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A Part of Prusias Ad Hypium Waterways: Kemerkasim Village Aqueduct Architecture, Problems, Restitution, and Restoration Solution Suggestions

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Abstract

Given its crucial role as a source of life, water has been a significant factor in determining the location of human settlements. However, when settling near a water source was not feasible for various reasons, water had to be transported, stored, and made accessible for use. For this purpose, water structures were designed and aqueducts were built to transport water through deep valleys. In this study, the Kemerkasim Aqueduct, which is a part of the Prusias ad Hypium waterways, was evaluated. The study aims to document the aqueduct, which is about to collapse and make decisions for its conservation. The features of the structure were identified by documenting the structure and through research in the literature, which revealed that it was constructed in the 1st century, and underwent repairs in the 2nd and 3rd centuries. The deterioration throughout the building was examined and identified, and a restitution proposal was made by evaluating different aqueduct structures together with the traces from the building. Decisions were taken for conservation and suggestions were made for the survival of the rare example remaining on the route of Nikomedeia waterways. For this reason, it is believed that the study can be utilized in the investigation and evaluation of aqueducts in different regions.

1. INTRODUCTION

Water, the most important source of life, is a fundamental necessity for societies. Therefore, it is understood that many societies have settled on the waterfront. Thus, water resources are utilized in an optimum manner and a solution is provided to the water problem. Regardless of the location of the settlements, even at the waterfront, different structures were needed for the use, transmission, and utilization of water. In addition, since it is not always possible to settle close to the water source, structures have been built for the transportation, storage, and use of water [1]. These structures were developed in two parts, to meet direct and indirect needs [2].

The oldest example of water structures, first seen in Mesopotamia, Egypt, and Anatolia, is the earthen dam built in Jordan in 3000 BC [3]. Early examples of dams include the Sedd-el-Kefere Dam (2950-2750 BC) [4] in Cairo and the Homs Dam (2000 BC) [5] in Syria. Structures such as cisterns and wells are encountered in Anatolia. Water structures were found in the remains of the Hittite period [6]. The most common of these are dams and sacred pools [7]. The dams and sacred pools at Kayseri Karakuyu, Konya Kadınhanı Köylütolu, Beyşehir Eflatunpınar, and Yalburt Plateau are examples of these structures [8].

Structures were also built during the archaic, Hellenistic, and Roman periods to collect, store and distribute water. In the archaic period, wells, water channels, arches, cisterns, and fountains were built. The most important feature of this period is that the canals were located underground for security reasons, and the water was transported by funnels. During the Hellenistic period, water structures further developed, with the construction of aqueducts, wells, pools, baths, fountains, and sewage systems [9]. In the Roman period, water structures were designed with advanced engineering, and water was transported to the cities in a planned manner [10].

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Different systems were used to transport water from its source to a specific point. One of these is the use of pipe networks. Pipes can be stone, terracotta, lead, or wood. The earthen pipes found in Hattusa in Anatolia prove that clay pipes were used in ancient times. During the Hellenistic and Roman periods, stone pipes were also used. Lead pipes were used in the Temple of Artemis in Ephesus [11]. During the Seljuk period, water was transported through subterranean clay pipes. During the Ottoman period, in addition to clay pipes, lead pipes were also employed for water transportation [12].

The transportation of water could not always be done naturally, and aqueducts had to be built for different reasons. Aqueducts are structures built to transport water, especially in areas with high slopes and valley formations. These structures are also called water bridges [13]. These structures, which are a kind of bridge, are of great importance in terms of water engineering and can have arches with one or more floors. The arches were largely built with stone or brick materials. The Romans limited the arch heights to about 21 meters against strong winds and natural events. When the height of the arches needed to be higher, they built a second level of arches in line with the lower one. In this case, the arch piers of the lower level were thicker, while those of the upper level were thinner [14].

There have been many international studies on aqueducts. Russo examined the aqueduct structure built for the transportation of water during the Ancient Roman period [15], and Antoniou examined the Ottoman aqueduct system in Kos Island, Greece [16]. There are also studies on specific aqueducts. The most notable of these are the studies describing the archaeological and architectural features of the Reccopolis [17], Magra Al Ayoun [18], Hezekiah [19], and Aspendos [20] aqueducts. Özbay analyzed the architectural and historical features of the Alvan Aqueduct and studied its restitution [21]. A study was carried out for the preservation and reconstruction of the Kuru Köprü Arch, and Augmented Reality (AR) method was used in the study [22].

The scope of the present study consists of the Kemerkasim Aqueducts, which are part of the Prusias Ad Hypium waterways. To obtain information about the water channels of the arches, surveys were made along the route and the channel system was also identified in the study. The study aims to identify the historical aqueducts, investigate their deterioration, and propose the most appropriate solutions for their survival. It is of great importance for protecting the remains of the construction belonging to the Roman period. Therefore, a literature review was conducted to get insight from previous studies in the field. In this context, the waterways of Nikomedeia were identified and their connections were understood. Advanced documentation techniques were utilized in the on-site measurements, and surveys of the aqueduct were created with a laser scanner. The architectural features and the deterioration of the structure were identified and analyzed. The distortions were revealed by the observation method. Projects were created and all data were shown on separate sheets. In light of structural and environmental data, a restitution proposal was made by evaluating similar examples, and solutions were proposed for conservation.

2. KEMERKASIM AQUEDUCT

2.1. Location and General Characteristics

The ancient city of Prusias ad Hypium is located in the north of the Düzce Plain in the Bithynia region, within the borders of Konuralp town of Düzce province, Turkey, today [23]. Remains of an arch from a water bridge, dating back to the Roman period, have survived to the present day in the section known as the acropolis of the ancient city Prusias ad Hypium. It is believed that these remains in the town in question are connected with the aqueducts in Kemerkasim Village, about 5 km to the east, and it is stated that they are parts of the waterway that transports the spring water from the Dokuzpınarlar locality of Kozluk Village to the city [24]. In the past, the transportation of water to cities from a distant source was accomplished by letting gravity guide it downhill, without pressure. The water from the 400-meter-above-sea-level Dokuzpınarlar water source in Kozluk Village must have been transported to the city via the water bridge in Kemerkasim Village, which passes through the valley's lowest point at 214 meters above sea level. The bridge is located at an altitude of 222 meters on the northern summit of Konuralp Town, about 5 km to the west. In addition, there are traces of a masonry channel in a garden at the southwestern end of the water bridge, extending on the northeast-southwest axis in Kemerkasim Village, about 70-75 meters from the last arch that has survived to the present day. The remains indicate that water bridges and masonry channels were used in the water transmission system of Prusias ad Hypium.

