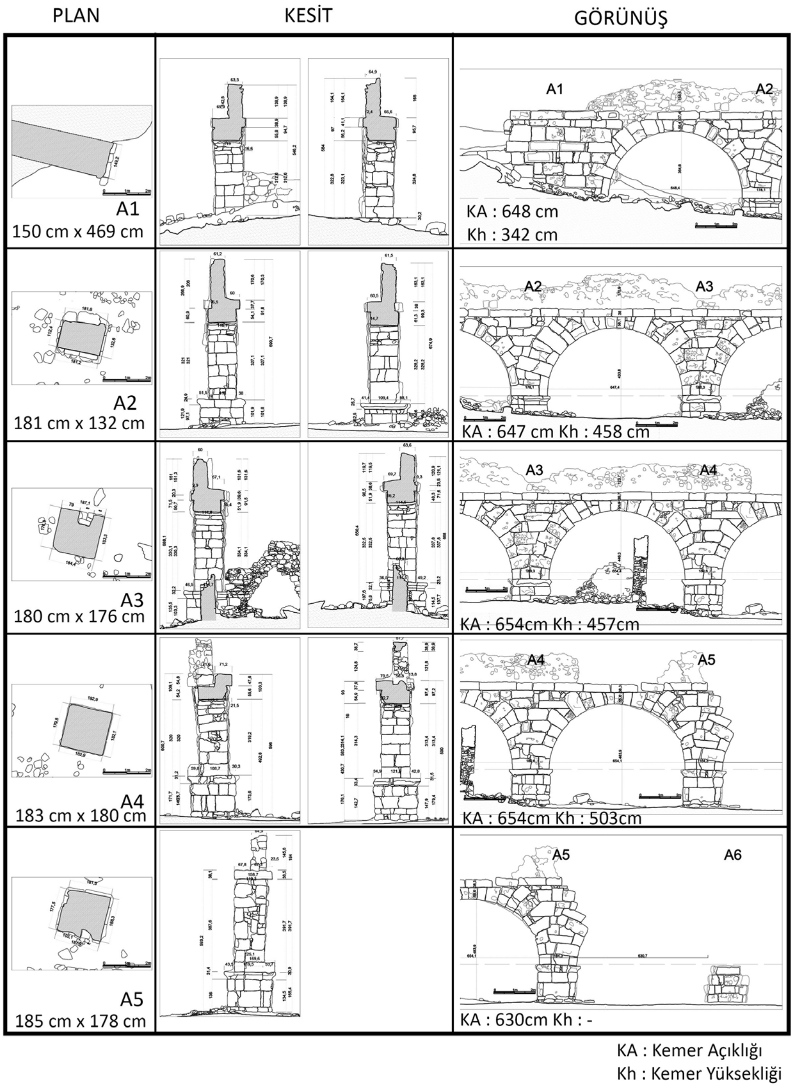

Fig. 18. Plans, Sections, and Elevations of A1, A2, A3, A4, and A5 (Cesur 2024, 100)

However, due to the collapse of the three arches located between supports A5, A6, A7, and A8, there is no existing masonry rubble wall. Starting from arch support A8, a masonry rubble wall approximately 21 m long begins to rise again; however, it could not be preserved above arch support A11, likely due to tectonic movements during which the rubble wall collapsed (fig. 19-20). After an opening of about 8 m, the wall rises again above arch A12 and continues for 21 m up to arch A14. Since there is no arch between arch support A14 and arch support A15, the rubble wall has not survived to the present day. Arch supports A15, A16, and A17 have also suffered significant damage, resulting in the collapse of the water wall above them. The A11 arch support is built longer to extend in both directions, as the aqueduct changes direction by 22 degrees to the west. The height of the rubble wall decreases from 2.8 m to 1.5 m from the north to the south (fig. 21). Schäfer suggests that the estimated height of this wall could be considered to be 2.6 m [56]. However, he posits that this height may not have been uniform throughout the entire waterway due to the need to balance the height differences at the bases of the arch supports and to maintain the necessary gradient of

[56] Schäfer 1981, 30.

the water line[57]. Schäfer identified the arch support we refer to as A11 as the 22nd support and noted that the water line curves slightly to the west. Additionally, he mentioned the presence of scaffold holes measuring 0.18 m x 0.18 m at regular intervals, spaced between 3 m and 4 m apart[58], which can still be observed today.

