

DOCUMENTATION FOR PRESERVATION OF THE FERHAT WATER CANAL IN AMASYA

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All photographs by the authors unless
otherwise stated.

1. Amasya, the central town of the Amasya Province (formerly named Paphlogonia) is located in the Central Black Sea Region in the north of Turkey, on the foothills of the Fon and Pont mountains, situated on both flanks of the Yeşilirmak river (formerly called Iris and Tozanlı), stretching along a narrow valley strip running from northeast to southwest. (Perrot, 1984, 440; Gouz, 1957, 68; Hüsameddîn, 1911-12, 8; Texier, 1921, 134; Turkish highways map; Yinaç, 1961, 392; Strabon, 1969, 445; Gabriel, 1934, 3; Banse, 1916, 90; Evliyâ Çelebi, 1896, 184)

INTRODUCTION

The Ferhat Water Canal was built in the Late Hellenistic - Early Roman Period, with the objective of meeting the water needs of the town of Amasya, by boring into the rock and building stone-vaulted canals that run across the riverbeds (1). H. Hüsameddîn mentions about the origin:

It is an 18km long canal that starts in front of the 'Şahin' Rock located at a distance of about 15km to the south of Amasya, which passes the front of 'Ferhat Arası' and 'Memi Dede', winding around the 'Gökmedrese', 'Şâmîce', 'Receb', 'Çeribaşı', 'Acem Ali', 'Uzun Mustafa', 'Gümüşlü-zâde', 'Mehmet Paşa' and 'Sevâdiye' districts and reaches a hole of square cross-section, 4 meters at sides at 'Kibrithane', which is in the 'Bayezid Paşa' district. (Hüsameddîn, 1911-12, 36-37).

The major part of the 6 km section of this canal, which runs from the 'Helvacı' District (the Prison Point) at the west of the town to the 'Bayezid Paşa' district's old industrial zone 'Kibrithâne' on the east, runs as a tunnel under the present city settlements. The portion of the canal which is around 675 meters in length, runs around a curve at the 'Ferhatarası' point, located at the eastern foot of the 'Ferhat' Mountain, lying above the ground. This open part of the canal was registered as "a monument and an immovable cultural artefact" (T.R. Ministry of Culture the High Committee for Ancient Real Estate and Monuments, 1975; T.R. Ministry of Culture Ankara Commission for the Conservation of Natural and Cultural Entities, 1988) (Figure 1, 9). However, the monument was not the object of any analytic investigation since its registration in 1975 and no study was carried out for its preservation until 1997. The Amasya City Governor, the Amasya Mayor and the Amasya Museum Director in 1997, all aware of their responsibility of preserving cultural heritage of the city, initiated the studies for the preservation of the over ground and registered section of the canal and assigned this task to the Gazi University faculty members Işık Aksulu and Gediz Uruk, to obtain the 'Amasya Ferhat Water Canal Preservation Proposals and the Environmental Reorganization Project'

2. The authors thank the ex-governor and the present Advisor-in-Chief to the President of Republic of Turkey Kemal Nehrozoglu for his support.

(Aksulu and Urak, 1998) (2). This project was realized for the 675m long registered portion of the canal that is located in the Central Amasya 'Helvacı' District's 'Ferhatarası' region, which runs parallel to the Amasya - Tokat highway, and is the most suitable part for the canal preservation and for reorganization purposes.

The initial analyses were carried out prior to the start of the project, to identify the canal's inherent potentials; a problem defining outline and a field-research project was developed in order to preserve all the potentials, proposing solutions for possible problems. In this context, the below mentioned potentials and problems of the Ferhat Water Canal and its location were determined as below:

- The over ground and registered portion of the Ferhat Water Canal, which is the scope of this project, has an important location recognized as the entry of the Town of Amasya from the Tokat direction.
- The large piece of land between the canal and the road may provide convenient recreational space for the Town of Amasya, which is topographically restricted between two mountains and the river of Yeşilirmak, offering a linear urban settlement.
- The area is easy to reach, because of its proximity to the town.
- The study area poses a rare cultural entity, as an object of the World Cultural Heritage, that documents the urban history, the historic waterway planning, the old technology and the materials employed, and even, the environment approached as an object of aesthetics during the Late Hellenistic and the Early Roman periods.
- There is a local plant cover, or the specific flora.
- The preservation of the canal could help develop the cultural and preservation consciousness of the townspeople and its future generations, once they are acquainted with their cultural heritage.
- The preservation of the canal environment and opening it to public-use could contribute the increase of potential in urban touristic development.

The above defined as the inherent potentials, where the below constituted the possible problems:

- Currently, the area between the canal and the road that are occupied by functions incompatible with preservation and the historic site. These are a quick-lime plant, an auto service station, a tile and brick storage yard, and a sand-sieving plant and their office buildings with storage facilities, which are visually and functionally disturbing.
- Parts of the Ferhat Water Canal is covered with debris, parts of it over ground but filled with loose materials, cracked, caved, and even plant covered at places.
- There are cracks inside the rocks at the canal's hill slopes, which pose a threat to human safety.
- The canal does not have a linear axis, but a curving shape in plan, posing problems in defining the method of measurement.

As the canal and its environment posed multi-faceted potentials and problems, a need for an interdisciplinary team study arose, starting with the architectural survey, to be adopted in the selection of techniques

3. The optical measurement and drawing method used is still in current use, but today, Total Station and Photogrammetric Scanner instruments and related computer programming languages allow shorter measurement and drawing durations (Sağiroğlu, 2004, 15, 17).

4. The authors thank Mapping and Real Estate technician and architectural photogrammetry specialist Şinasi Kılıç, Amasya mayor's mapping technician Sadık Karakoç, Gazi University City and Regional Planning Department assistant Halil Emür, restoration specialist Faruk Zarzhet, and architect Zehra Tulunoğlu for their assistance in the measurement, analysis, and other technical work.

for detailed procedures of documentation, laboratory analyses, damage assessment, geological and rock mechanics analyses, for the identification and preservation of the material properties (chemical, visual and technical analyses of the materials) and the botanical analyses. This realized, the cleaning of certain portions of the canal that were filled with stones and earth at places followed, and excavations were conducted at places where the canal was totally filled with debris. Findings from these surface studies were used in developing the proposal for the preservation of the canal, as well as the stages of intervention.