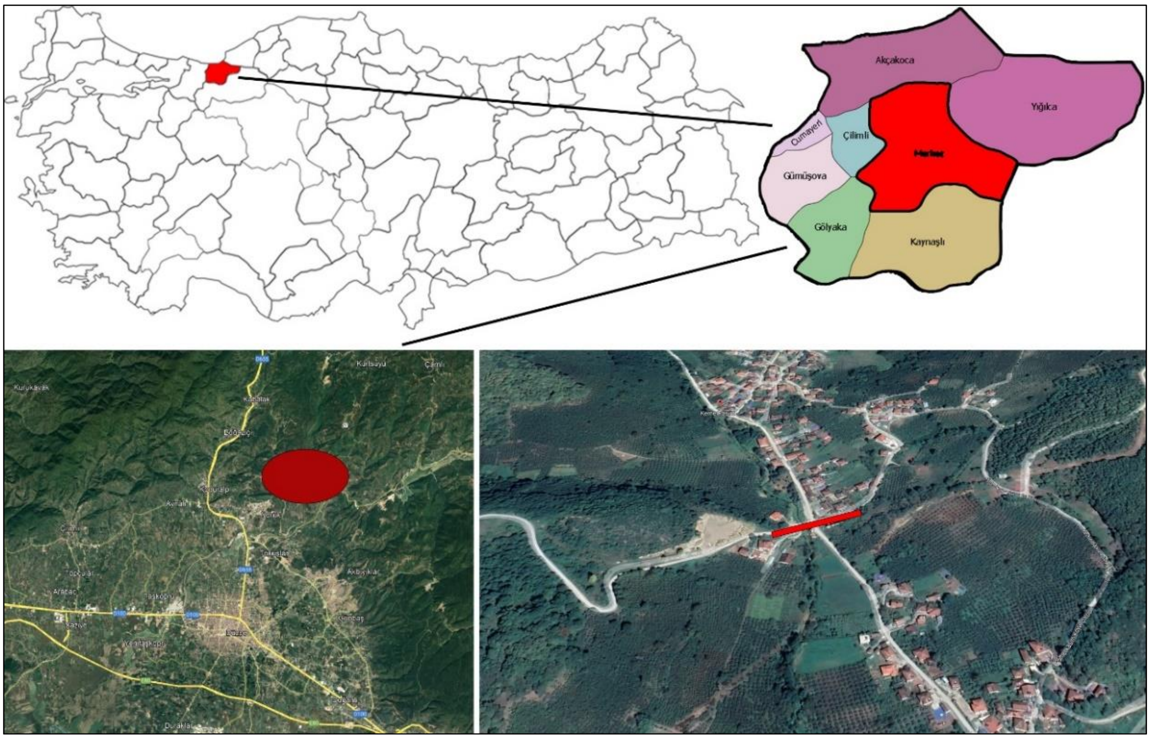

Figure 1. *Location of Kemerkasim Aqueduct [25]*

The historic aqueducts can be found at the Kışla locality within the borders of Kemerkasim Village in the central district of Düzce province. They are situated along a stream bed between two hills and run along a northeast-southwest axis (Figure 1). There is very little development around the structure, and currently, there is a village school to the north and private property to the southwest. Besides these, there are empty plots of land surrounding it (Figure 2).

The aqueducts can be accessed from the south via the highway, which then continues to the north and splits off to the east and west through the intersection in the middle. To the east of the road, a large part of the aqueducts is still standing. In the west, the arch piers are visible. The arch walls and piers, which have only survived as ruins, have been severely damaged due to day and night temperature differences, and frequent earthquakes for centuries.

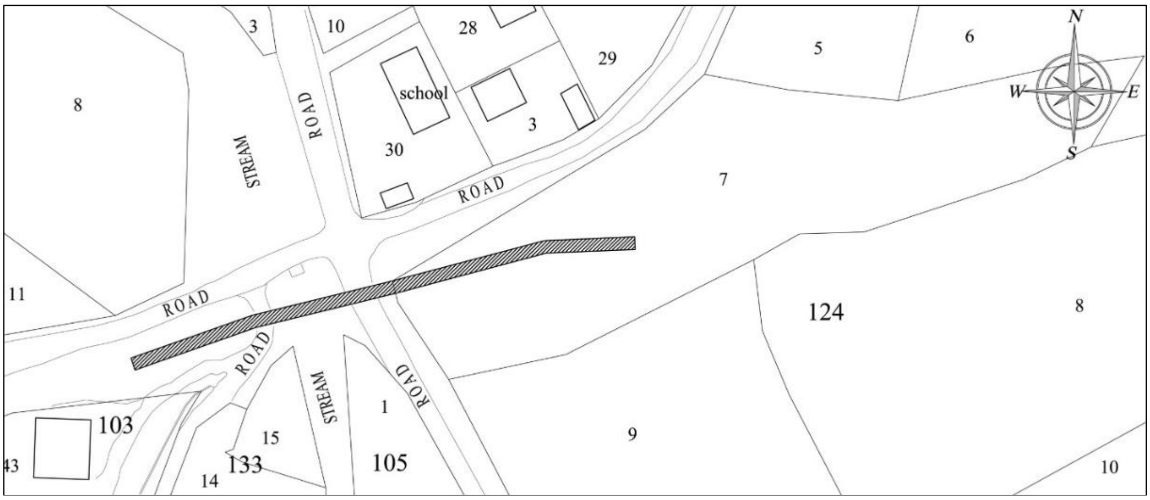

Figure 2. *Settlement Plan (drawing belongs to the author)*

There is no written or visual information about the historical background of the ruins in Kemerkasim village. However, the aqueduct in question was built in the Roman period, probably in the 1st century BC, as an imperial construction activity that dominated the Bithynia region in northwestern Anatolia. In the nearby city of Prusias ad Hypium, now within the borders of Konuralp, P. Domitius Iulianus provided financial support to bring water to the city in the early 2nd century AD, and Gavinius Sacerdos, one of the city's leading aristocrats, provided financial support for the construction of the aqueducts in the 3rd century AD [26]. Based on the similarity of the construction material of the aqueducts at Konuralp, it can be assumed that the repair of the Kemerkasim aqueduct was also carried out in the 2nd or 3rd century AD.