Fig. 19. West Elevation and Plan/Section of A11 Support (Cesur 2024, 74)

Fig. 20. West Elevation and Plan/Section of A11 Support (Cesur 2024, 74)

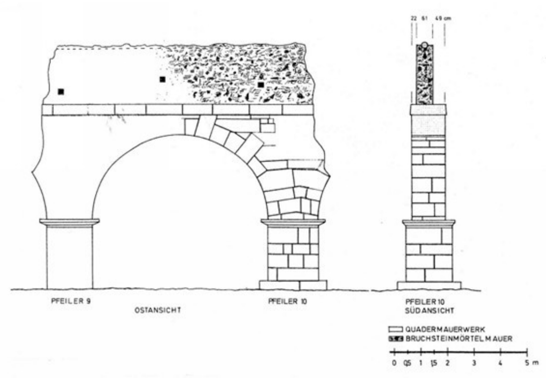

Fig. 21. Elevation and Section Drawings of the Phaselis Aqueduct by Schäfer (Schäfer 1981, 43)

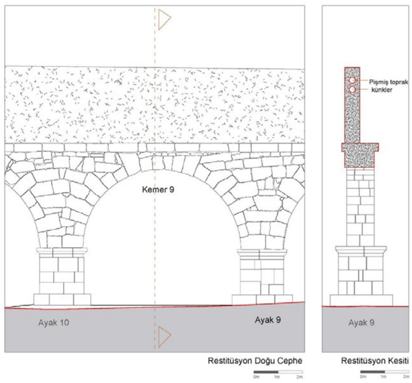

Fig. 22. Eastend Elevation and Section Restitution Drawing Drawn by Author (Cesur 2024, 120)

The Phaselis Aqueduct is constructed from stone blocks, while the water wall section is made of rubble masonry. The majority of the primary building stones used in Phaselis consist of travertine breccia found in the surrounding area of the city. These travertine breccias were generally utilized as blocks in the walls of structures. Additionally, travertine breccia blocks were employed in the pedestal, supports, and arch sections of the Phaselis aqueduct[59].

Fig. 23. Findings Discovered from the Supports of the Aqueduct

In 2023, excavation works were carried out on the pier supports numbered A1 to A17, as well as between the supports. Various findings such as amphora bases, loom weights, and bronze coins were uncovered as a result of the

[57] Schäfer 1981, 30.
[58] Schäfer 1981, 43.
[59] Öner 2018, 354.

excavations (fig. 23)[60]. Between supports A6, A7, and A8, wall remains associated with the Central Port structures, linked to Late Antiquity building groups, were revealed. Following the excavation works, conservation efforts were conducted. After cleaning the plant and soil remains found in the gaps between the blocks, repairs were made using a binding material prepared in accordance with the structure. Previous years' erroneous applications of cement-based materials had caused significant decay and flaking in a large portion of the structure, necessitating the renewal of the joint fillings[61].

During the Late Roman Period, the wall construction techniques used in the construction of aqueducts were developed to enhance the durability of the structure, provide an aesthetic appearance, and ensure cost-effectiveness. Aqueducts elevated in valleys were particularly expected to exhibit resistance to tectonic movements such as earthquakes[62]. The Phaselis Aqueduct was built on supports strengthened with outer layers of precisely cut stone blocks and inner cores filled with mortar and rubble. The arch stones, starting from the springing level, were arranged radially in varying lengths, integrating with the intervening walls. Above the arches, there is a mortar-filled small rubble stone wall that supports the water pipes. However, due to surface erosion, it is not definitively clear whether this rubble stone wall was constructed using a masonry technique or with the aid of molds.