In this context, the project proposal comprising the documentation to implementation stages was prepared with a report and drawings at 1/50, 1/200, 1/500 and 1/10 scales, in accordance with the international rules and techniques, regarding the specific conditions presented by the structure. The field work and the reports were completed from June 1997 to June 1998.

ARCHITECTURAL SURVEY

From the investigations made in the area, it was felt that the use of conventional measurement methods would be inadequate for a structure like the Ferhat Canal and a 'polar normal coordinate measurement method', jointly with Zeiss-Theo-20A brand theodolite and Leica-NA 820 brand level equipment were used, which allowed the measurement of irregular and curved structures (such as the Ferhad Canal) with minimum error margin. Measurements and drafting of the vaulted canal sections that are narrow and do not allow use of such instruments were made using conventional measurement and drafting methods. The silhouette of the mountain and some canal cross sections located at higher altitudes were measured using the forward deduction method. Some canal cross sections were measured using the Tacometric Measurement Method and the remaining were done by using the 'Normal Coordinates' system (3). With the mentioned survey method and systems, architectural survey studies have been performed at two stages; before and after the cleaning and excavation operations (Figure 1, 2 – 8, 10 - 17).

In the following two stages of architectural surveys, polygon and crossing points were computed and converted to the map format, using the AutoLISP programming language and draft plat plans developed (4). Data collected from field measurements, and sketches, photographs and videos were evaluated and, with the aid of the draft plat plans developed for the first and second stages of the architectural survey, were drafted onto the same size paper, resulting in plat plans, sections and silhouette showing the canal and its environment's detailed pre and post excavation architectural survey.

The First Level Architectural Survey (Figure 1, 2, 4)

53 polygon points have been set up inside the canal to enable the development of the 1/50 scale architectural survey map of the Ferhat Water Canal. Polygon points have been marked with wooden stakes and steel nails, and highlighted with removable paint. Polygon angles were measured with theodolite using the sequential angle measurement method. The distances were measured twice, using the tape measure. Mean values were used for the polygon calculations. The polygon's starting point was P21, the starting direction was P21-P20 and the coordinates for P21 were taken as $x=300.00$ m., $y=300.00$ m., $z=103.21$ m. This z value is common