2.2. Architectural Features and Building Materials

Despite the significant collapse of the aqueduct, some of the arch piers are still visible. The span between the surviving arch piers varies between 4,50 and 3,50 meters. However, the span between the arch pier to the east of the highway dividing the arches in the middle and the first arch pier to the west is more than 10 meters. The width of the structure reaches 3,70 meters in the thickest part and 1,10 meters in the narrowest part. The large losses in the paving stones in places cause thinning especially in the arch axes. In the repaired sections, the walls were found to be about 1,50 meters thick. The heights of the three surviving arches were determined to be 1,40, 3,30, and 4,20 meters in the west-east direction, respectively, when viewed from the north facade due to the earth fill. On the other hand, the largest of the arch piers is located in the middle of the stream bed and has a height of 14,50 meters. The structure, which can also be referred to as a waterway, has a length of approximately 102 meters (Figure 3).

The aqueducts are typically built with rubble stone, but in a few exceptional cases, the cut stone is used at the base. The cut stone material is generally preferred as a cladding material, but in some parts, it was also used to form a water basin at the ground level. Moreover, the use of bricks in addition to stone is limited to partial use in the form of 2-3 rows of brick arches, starting at the base line of the arch piers, while occasional single brick uses can also be seen in stone arched aqueducts. The measurements of the bricks are the same as those seen in the Roman and Byzantine periods (4,5/5 x 34 x 36 cm and 4,5/5 x 16 x 36 cm). The mortar used as joint filling material appears irregularly in the cladding stones and rubble stone masonry.

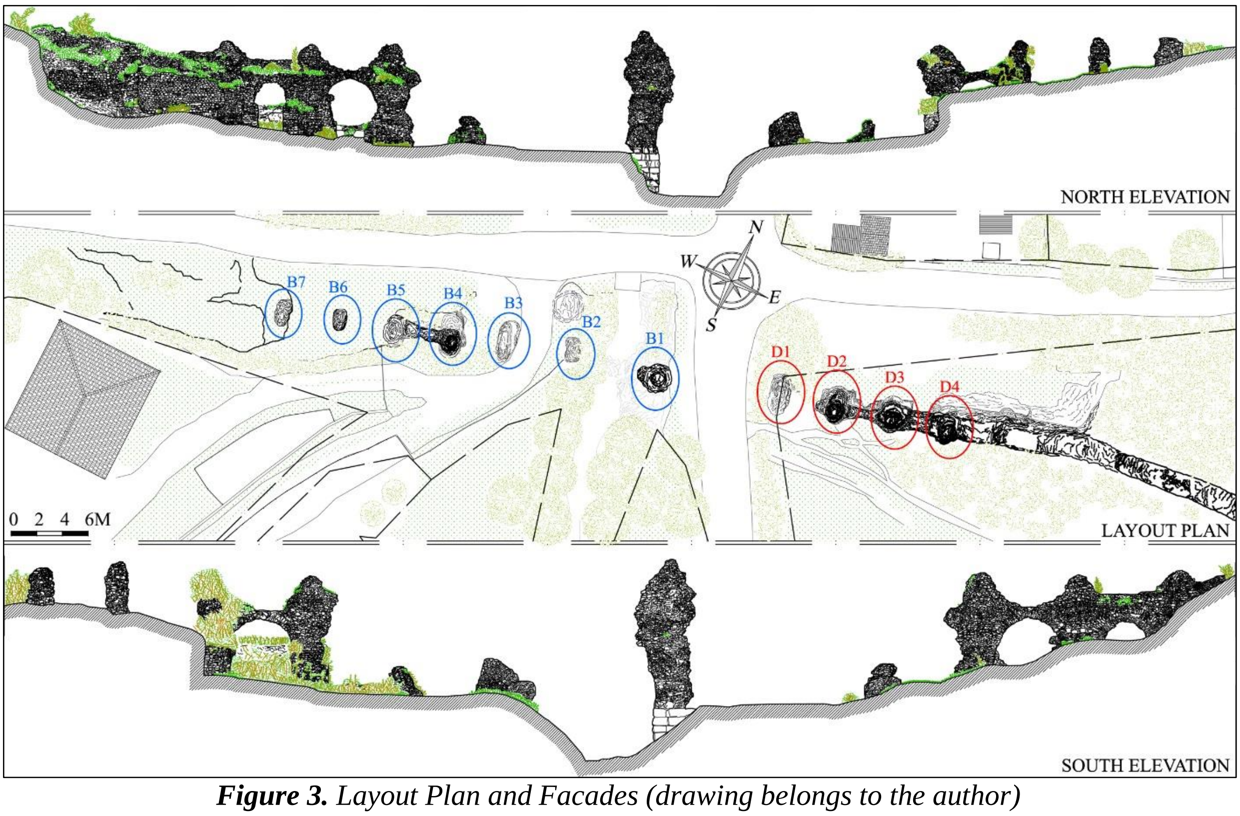

Figure 3. *Layout Plan and Facades (drawing belongs to the author)*

2.3. Current Situation and Deterioration

The piers and arches, which have partially preserved their original integrity, have largely collapsed and changed due to partial repairs, deterioration due to climatic and environmental effects, and earthquakes are known to have occurred in the region. In addition to human factors such as disuse/lack of maintenance, natural and climatic factors such as floods and landslides, rainfall, wind, temperature, humidity, and plant growth and their effects play a corrosive, destructive, and/or deteriorating role on building/structural materials.

The problems identified as a result of the inspections carried out throughout the aqueducts can be analyzed under three main categories: structural problems, material deterioration, and repair interventions (Figure 4).