Since its construction, the Phaselis Aqueduct has undergone continuous maintenance and repair, and it appears to have been reinforced by adding an additional pipe due to a decrease in water pressure within the transmission system. However, it is unclear whether both clay pipes were used simultaneously[63]. During its time, the aqueduct supplied water to public structures located in the southern part of the city, such as the Small Bath, Large Bath, Nymphaeum, and Latrina, but as the urban fabric changed, the buildings it supplied also transformed. The Large Bath, which underwent a change in function after the Roman Period, was repurposed into an administrative building, while the Tetragonal Agora was converted into a Church and Episcopal Palace. In its place, small baths were constructed in close proximity to the aqueduct. The sections of the aqueduct on the Central Port side were filled with dense construction. During this period, the aqueduct also served as a boundary for the city, with the spaces between the arches being enclosed by buildings and walls. Indeed, numerous structural remains adjacent to the sections of the aqueduct within the city were uncovered during the 2023 excavation works.

It is believed that the Phaselis Aqueduct completely lost its functionality due to the destruction of its sections in the North Port as a result of disasters such as earthquakes and tsunamis, leaving the city deprived of its primary water source. Following the aqueduct's loss of function, the city's water needs were likely met for a while through cisterns, wells, and small streams, but as its importance diminished, the city was ultimately abandoned. However, it is also thought that settlement may have continued for some time on the Acropolis, which is now covered by dense vegetation. This suggests that the city underwent an adaptation process by turning to alternative water sources in the absence of the aqueduct[64].

The Phaselis Aqueduct exhibits distinct similarities and differences when compared to other aqueducts in Lycia. In terms of material usage and construction techniques, it employs local materials and similar building methods, consistent with other aqueducts in the regionr[65]. However, the fact that the section of the aqueduct carrying water is located in the city center distinguishes it from the general characteristics of Lycia. There are no other examples in the region that are as

60 Arslan & Tüner-Önen 2023, 78.
61 Arslan & Tüner-Önen 2023, 123-124.
62 Kütükçüoğlu 1962, 56-57; Smith 1978, 154-161; Kessener & Piras 1999.
63 Schäfer 1981, 46.
64 Bean 1968, 146; Kürkçü 2015, 70; Cesur 2024, 62.
65 Öner 2020, 27-28; Cesur 2024, 112-114.

closely integrated with the city's architecture as the Phaselis Aqueduct. Furthermore, the immediate association of the ancient city of Phaselis with its aqueducts indicates that these structures hold a significant place in the urban memory of the city[66].

In the water system of Phaselis, it is possible to mention the development of an effective system for the transportation of water through the integration of underground water channels. However, compared to aqueducts that require greater engineering skills, such as those in Patara and Aspendos, which utilize underground tunnels and inverted siphon systems, it is understood that Phaselis has a smaller-scale water transportation system[67]. Additionally, one can refer to the existence of a system in Phaselis that aims to transport water over shorter distances compared to other Lycian cities. For instance, the aqueducts in Patara necessitated a longer water route[68]. The aqueducts in Patara represent a larger-scale project compared to those in Phaselis, featuring both taller and longer structures. The distance to the water source posed greater engineering challenges, requiring the construction of larger structures in the designed water system.

While cities require various elements to sustain their existence, water is the most fundamental and vital of these. As the lifeblood of a city, water not only meets physical needs but also shapes social, economic, and cultural structures. For ancient port cities like Phaselis, water is, in this sense, a vital artery. An indispensable part of daily life, water is necessary not only for drinking, eating, and sanitation but also for production and industry. As long as water is available, urban life flourishes, and the community strengthens its social bonds by sharing this resource. Water, which forms the foundation of economic activities, has facilitated increased product yields and expanded trade. Thanks to its strategic location, Phaselis became a center of trade over time, and the availability of water resources supported this economic dynamism. The water provided by the aqueducts contributed to the development of both local and regional trade, leading to an increase in the city's prosperity. Throughout history, the destruction of aqueducts due to various natural disasters and the loss of the city's water source have diminished the importance of urban life. The gradual disappearance of the aqueducts, which were critical for the city's survival, led to the slow abandonment of the city.