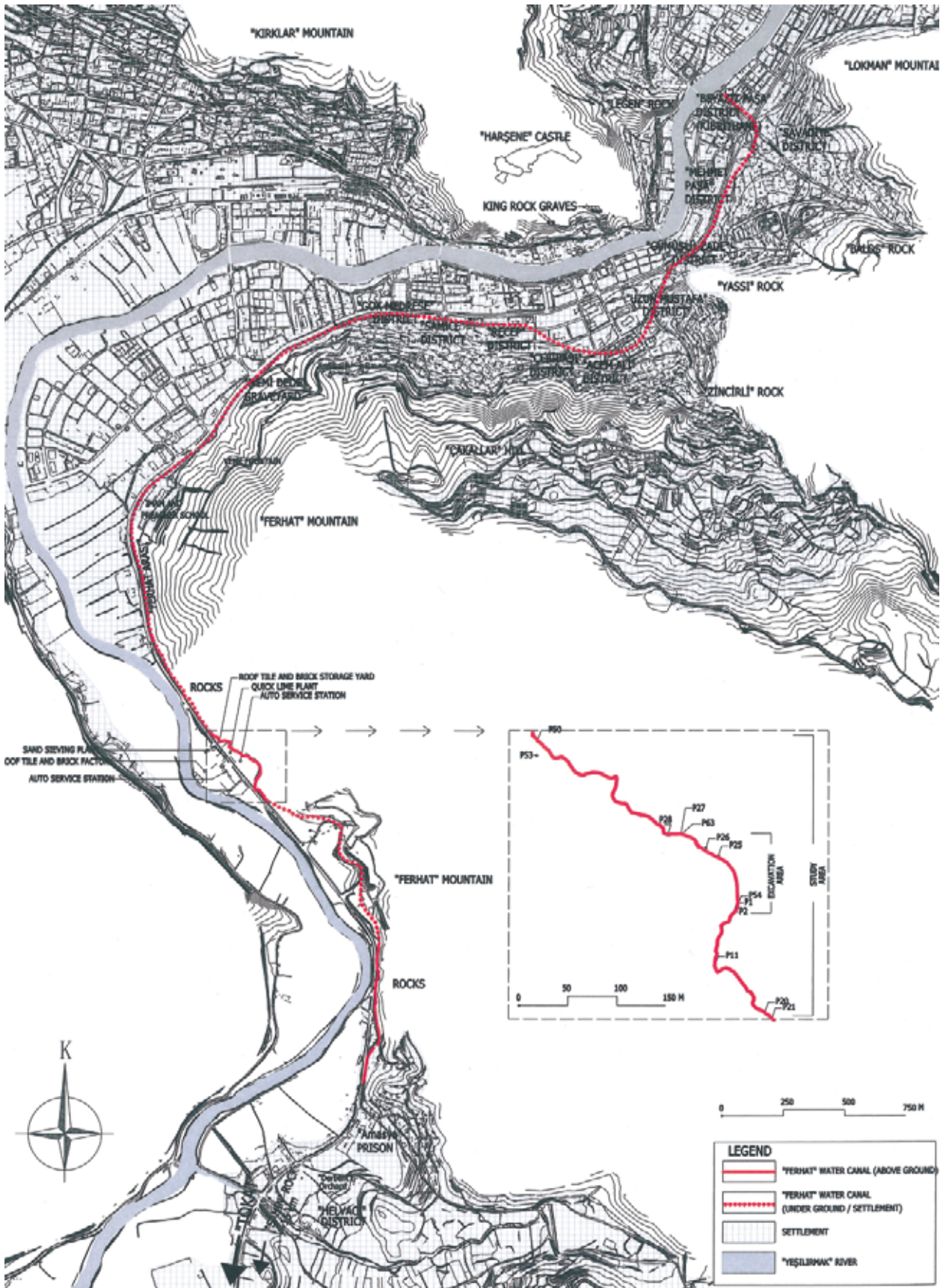


Figure 1. Location of Ferhat Water Canal and the Study Area

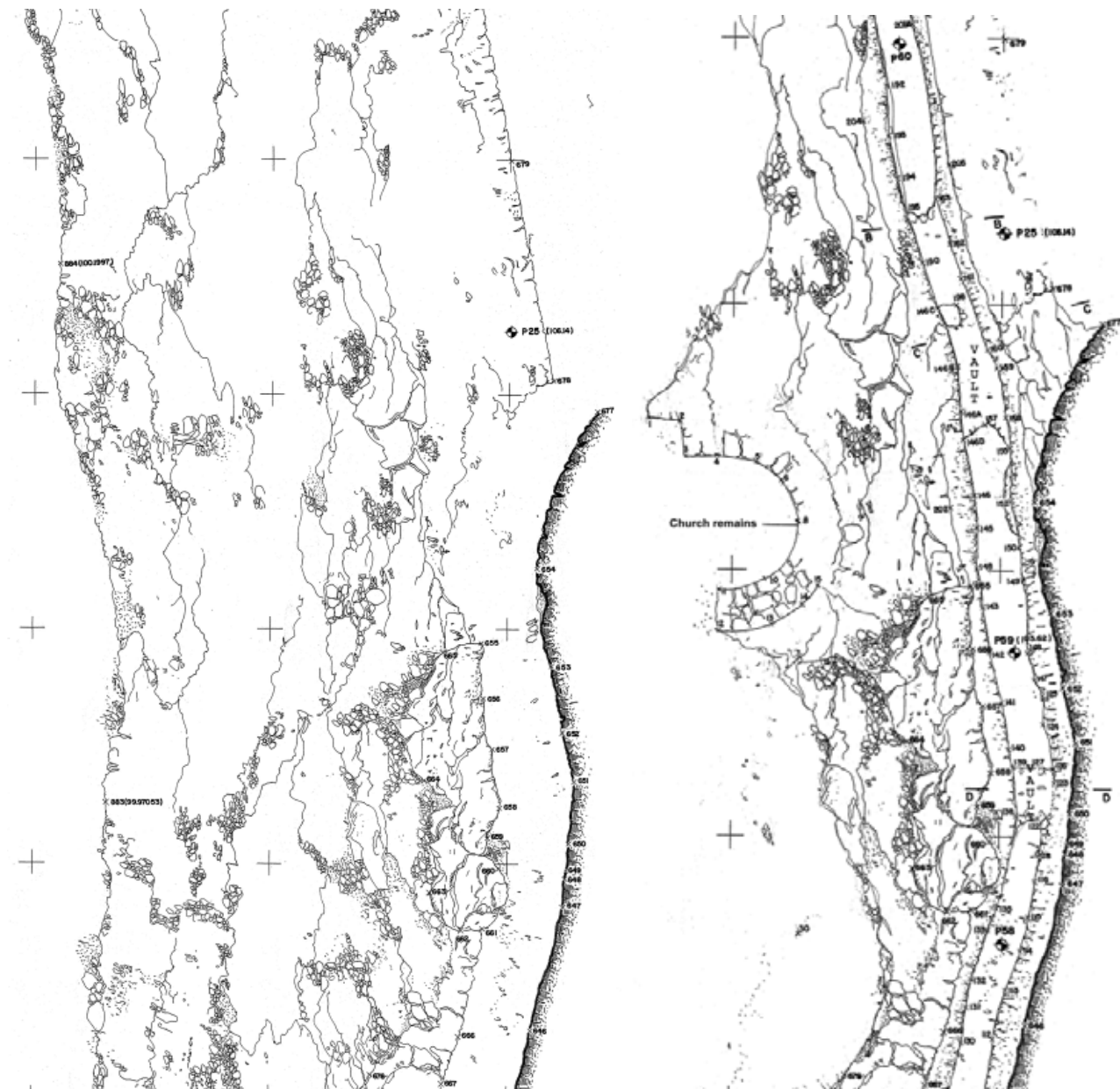


Figure 2. Ferhat Water Canal–
Architectural survey prior to excavation–
Between polygons 24 to 26.

Figure 3. Ferhat Water Canal–
Architectural survey after the excavation–
Between polygons 58 to 61 (24 to 26).

with the elevation of the monument established for the area elevation map developed in 1994.

The polygon's trajectories were established as; Unclosed Polygon, Closed Polygon, and Subordinate Polygon and the coordinate calculations were carried out accordingly. Identification of the pass points at required locations have been made and their horizontal angles and distances from the polygon points were measured for the preparation of the 1/50 scale Architectural Survey of the canal.

Measurements for defining the rock mass have been made using the Tacometric Measurement Method. The north direction angle has been measured at P21 as 57.97 Grads clockwise in the Poligon point 21 to 20 direction. The Tacometer measured coordinates and the elevations of the pass points were calculated, using mathematical functions and formulas provided in the Microsoft Excell Program. After the preparation of the plat



Figure 9. Ferhat Water Way– General view from the Amasya-Tokat Highway, 2006.

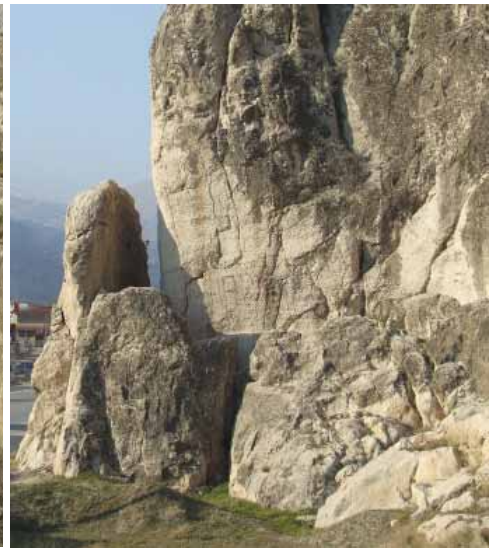


Figure 10. Ferhat Water Way– General view from the Amasya-Tokat Highway– Between polygons 11-13, 2006.



Figure 11. Ferhat Water Way – Canal inside–Around polygon 13.