Joint openings, joint mortar discharges and losses that unit material/sections were determined in structural deteriorations. The most common deterioration is material losses and can be observed on all wall surfaces. The problems that pose a risk to the structure are moisture and salt outputs, earth filling and herbal growing. Especially in the arches at both the eastern and western ends, the earth fillings are dense. Herbal growing is frequently seen on the arches and facades.

Parts loss, abrasion (erosion) and disintegration, microbiological patina (algae like alge and lichen) are observed in materials. In this direction, it is possible to see abrasion (erosion) and disintegration on all facade surfaces. Parts losses are mostly seen in the materials remaining in the plant formations.

Under the general problems, the fact that the building is unprotected and directly open to atmospheric effects is discussed. The capping problem causes the structural problems in the aqueduct to increase.

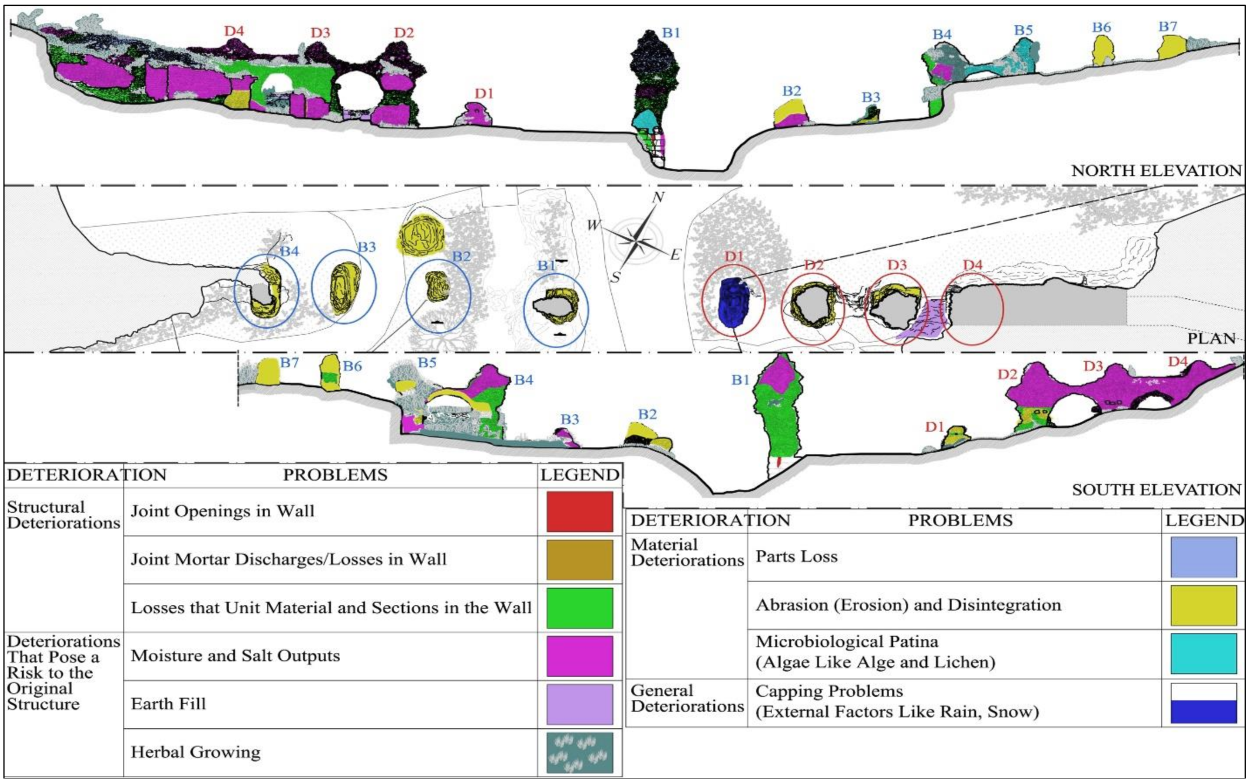

Figure 4. *Deteriorations in the Aqueduct (drawing belongs to the author)*

To the east of the road, four aqueduct piers and an aqueduct wall are visible toward the eastern end. Between the 2nd, 3rd, and 4th arch piers, the arch has survived to the present day (Figure 5a). The arch pier, wall, and arch surfaces were left unprotected due to the collapse of the outer cover, salt deposition by rainfall and water absorption from the surrounding soil fill, and physical stresses caused by vegetative growth caused structural problems such as losses in structural elements and masonry sections, joint openings in the masonry, joint mortar discharge and losses (Figure 5b). In addition, deterioration in building materials such as crumbling, abrasion, microbiological patina formation, and superficial deposition are also visible.

To the west of the road, seven aqueduct piers and an aqueduct wall are visible from the 5th arch pier at the western end up to the elevated land (Figure 5c). The 1st arch pier is still standing despite a lot of stone, joint, and mortar loss. In general, however, it is about to collapse. While there are cut stones at the base close to the ground, the body is made of rubble stone. Joint mortar loss throughout the arch pier, joint mortar discharge and losses in the masonry, and losses in the unit material and sections are visible. In addition, there are losses in pieces, abrasion, and crumbling in terms of building material (Figure 5d). The arch has survived to the present day only between the 4th and 5th arch piers. However, a part of it has remained under the soil due to the terrain shape (Figure 5e). Vegetation increases from the 5th arch pier onward, and almost all the 6th and 7th arch piers are covered with vegetation (Figure 5f). Especially the trees and/or plants, growing in the soil accumulated in the gaps in the wall joints and on the tops of the walls, are damaging both the masonry and the building materials with their roots and trunks (due to the mechanical pressures they create during the root and trunk growth). On the north side of the aqueduct, which is east of today's asphalt road, where there is no earth fill, it is observed that the arch sections between the piers, the arch interiors, and the openings between them were covered with rubble masonry. It is believed that this intervention was made in the 2nd or 3rd century after the initial construction, probably after an earthquake. Problems such as moisture and salt deposition, joint mortar discharge, and microbiological patina (Algae and lichen-like moss layering formations) are also visible on these wall surfaces (Figure 5g).