Evaluation and Conclusion

The Phaselis Aqueduct, beyond being merely a technical engineering solution, made significant contributions to the social, economic, and public life of the ancient city. Built in the 2nd century AD, this structure was developed to meet the increasing population and water needs of Phaselis, shaped by advanced construction techniques characteristic of the Roman Period. The architecture of the aqueduct, designed to suit the topography of the city, facilitated the transportation of water over long distances, thereby fulfilling the water requirements of public spaces, baths, and fountains within the city.

In the past, researchers have only partially addressed the Phaselis Aqueduct at different times, and a comprehensive research and documentation study has not been conducted. The incomplete documentation of the architectural, technical, and functional characteristics of this significant structure from the antiquity has hindered a holistic assessment of the aqueduct's structural analysis and the city's water transmission system, as well as the development of effective conservation

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66 Bkz. Cesur 2024, 68-79.

67 Cesur 2024, 39.

68 The Delikkemer inverted siphon, located in the Patara water system, is mentioned as one of the most important water structures in the Lycia region. Baykan and İşkan report the following about the structure: "*According to two inscriptions located above the Delikkemer inverted siphon, which is considered one of the unique structures of Anatolian archaeology, the structure was damaged after an earthquake and underwent extensive repairs by the governor of the time. During the repair process, since the city was left without water for four months, a backup water line was installed next to the Delikkemer, consisting of three rows of baked clay pipes with an inner diameter the width of a hand*" (Baykan & İşkan 2011, 70-71).

strategies. In this context, the present study, which employs modern digital documentation techniques, is of great importance for accurately identifying the architectural and engineering details of the structure and initiating a complete documentation process.

In this study, the advantages of digital documentation techniques have been utilized to create three-dimensional models of the aqueduct, providing a solid foundation for the documentation and restitution efforts of the structure. Particularly through laser scanning methods, material degradation within the structure has been detected with high precision, yielding important data for accurate restoration analyses. The data and information obtained from the documentation efforts have enabled the identification of the potential locations of the arches and supports of the Phaselis Aqueduct that have not survived to the present day, facilitating the preparation of restitution proposals for the structure (fig. 24-25). In this context, it has been determined that the water transmission system extends in the direction of the North Harbor in the North Necropolis area, partially below the surface and above ground with walls; it continues with arches at approximately a 5-degree angle at the first support on the northwest coast of the North Harbor; and follows the same direction from the western coast of the North Harbor (nr. A31-A19) to the northwestern section of the Central Harbor (nr. A19-A31). Here, it encounters the sea wall surrounding the Central Harbor (nr. A16); subsequently, it again changes the angle to 22 degrees (nr. A11) and extends over arches to reach the hill located in the western section of the Port Street basin in the city center, reaching the distribution point again atop the wall to the west of the Great Bath-Gymnasium structure (nr. A1).