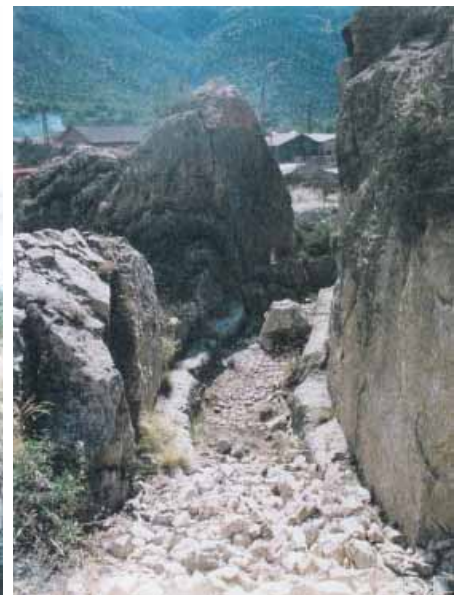


Figure 12. Ferhat Water Canal – Canal inside–Around polygon 28.

to the 'P28' polygon point. One end of the newly developed polygon trajectory is tied to the 'P1', while the other end is tied to the 'P28' polygon point. The developed 10 polygon points are, consecutively numbered as 'P54-P63'.

The measurements for defining boundaries of the rock mass were carried out using the Tacometric Measurement Method, after the removal of the earth fillings left from the excavations made before these measurements. The elevation and angle measurements made after the excavation and debris cleaning benefited from the polygon points established before the excavation and debris cleaning operations.

After the field studies, coordinate computations, plat plan preparation and drawing of the points, detailed post excavation architectural survey of the canal region showing the canal and its environment in the form of 18 plat plans (14 plans, 3 cross sections, and 1 silhouette) were drawn.



Figure 13. Ferhat Water Canal – Canal inside- Around polygon 51, 2006.

Figure 14. Ferhat Water Canal- during excavation (From Amasya Museum).



Figure 15. Ferhat Water Canal - Canal inside after cleaning / excavation - Around polygon 13.

CLEANING AND SURFACE EXCAVATION STUDIES AND DATING OF THE FINDINGS

The cleaning and excavation studies performed for the 675 m long over ground and partially under ground segment of the Canal, which passes behind a quick-lime plant (southern section), the auto-service station, and a roof tile and brick storage yard and ends in front of a sand-sieving plant (constituting the entire project area), took thirty working days (5).

For the inventory of the botanical plant cover and its characteristics, studies were performed at site before the cleaning and excavation started. Findings revealed existence of fifty different plant types; the most interesting plant identified is the region specific *Sideritis Amasiaca Bornm*, which is a flower. This region specific plant, blooms into yellow flowers in the seventh month and spreads onto the dry mountain slopes and the vineyards (6; Karaer, 1998) (Figure 18).

Cleaning studies were conducted between polygons 21-11 and 28-50. Excavation studies were made for the region that extended from polygon 1 to 28.

The existing water canal, which was constructed by boring into the limestone, was followed and explored by cleaning the filling materials, rocks and earth fallen and the trees and plants grown in between the rock cracks. The canal was observed to have deteriorated and filled with earth in locations where it traversed small streams. The top of the canal is observed to be covered with a vault between polygons 25, 26, and 27 (Figure 3, 6, 7, 14, 16, 17). The length of vaults in this region is 240 cm, and the inside width of the canal is 70 cm, height varying from 125 cm to 150 cm depending on the canal slope. The 30 cm thick vault is constructed using rubble stone masonry technique. These vaults are supported by walls of height 80 to 105 cm, of thickness 20 cm on the sides opposing each other. The width of the canal in its stone bored sections varies from 87 to 94 cm. The plaster remnants that are observed at various locations indicated that the canal had been originally plastered by 'Horosan' type plaster (7).

5. In compliance with the cleaning study and the excavation permission given by the Turkish Ministry of Culture General Directory of Museums, dated September 12, 1997 and the consent given by the Governor of Amasya, dated September 29, 1997, numbered 1536; the work was conducted by the Amasya Museum director Ahmet Yüce, museum researchers Celal Özdemir, Muzaffer Doğanbaş and the museum photographer.

6. This plant was collected for the first time by J. Bornmüller on July 20, 1989 at Amasya's Lokman mountain (Karaer, 1998).

7. 'Horosan' is a local plaster / mortar made by mixing ground terra cotta and sand with quick lime.



Figure 16. Ferhat Water Canal– Cylindrical arches discovered during the excavation– Around polygon 14.



Figure 17. Ferhat Water Canal– Cylindrical arches discovered during the excavation– Between the polygons 59-60.



Figure 18. Sideritis Amasiaca Bomm flower found around the Ferhat Water Canal Region (From F. Karaer).

Figure 19. Ferhat Water Canal– Terra cotta materials discovered during the excavation (From Amasya Museum).

Terra cotta pots and a round pot cover with a single handle, belonging to the 11th-12th centuries A.D. were found during the cleaning of the earth fill inside the vault between the polygons 25-26 (**Figure 19**). A 80 cm thick 75-80 cm high apsis with rounded walls, constructed of rubble stone, was exposed on the canal's outer surface near the main rock between the polygons 25-26 (**Figure 3**). The inner sides of the walls were coated with Horosan plaster. An uneven surfaced floor mosaic with designs made of partially decomposed white, brown, light green, yellow, green colored pieces was observed in the base of the apsis. (**Figure 20**). Roof plates embossment-decorated and building decoration plates of terra cotta were found outside the southern side walls of the apsis. A 60 cm wide, 80 cm thick wall opening that cuts the canal at a perpendicular direction near a small arch cover was observed during the excavation studies conducted near the Polygon 26 region. In front of this small wall, 120 cm high walls constructed of even-surfaced cut stones that run towards the inside of the canal, parallel to the inside walls, were observed.

A simple grave was found in front of this wall (**Figure 8**). The wall of rubble stone, cuts the canal once more towards west after following the canal for about 4m. A long rectangular setting with plastered interior walls and floors running in the north-south direction over this perpendicular wall has been exposed.