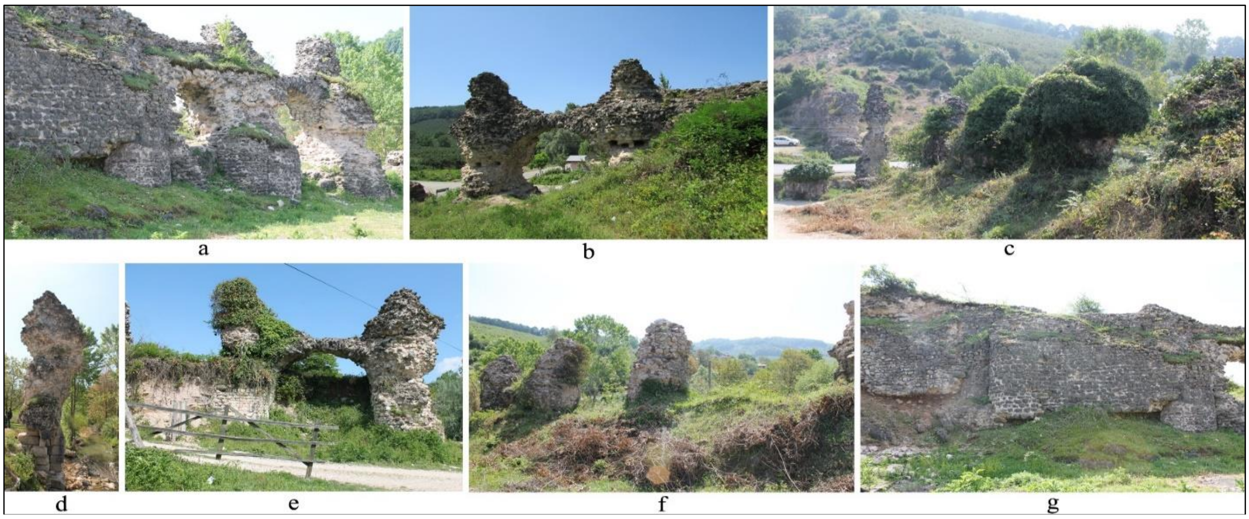

Figure 5. *Kemerkasim Aqueducts Views (photos belong to the author)*

2.4. Restitution Proposal

The aqueduct line runs along a northeast-southwest axis on a stream bed between two hills, with two arch openings on the northeast side and one arch opening on the southwest side. When these arch openings and the aqueduct formations in similar examples are examined (Figure 6), the present arches were lined up based on the existing arch heights between the arch piers along the northeast-southwest axis, considering the existing arch piers and the measurements between the piers. The uninterruptedness of the arch piers will likely become visible once the existing vegetation and soil deposits are removed.

In addition, when similar examples from the Roman period are examined, it is seen that encasements (stone footing) must have been constructed close to the ground in such a way that they would be above the water level to prevent flooding or guide the water to another direction (Figure 6). As in the examples, in the aqueducts here, although the size and shape are clear from the existing traces, there are elliptical-shaped encasements that stand as a kind of beams under the arch piers. As in the arch openings, it is considered that there may be encasements at the bases of the arch piers, which have disappeared under the road or soil, in addition to the existing encasements. In addition, based on the field survey data, the height between the two hills, and the traces of arch piers and walls showing the formation of a second floor, it can be interpreted that there may be a second aqueduct floor with a second arch sequence. It is believed that the arch walls could have been terminated with a barrel vault channel for transporting drinking water, and a hipped roof solution with stone slabs to transfer the rain and snow water toward the sides due to similar examples and necessity.