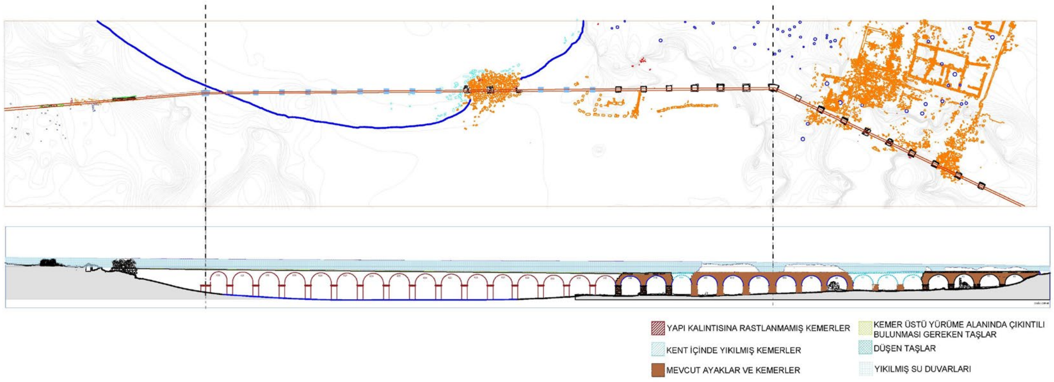

Fig. 24. Proposal of the Eastern Facade (Cesur 2024, 121)

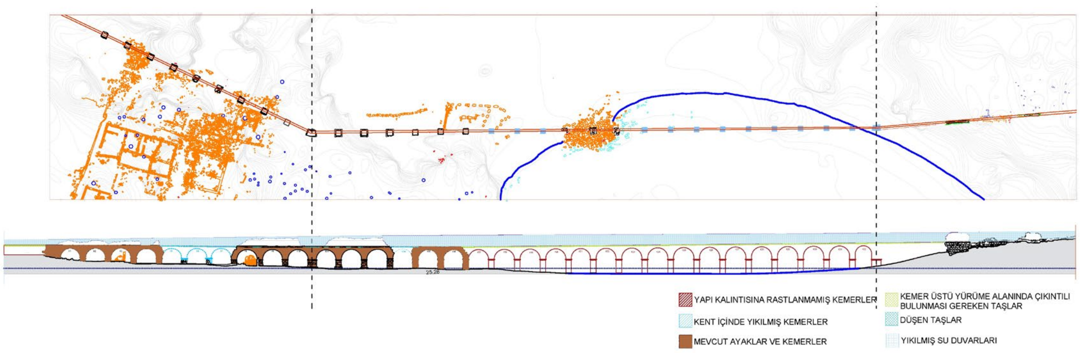

Fig. 25. Proposal of the Western Facade (Cesur 2024, 121)

Today, in the western section of the North Harbor, only the foundation stones of the arch supports on the southern shore (nr. A19-A21) are still legible. These remnants, which include numerous spolia blocks and columns, were likely used to reinforce the settlement against structural concerns arising from tectonic movements and rising water levels during the Late Antique Period.

Moreover, it has been determined that during the Late Antique Period, the North Necropolis area was devastated, and near the waterway, a bath structure was likely constructed using spolia materials on top of early burial structures to utilize water, dating to the Early Byzantine Period. The plan of the aqueduct cannot be deciphered due to the destruction it suffered during the last settlement period. The nearby lime kiln and areas surrounded by columns suggest that they were used for different functions, such as workshops, in a later period. However, the connection of the said bath structure to the waterway has not been identified.

Currently, it is believed that the pier section of the North Harbor, which is submerged, was entirely part of the land at the time it was built, and that the aqueduct continued above the pier. The walls and structures located in the southern section of the North Harbor may be part of the seawall that comes from the Central Harbor, but they could also be considered components of these pier structures. In the portion of the aqueduct that reaches the Central Harbor basin, a significant part is also damaged, with only 17 arch supports and 12 arches remaining in situ to the present day. At the point where the aqueduct reaches the Central Harbor basin, it encountered the Hellenistic Period seawalls and was likely integrated with them. The aqueduct, which was built as a more independent structure, was later integrated with the central harbor structures. The excavation and restoration work conducted in Phaselis in 2022 and 2023 has focused on the structures of the Central Harbor and the arches and supports of the aqueduct located within the city. During surface and landscaping works, remnants of walls have been found in areas where the arch supports are located. Today, the remains that do not exceed the foundation and upper levels indicate that, in the later period, the spaces between the supports of the aqueduct were filled with structures and walls, suggesting that the use of the aqueduct continued, and that the Central Harbor basin was enclosed for security purposes.

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