A round bodied arrow of 10 cm length and 1 cm thickness, with an oval head having two sharp-sided wings, which most likely belongs to the Early Roman Period, was found between polygons 1 and 2 at a depth of about 20 cm from the surface (Yüce, 1999, 201, 202) (**Figure 21**).

The excavation and cleaning work showed that, in general, the water canal was constructed by boring into the local limestone in the leveled style. No carving tool was found. However, the diagonal 2 cm deep chisel prints which can be easily observed on the canal sides revealed that the rocks were bored by metal chisels, hammered by arm power (**Figure 11**). At the creek / stream locations where the ground conditions were not as favorable, to fend against various impurities, rubble stone walls supporting



Figure 20. Ferhat Water Canal– Mosaic decoration on apsis floor during the excavation (From Amasya Museum).

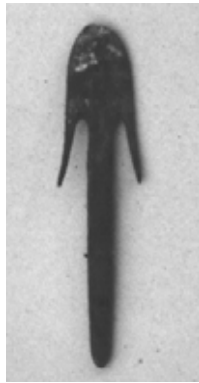


Figure 21. Ferhat Water Canal– Arrow tip found during the excavation (From Amasya Museum).

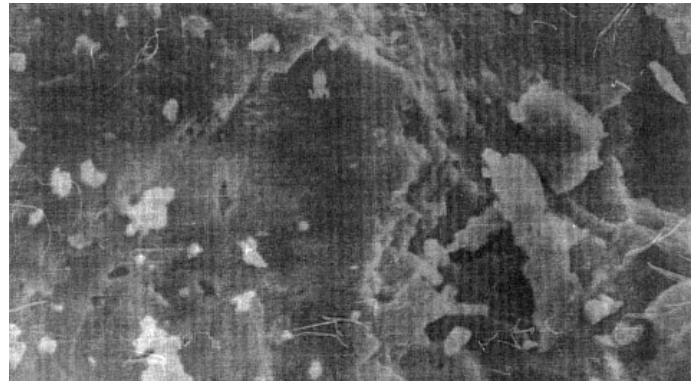


Figure 22. Calcite crystals.

rubble stone vaults were built at both sides of the canal and the inside was plaster coated (**Figure 3, 6, 7, 14, 16, 17**). Sedimentation ponds of various dimensions were also observed at the portions that were carved into the stone.

The Ferhat Water Canal construction techniques show similarities with those used in the Amasya King Burial Sites constructed during the 2nd century B.C. , i.e. in the Hellenistic Period. The canal was most probably built during this period with the objective of transferring drinking water to the ancient Amasya Town. The vaults excavated at locations where the canal crosses small creeks or flood stream beds, were repaired at several locations during the 3rd century A.D. (**8**; Nicholson et al., 1993, 145). From the excavation area between polygons 1 to 28, it is found that the canal had lost its function during the late Byzantine Period (12th century A..D.) and settlements were built around the periphery (Yüce, 1999, 203) (**9**).

DAMAGE ASSESSMENT AND PRESERVATION PROPOSALS

A geological study and rock mechanics / stabilization design was developed immediately after the completion of the architectural survey, with the objective of conserving the Ferhat Canal and of providing security for possible visitors in the future.

In parallel to this, a damage assessment was carried out with the objective of identifying the materials used, observing the problems, and developing the necessary preservation proposals for the canal and its immediate vicinity. Material samples were taken at critical locations for conducting laboratory analyses. All damage assessments and the locations where these samples were taken from, have been included in the 'Damage Assessment Drawings'. Out of the 13 specimens taken from the canal and its immediate vicinity, three stone samples measuring about 15 cm in diameter, were selected to be sent to the laboratories of Turkish Cement Manufacturers' Union for mineralogical and morphological investigations. The remaining 10 plaster samples were sent to the Turkish Ministry of Culture, General Directorate of Monuments and Museums, İstanbul Central Conservation and Restoration Laboratory for visual inspections, as well as to determine the lime-silicate ratio, the aggregate type and granular distribution, and strength determination and identification of similaries of cementing material in comparison with those known to be built during the same period.

Geological Study, the Rock Mechanics / Stabilization Design and Intervention Proposals

A geological survey and a rock mechanics / stabilization design that describes the implementation techniques for the consolidation and stabilization of the rocks have been prepared, with the objective of preservation and consolidation of the Ferhat Water Canal, but also of providing safety for human life within and around the periphery (Ökseloğlu, 1998, 25).

The portion of the canal which is 600 m and passes through limestone is called the Ferhatkaya Formation. Limestone, characterized by planer layers, flow canals and cave-like voids, is very sensitive and vulnerable when exposed to underground water seepage which causes chemical deterioration. The topographic slope in the region is significantly high. The rock block heights in the canal route vary about 15 to 20 m.

There are three primary fault lines in the region. The fault interfaces are filled with carbonated clay of thicknesses varying from 5 to 15 cm. There are a large number of fractures developed in perpendicular directions to these fault lines. The fracture planes in the top and bottom sides of the canal run parallel or approximately parallel to the canal route. The sliding directions of blocks that developed as a result of these fractures are in the canal direction. Because of the layered structure of limestone, the fractures have developed diagonal to the fault lines and this resulted in a multi-partite structural formation. Some of these blocks should be reconnected to their original rock masses using anchor bolts. The length of these rock anchor bolts will have to be between 1-7 meters. Rock anchor bolts are steel rods that are inserted into the ground shell, given the task of strengthening the rock surfaces to resist tensile stresses, transmitting these stresses to the main rock mass below, thereby increasing the friction strength of the discontinuous rocks or developing a triaxial stress condition within the rock.

The fact that the rock anchor bolting costs will be high and the small surface rock blocks are multi-partite, necessitates the adoption of a concrete shimming approach. To slow or to stop the deterioration, the cracks that are open to water penetration must be injected with 350 kg/m³ (350 dosage) cement grout.