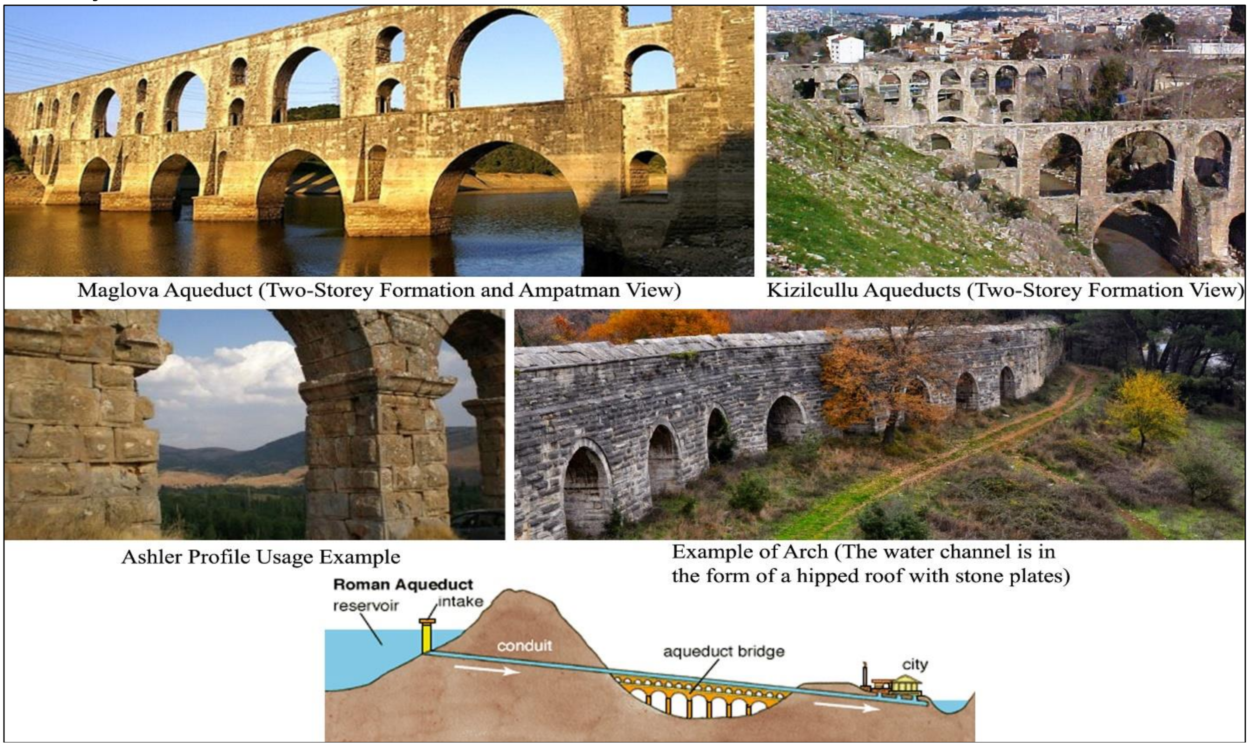

Figure 6. *Examples of aqueducts [27]*

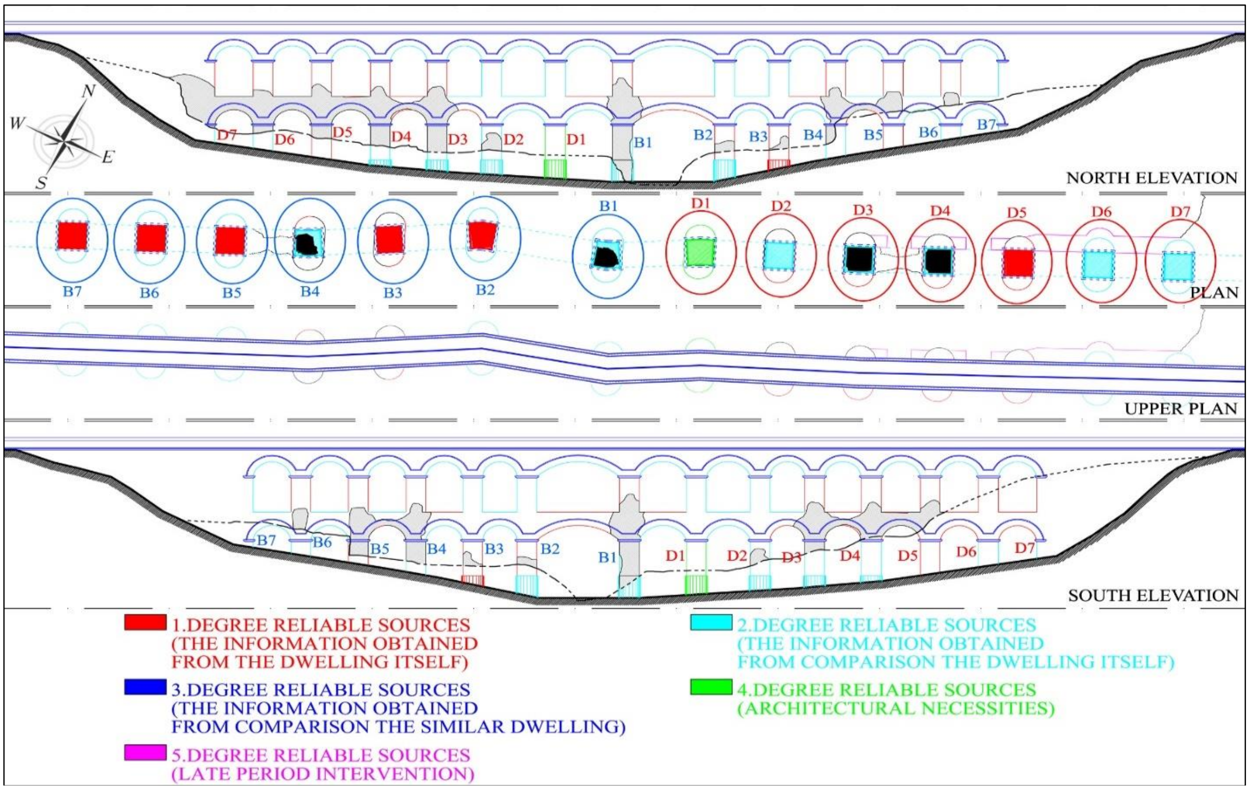

Figure 7. *Restitution Proposal (drawing belongs to the author)*

It can be suggested that the arch piers be surrounded with stone profiles at the beginning of the arch architrave when considering facade decorations within the context of similar examples. It can also be suggested that there may have been a stone profile where the general aqueduct wall would terminate at a certain height (Figure 6).

In the restitution proposal, 4 degrees of reliability were used. These are the data collected from the building itself, the data obtained from the intra-comparison of the construction, the data obtained from the comparison of the construction with similar constructions, and the data that should be present due to architectural necessity. The additions to the eastern walls, which were made as an early intervention, are also indicated separately, although they have traces on the construction (Figure 7).

2.5. Conservation Recommendations and Restoration

The priority in the conservation of monuments should be not to damage historical values. Especially in structures that have lost their function, their former use should not be considered again, and care should be taken to preserve them in their current state. There are also articles in international regulations regarding the method to be applied to ancient monuments and/or structures. In this context, Article 3 and Article 8 of the "Carta Del Restauro" state that in any past civilizations and ancient works, all forms of restoration should be avoided and only the scattered pieces should be combined based on the minimum use of materials to reveal and preserve the general outline of the remains, through the application of 'anastylosis."' It is also stated that in case of an addition, it should be clearly and precisely distinguishable from the original material [28]. The practice of "anastylosis" is also mentioned in Article 15 of the Venice Charter, and Article 12 states that if missing parts are completed, it should be done in harmony with the whole, but that this practice should be distinguishable from the original to avoid reflecting the artistic and historical value incorrectly [29]. Article 11 of the same charter and Article 6 of the Charter on the Built Vernacular Heritage, titled Principles of Implementation, stipulate that existing additions to the monument made in different periods should be preserved and should not be demolished if they do not constitute a contradiction [30]. The additions must show the features of the period they were constructed in and are distinguishable.

Based on the available data, the restoration plan for the historical aqueducts should aim to preserve the current state by cleaning and repairing it. For this reason, a function for the reuse of the structure is not envisaged, but measures to keep it healthy in its current state are considered. Completion, renovation, consolidation, filling, and cleaning are suggested as conservation methods. Decisions are evaluated in the titles of structural elements, building materials and construction method.