8. The three lined inscription plate in Greek, found on the wall of the Ottoman Period Yörgüç Paşa Mosque structure, states that the canals have been repaired in 3rd century A.D. (Nicholson et al., 1993, 145)

9. Some folkloric sources state that the Ferhat Water Canal was bored and completed by 'Ferhad' who was in love with 'Şirin', in nineteen days, with the objective of reaching his loved one. As rehearsed by H. Hüsameddin; "Attributing the construction of this great work which was most notably accomplished by boring into the rock in 5 locations with tunneling into the rock is totally naive. It is doubtless that whoever built it must have or had possessed large amount of property and wealth". Excavation discoveries also confirm that this claim has no scientific basis. The basis of this rumor could most likely be due to the rock and the mountain where the canal is located both being called 'Ferhad'. The 'Kesri and Şirin' love story must have been modified into the 'Ferhad and Şirin' story. 'Kesri' is the Shah of Iran 'Hüsrev-i Perviz', while 'Şirin' is Maria, the daughter of the Byzantine emperor Moris. This story is carved onto a rock located on the Bistun mountain in Iran. An essay in a magazine of history, date and author unknown, states that when the Iranian shah 'Hüsrev-i Perviz' invaded Anatolia and Amasya, he had assigned his commander (Emir) 'Ferhad b. Efrühte' as the governor of the Amasya region and this governor had the Amasya Waterways constructed, which were then named after him. However, the fact of 'Ferhad b. Efrühte' being the governor of Amasya and having the Amasya waterways repaired is historically debatable. Another claim is that when 'Melik Ahmed Dânişmend-i Gazi' put siege to 'Harşene (Amasya)' in 1075 A.D., one of his commanders, 'Ferhat Gazi' was martyred on the Fon mountain and was buried there (the mysterious grave discovered perhaps belongs to 'Ferhat Gazi') and the mountain was renamed after him, this later to be attributed to the lover Ferhad." (Hüsameddin, 1911-12, 38 - 41)

Some of the loose rock debris, located over the canal area and behind the auto service station, must be removed. This excavation amounts to 1200 m³. After this excavation, a retaining wall measuring approximately 65 m long and 1.5 m high that will protect the canal against the loose rock debris above, must be constructed.

There are small to large sized streams flowing in the region. The fact that their flow directions run over the canal, necessitated the placement of drainage openings in five separate locations, to protect the canal by diverting water from the area.

The machinery and materials to be deployed for these operations were selected in such a way that they did no damage, or minimum damage, to the structure. The work was conducted in a manner assured the survival of the existing natural plant cover in the area.

Visual Technical Analyses, Damage Assessment, Evaluation of the Analysis and Intervention Proposals for the Canal

The visual analyses conducted in the canal and its immediate vicinity after the architectural survey study consisted of identification and drafting efforts. These identified damages such as; erosion, development of gaps between blocks, fire damage, cavity - material loss, separation, surface debris, hole formation, deformation, moss, color and value change, cracking, and holes that require filling. The Turkish Cement Manufacturers Union (TCMU), the Turkish Ministry of Culture, General Directorate of Monuments and Museums İstanbul Central Conservation and Restoration Laboratory and the Canal Geological Study and Rock Mechanics / Stabilization Project Report have been taken as the base for visual and technical analyses and damage identification and assessment (İdil, 1998).

Results from the mineralogical analysis of the three 15 cm x 15 cm rock specimens sent to TCMU showed that the rocks in the area consisted of smooth calcite crystals (**Figure 22**). This will enhance the effectiveness of the plaster/mortar to be injected in the areas where filling will be required. Additionally, because of its smooth crystal structure, aggregate that will be prepared using these calcite materials found in the region will lengthen the bond life of the injected plaster/mortar to the inside surfaces of the cracks and holes.

The visual analyses results from 10 plaster specimens (**Table 1, 2**) studied in the central laboratories showed that the specimens 1, 2 and 7/2 have similar characteristics with the specimens 4, 5, 6/1, 6/2, 6/3, and 7/1. It is found that the terra cotta aggregate pieces of varying dimensions and river sand aggregate were used for preparing the plaster to cover the canal side walls and base.

Analysis of the canal floor cover revealed that the amount of quick lime used for the bottom layer is similar to that used for the rectangular domain (**Table 2, 3**). Preservation and consolidation applications should adopt the same amount of quick lime. The ignition loss and the variable aggregate sizes used for the specimen 3 shows that this was not due to a deliberate effort. Based on the location where this specimen was taken from, it is most likely that this layer was formed during the water flow and afterwards from the accumulations formed on the side walls of the canal. This observation shows that the preservation and consolidation work must be done with care.

Specimen No	Site taken	Color	Aggregate shape	Observation
1	Top of vault	Whitish-gray	Heterogeneous distribution	Spongy appearance
2	Vault on top of the Imam & Preacher School	Whitish-gray	Heterogeneous distribution	Spongy appearance
3	Canal side wall	Black, Dark grey	Tuft characteristics	Spongy appearance
4	Canal base floor	White	Dense lime nodules	Weak Horosan mortar
5	Inside the rectangular region	Terra cotta tile colored	Large lime nodules	Weak Horosan mortar
6/1	Canal base floor	Light pink	1,5-2 cm terra cotta pieces	Horosan mortar (no terra cotta dust)
6/2	Top plaster layer	Pink	2 mm thick sand and terra cotta aggregate, few lime nodules	Weak Horosan mortar
6/3	Bottom plaster layer	Red	Dense terra cotta pieces	Horosan mortar, 0,2 mm thick smooth aggregate
7/1	Side wall of canal body, attached to specimen no 7/2	Pink	Uniform sized terra cotta pieces	Horosan mortar
7/2	Side wall	White	Equal aggregate dimensions	Spongy appearance

Table 1. Evaluation of the specimen sites and visual inspection findings.

Specimen No	Observed mineralogical Structure	Material composition
1	0,5-4 mm radius sand, quartzs, gravel, basalt pşroksen, olivine plajioklas	Krypto crystallised lime
2	0,5-4 mm radius sand, quartzs gravel, basalt pşroksen, olivine plajioklas	Lime
3	Tuft, spongy form	Lime particles dissolved in water
4	No mineral content. Terra cotta aggregate of 1,5 mm dimension	Lumps of lime
5	Quartz, feldspar, biotite, terra cotta aggregate of 3 mm dimension,	Lumps of lime
6/1	Calcite, terra cotta pieces and marble aggregate	Lime and small amount of terra cotta dust
6/2	Quartz, schist, plajioklas, terra cotta aggregate	Lime and small amount of terra cotta dust
6/3	Quartz, volcanic opaque stone, limestone, terra cotta pieces	Lime and dense terra cotta dust
7/1	Quartzs, feldspar, peridodite, radiolit,	Lime and small amount of terra cotta dust
7/2	0,5-4 mm radius sand, quartzs, gravel, basalt pşroksen, olivine plajioklas	Lime

Table 2. Petrographic and mineralogic observations.

Sieve analysis and acid insoluble aggregate amounts are shown in **Table 3**. Specimens classified in 'Sieve Analysis' phase are shown in **Table 4** and the 'Cumulative Distribution and Fineness Modules' are shown in **Table 5**.

Specimen no	İgnition loss	Soluble in acid	Insoluble in acid	1000 mik	500	250	125	125 >
1	25.51	27.48	72.52	61.60	11.37	23.51	1.76	2.76
2	23.00	26.67	73.33	55.10	8.04	30.60	1.76	4.50
3	71.00	83.53	16.47	2.77	17.39	47.92	9.14	22.78
4	62.41	63.09	36.91	30.87	6.66	24.29	6.58	31.60
5	26.62	69.94	30.06	35.02	5.69	18.65	3.98	36.48
6/1	42.44	37.64	62.36	82.79	2.76	7.75	0.95	5.77
6/2	58.49	48.30	51.7	45.47	6.25	20.71	3.78	23.80
6/3	28.82	69.74	30.26	47.41	7.51	25.71	3.04	16.32
7*	--	33.33	66.67	32.20	13.01	44.03	3.21	7.55

Table 3. Relation between the acid solubility, ignition losses and sieve analyses of the specimens (unit % gr).

* As the specimen 7/2 is pure lime, it totally dissolved in acid.

Specimen no	İgnition loss	Soluble in acid	Insoluble in acid	1000 mik	500	250	125	125 >
1	25.51	27.48	72.52	61.60	11.37	23.51	1.76	2.76
2	23.00	26.67	73.33	55.10	8.04	30.60	1.76	4.50
4	62.41	63.09	36.91	30.87	6.66	24.29	6.58	31.60
5	26.62	69.94	30.06	35.02	5.69	18.65	3.98	36.48
6/3	28.82	69.74	30.26	47.41	7.51	25.71	3.04	16.32
6/1	42.44	37.64	62.36	82.79	2.76	7.75	0.95	5.77
7	--	33.33	66.67	32.20	13.01	44.03	3.21	7.55
6/2	58.49	48.30	51.7	45.47	6.25	20.71	3.78	23.80
3	71.00	83.53	16.47	2.77	17.39	47.92	9.14	22.78

Table 4. Classification of the specimens (unit % gr).

Specimen no	1000	500	250	125	125>	Fineness modulus
1	61.60	72.97	96.48	98.24	101.0	4.30
2	55.10	63.14	93.74	95.50	100.0	4.07
3	2.70	20.09	68.01	77.15	99.93	2.67
4	30.87	37.53	61.82	68.40	100.0	2.98
5	35.02	40.69	59.34	63.32	99.8	2.98
6/1	82.79	85.55	93.29	94.24	100.01	4.55
6/2	45.47	51.72	72.43	76.21	100.01	3.45
6/3	47.41	54.92	80.63	83.67	99.98	3.66
7	32.20	45.21	89.24	92.45	100.0	3.59

Table 5. Cumulative distribution of the sieve analysis and the fineness modulus (unit % gr).

Specimens, with similarities regarding the 'Fineness Modulus' are shown in **Table 6**.

Specimen no	1000	500	250	125	125>	Fineness modulus
1	61.60	72.97	96.48	98.24	101.0	4.30
2	55.10	63.14	93.74	95.50	100.0	4.07
6/1	82.79	85.55	93.29	94.24	100.01	4.55
3	2.70	20.09	68.01	77.15	99.93	2.67
4	30.87	37.53	61.82	68.40	100.0	2.98
5	35.02	40.69	59.34	63.32	99.8	2.98
6/2	45.47	51.72	72.43	76.21	100.01	3.45
6/3	47.41	54.92	80.63	83.67	99.98	3.66
7	32.20	45.21	89.24	92.45	100.0	3.59

Table 6. Classification of specimens with respect to the fineness modulus (unit % gr).

Intervention Proposals for the Preservation / Consolidation of the Canal

Following interventions for consolidating some of the discovered materials, which were brought out to open, protection of these from the visitor caused damage and protecting the visitors from potential accidents should be considered (İdil, 1998, 6-7).

a. Completing the Cracked / Cavitated Sections that Require Filling

Tectonic and seasonal (wind, precipitation) changes caused fracture and formation of large-small cavities at several places of the sedimentary masses within the canal perimeter. It is planned to fill these cavities using epoxy mortar. The cavities and cracks were first filled with a mortar-mix made of quick lime (hydrolic lime), terra cotta dust and calcite aggregate, up to a depth of 5 to 10 cm from the surface. For this, aggregate obtained by grinding the local stones, terra cotta dust, and quick lime (hydrolic) was used. The work-site granular distribution ratio for the mortar mix was prepared based on the sieve analysis results. This was followed by filling the remaining portion to the surface with Eposet RSTU. This mix was prepared in consideration of the cavity to be filled. Eposet mixture is prepared in consideration of the appropriate time required by the Hardener (Hardener HS 67) and the hardening ratio. The lowest possible water amount was used. A better plaster mix could be achieved if only the water that comes with quick lime (hydrolic) was used. Top portions of the filled sections were filled with plaster of 5 to 10 cm thickness. The work-site granular distribution ratio for the mortar mix was similarly prepared, based on the sieve analysis results.