2.5.1. Structural Elements

Completion is recommended for missing materials where there is no doubt that they existed once. The wall should be completed with a similar type of masonry using a similar type of stone and stone-dusted lime mortar to prevent further soil erosion of the damaged section. Care should be taken to match the original material in the finishing of the masonry. In this context, the most appropriate solution would be to use lime mortar (without the addition of additives such as cement that may cause damage in the future) on walls with lime mortar. In masonry renovations, stones and mortar types similar to the original masonry material should be used. However, the intervened area should have features that can be distinguished from the original wall texture, respecting the "principle of indicating the restored areas". An indication can be achieved by changing the application method of the mortar that forms the joint fillings between the masonry stones (such as the application of collapsed joints 1 cm inside the masonry instead of flush joint mortar). This type of indication application is one of the easiest and most effective application methods. Indeed, after the application, the mason can easily scrape these joints and provide the collapsed form to the desired extent. Additionally, a similar approach is suggested for filling the joint fillings to provide restoration unity.

For the aggregate-binder ratios to be used in mortar making, trials should be carried out by taking into account the results of material analysis of the structure, and the appropriate one should be selected and used in terms of color, texture, mixture, and durability according to the results to be obtained.

Joint openings in the masonry should be filled with lime binder mortars prepared in the appropriate color and texture in all masonry areas. In joint filling applications, keeping the fillings at a specific depth (such as 5-10 mm) will provide both an indication of the repair and an adequate application quality limited for the necessary conservation. Indeed, the repair intervention will prevent rainwater from leaking inside the masonry and plant growth and will allow for more protection. Joint filling replacements should only be applied in fallen-off joint gaps in line with the "principle of minimum intervention". Mortars that have melted on the wall surface should be renewed as lime mortar filling.

The roots of trees, grasses, etc. growing on the masonry, in the joint gaps, and/or in the cracks and crevices in the stone structures should be cleaned by drying their roots. It is recommended to carry out the application in two stages. The first application is the use of herbicides and pesticides in addition to mechanical applications that do not damage the original stone surfaces to clean the plant roots. The liquid product should be diluted in water and applied by spraying on the fresh leaves of trees, grasses, and vines. The product applied in this way will be absorbed by the leaves to the roots and will be effective within a few weeks and will cause the plants to dry from the roots. The second stage of the application should be carried out to prevent the re-growth of the plants that were dried and cleaned in the first stage. In the areas and gaps with visible plant growth, the existing (wind-borne) soil fillings should be cleaned and then the gaps should be filled with suitable mortar fillings to prevent new soil filling and seed accumulation.

With the deterioration of structural integrity and the loss and gaps in the masonry (arches, piers, and walls), the remains of the buildings have become vulnerable to deteriorating environmental factors, and have become open to conservation risks such as disintegration/collapse and/or loss of masonry over time. The most effective conservation intervention against the problem should be to take precautions by covering the walls with a new/restricted additional masonry called capping to stop the progression of deterioration and prevent new deterioration formations. Capping is an application that aims to prevent the existing wall from getting wet, especially during rainfall, and in fact, it is carried out to take precautions against the deterioration that will occur in the presence of water in the form of moisture, salt and plant formations, crumbling of mortars, joint mortar, and masonry material losses. For this reason, it is recommended to be applied on all masonry sections with collapsed tops and masonry openings. The main goal here is to ensure the survival of the integrity of the wall with periodic maintenance, not only the original wall, which becomes weaker against external factors. In practice, it should be considered (in special cases where necessary) to prevent water ingress by placing an insulating material (such as thin bituminous paper kept 2-3 cm inside the edges, invisible from the outside) in the first mortar layer. This will prevent the wall from being at risk even if the additional layer falls off. This additional measure makes it easier to avoid the appearance of new additions, especially in masonry that will be left flatter on top (such as a wall consisting of brick glazes). Such an application will not change the integrity of the wall, but the original wall will be sealed and insulated against the deteriorating effects of environmental conditions.

2.5.2. Building Materials

Largely crumbled stones should be decomposed and replaced. The parts of the wall where the surface coating of the wall has fallen off should be coated using hydraulic lime-stone powder mortar according to the existing type of stone masonry system, and the new coating should be 5 cm deeper than the original coating surface. This will ensure that the renovated parts are distinguishable. On stone surfaces with a loss of pieces, plastic completion will be made with lime binder mortars prepared in the appropriate color and texture. The same process should be applied to the stone surfaces and masonry with visible cracks and fractures.

Parts intended to be preserved in their existing condition should be consolidated with consolidation mortar. This mortar should be created using hydraulic lime mortar. Freeze consolidation is recommended for wall surfaces whose cladding has fallen off with exposed rubble stone fill, and for which no original information is available. Moreover, to extend the life of the original material, a transparent, water-repellent, vapor-permeable, natural silicon-based liquid gel should be sprayed onto the stone surfaces.

Cleaning the surface deposits (dirt) and microbiological patina formations that cover the surfaces of masonry and stone is a necessary and important conservation process to reveal the original color and texture. It is possible to clean such dirt with different methods. The most suitable of these methods for the structure is the "micro-sandblasting" method. The micro-sandblasting method, widely used in Western countries for cleaning the facades of historical buildings, is a physical cleaning process where powders/clays with varying structures and hardness levels, such as aluminum oxide, glass powder, quartz powder, stone powder, or finely ground fruit peels, are sprayed under pressure. To clean the original materials without damaging them, the application must be performed carefully and with appropriate values. Therefore, it is recommended that the spray pressure should be less than 1,5 bar, the sprayed granules should be 100-200 µm (micrometer) in diameter, and not higher than the existing stone hardness (2,5-3 mosh is the appropriate hardness), and the abrasives should be sprayed from a distance of at least 40 cm to keep the effect low. It is considered appropriate to use the same method for desalinization on the surface.

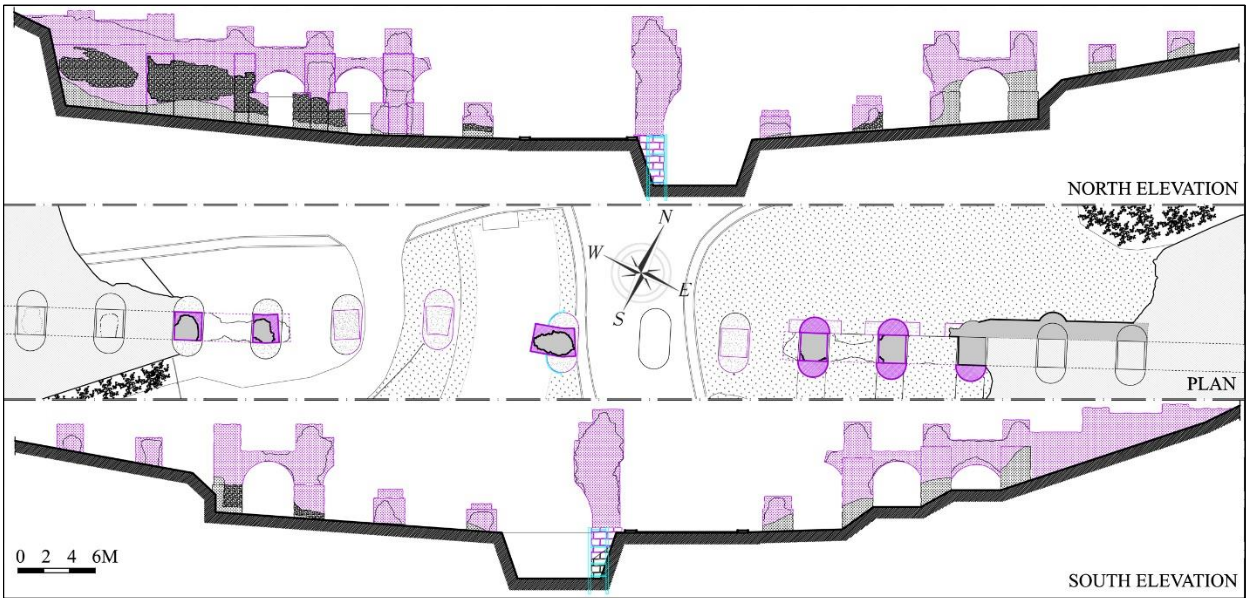

Figure 8. *Restoration Project (drawing belongs to the author)*

2.5.3. Construction Methods

The soil accumulated around the structure remains and on the structure elements constitutes an important source of moisture and plant growth, which constitutes a risk factor for the preservation of the remains of the structure. To protect the existing structural elements and materials from moisture, salt formation, and vegetation growth, excavation (systematic archaeological) and cleaning works should be carried out in the area to remove the surrounding soil accumulation and fill. Such an intervention will allow the remains of the existing structures to be fully revealed and recognized. In addition, the removal of the soil deposits will also allow for a full understanding of the possible (unknown) problems (in the areas surrounded by soil) and allow for intervention in all the problems.

In all applications, lime mortars similar to the original should be used. Using cement mortar shortcuts may lead to disintegration in the masonry in a short time (due to different hardness and expansion structures), causing new problems such as new degradation (transfer of moisture to other parts with less permeability and salt release), resulting in the inadequacy and invalidity of the application carried out.

The existing arch pillar, which is immediate to the left of the road when accessing the aqueducts from the south, should be supported with steel bearers and made statically safe due to its high risk of collapse. The existing cut stone base should be completed per its dimensions, and an internal joint should be made between the stones with hydraulic lime mortar (Figure 8).

3. CONCLUSION

Water structures have been of great importance since ancient times. Civilizations have developed specific structures due to the difficulty of transporting water to settlements and storing and using water, which is the source of human life. Structures that will be described as waterways or aqueducts are one of them. Aqueducts were built when it was necessary to bring water from distant places and cross deep valleys. Although the width and height of the aqueducts vary according to their location, they have similar features in terms of construction style.

Kemerkasim Aqueduct has survived to the present day, albeit partially, as a part of the Prusias Ad Hypium Waterways. Although many of its arches have collapsed, the presence of the arch piers and the traceability of the structure provides sufficient data for conservation. It is also of particular importance in the context of the Nikomedeia waterway, as it is a rare surviving structure.

The dating of the aqueduct to the 1st century and the fact that it underwent repairs in the 2nd and 3rd centuries indicate that it was built during the Roman period. It can be stated that the most important factors in the deterioration of the structure until today are natural disasters such as earthquakes and floods and some human activities. This is supported by the fact that the area where the structure is located is an earthquake zone and there have been many earthquakes of various magnitudes from the past to the present. Considering the current stream bed, it is likely that there was a wider stream in the past, and it may have damaged the structure due to rainfall.

The use of masonry channels is frequently encountered in aqueducts built for water transportation. These channels were also frequently used in the waterways of Nikomedeia [13]. Traces of a similar masonry water channel were found in a garden in Kemerkasim Village, at the southwestern end of the water bridge extending on the northeast-southwest axis, about 70-75 meters from the last arch that survived to the present day. Due to the garden arrangement, the section of the water channel has become an earthen wall with a section of about 2 meters in height. The badly damaged water channel was used to form the outer wall with irregular rough stones combined with mortar and filling. The width of the inner part is approximately 60 cm. Its base is not visible due to the collapse and filling of the upper part of the channel, and therefore its height could not be determined. Based on similar examples, it is estimated to be around 1 meter. For this reason, it is understood that the Kemerkasim Aqueduct had also a masonry channel.

When examining the deterioration in the structure, it can be understood that there is significant damage to the materials. In addition, the arch pier, especially on the edge of the asphalt road and in the stream bed, is structurally at risk of collapse. In the restoration proposals related to the aqueduct, avoiding a full completion was avoided, and strengthening the risky elements with partial completion was envisaged. In this way, it is anticipated that the structure can be kept alive while preserving the existing remains.

The study revealed that it is difficult to conserve structures in areas that remained in the background in terms of location. Indeed, no measures have been taken even for the arch pier, which poses a risk to human life and is structurally about to collapse. The fact that the local people are not knowledgeable about the importance of the structure causes them to engage in behaviors such as walking, grazing animals on the structure, etc. It was also concluded that taking no measures against this situation is contrary to the principles of conservation and also indicates that nothing has been done for the historical structure. The preservation and conservation of the aqueduct structure, which has significant international value, is of utmost importance.

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