If the cracked or cavitated areas were to be filled just with lime, the difference in the hardness of the rock formations within the cracked and cavitated geological formation would decrease the lifetime of the rock and the infill material. For of this concern, resins whose hardness could be controlled were used.

b. Consolidating Mortar / Plaster and the Accumulations

The aggregate in the canal floor and sides, where cementing material that is identified to be lost, was consolidated using a lime (hydrolic) mix with Casein. For the preparation of the material; 100 gr Casein is cured for 24 hours in a covered cup of water, strained through cheesecloth, mixed with 900 gr of quicklime (hydrolic), cured for 24 hrs and then strained through the cheesecloth again, then 100 gr PVA is added to the strained portion and then thinned down to suitable consistency by adding water. In application, using the injection method, prevention against crumbling should be assured, where the aggregate-to-lime ratios are changed. The prepared mixture could be injected using a syringe or should be brushed over using a paint brush. The surfaces should be cleaned before the plaster application and film formation due to light reflection should also be avoided. Then the base and side surfaces are covered with the material that will provide water insulation.

In recent years, it is indicated that Casein would have a positive impact in developing the microbiological domain (Investigations of the University of Rome, Institute of Restoration Laboratory of Microbiology). However, open air use will not cause such development for the canal, which is open to external effects, therefore it will be appropriate here. It could also be protected using other materials. In this context, the material to be used is Malta 6001.

c. Cleaning of the Moss near the Canal Area

Moss cleaning will be done in the canal region and footpaths. The work will be conducted through identification of the acidic/alkali elimination characteristics of the mosses in the area. Ravarex and / or Tartroks are being considered for this purpose. For 1 m² moss cleaning the amount

of Ravarex per 4.000 lt of water is 0.250 lt Usage of Ravarex / Tartroks depends on the acidic / alkali characteristic of the moss.

The materials under consideration have many years of continuous commercial manufacture and use in the microbiological applications related to our subject. It has a wide spectrum and it is easy to procure.

Microbiological studies that require long duration research are limited in our country. Therefore, instead of searching for more specific materials, we have selected a formerly experimented material easy to procure and that has a wide effect spectrum.

ENVIRONMENTAL REORGANIZATION PROJECT

As outcomes, it can now be emphasized that the facts below are of importance:

- The Ferhat Water Canal lies next to the highway;
- Larger areas that lie between the highway and the canal are suitable for recreational planning;
- The areas which have been used by incompatible functions, allow the introduction of functions with public purposes, in line with their historical and recreational convenience and in compliance with the town's demands, making room for the implementation of touristic and historic values;

for questioning to inquire the potentials for re-functioning the canal and its close vicinity.

All project phases adopted the scientific approach of passive conservation of the existing and excavated remains of the Ferhat Water Canal and the new plant specimens in Amasya within an open air museum, where the conservation of the existing and excavated canal sections by consolidating them in their current forms is a must. The historic structure will be the first attraction element in the activity area, open to the visits of local and foreign groups. The starting point of the canal, which functions as the entry gate to the city, will be crowned with a sculpture that has the objective of keeping the 'Ferhat' and 'Şirin' saga alive.

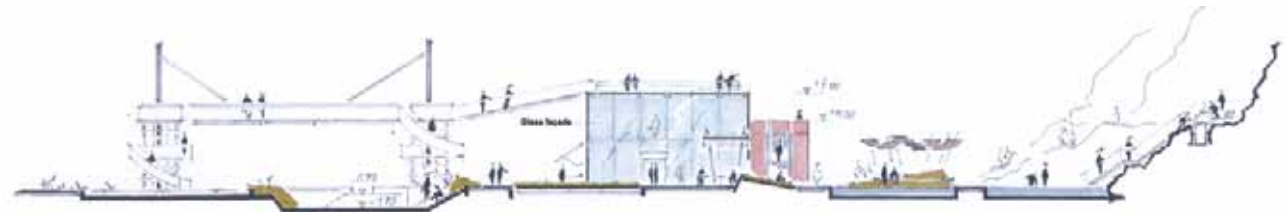
In order to realize the recreational potential of the area and offer the optimum display benefit, a new building and open areas that will not impair its appearance have been designed. A cafe-restaurant, open and covered sitting areas, walkways along the canal perimeter, two parking areas on both sides of the road, and an overpass that connects these, have been planned over a 3 hectare area (10; Figure 23-24). The cafe-restaurant building having 153 m² closed and 120 m² open area, which will be constructed in contemporary techniques and materials is planned not to overwhelm the historic structure. The glazed façades provide a contrast with and reflect the old structure behind, emphasizing the period difference, but complying with international preservation principles. Open and covered sitting areas, walkways, and a botanic garden where the types of plants specific to the Amasya region, can be positioned around the appealing 2.3 hectare pond and the green zone, serving a large number of people. The car park for 52 cars and 2 buses, a lightweight contemporary overpass not visually disturbing the environment, pedestrian paths and observation terraces around the canal perimeter that end with terraces enabling views and vistas from the area, have been provided in appropriate places using elements in a way not to disturb the historic

10. The authors thank the assistant Ekin Çoban, from the Department of Architecture at Gazi University, for her technical assistance.



Figure 23. Site Plan of the proposal.

Figure 24. Cross section of the proposal.



structure physically and visually. Thus, displaying the canal as an entity of the cultural heritage, as a concrete preserved object to educate the public, was intended to be realized.

CONCLUSION

The Ferhat Water Canal which never came to be the object of any analytic investigation before this study, was researched for the first time. Findings reveal about the urban history of the town, as well as information about planning, the technology used and material deployment of the canal are presented. These were;

- **Construction History of the Canal:** The Ferhat Water Canal was built in Late Hellenistic-Early Roman Period; repaired during the 3rd century A.D., and was no longer in use during the Byzantine Period (in the 12th century A.D.);
- **Purpose of the Canal:** The Ferhat Water Canal was built with the objective of supplying the drinking water of the Amasya town;
- **Design and Construction Techniques Employed:** It was built boring into local limestone rocks in the leveled style and constructing stone vaulted canals that run across the river beds. The chisel prints indicate that the rocks were bored by metal chisels hammered by arm power and the vaulted canal sections were built using rubble stone in masonry technique. The inner sections of the canal were coated with 'Horasan' plaster.
- **The New Botanic Specimen:** The region specific *Sideritis Amasiaca Bornm* flower was identified.

A team study and a need for an intense and interdisciplinary laboratory use was important. Thus an interdisciplinary team was formed to guide

the laboratory research in conjunction with museums, universities, and the local administrations.

In terms of conservation of a cultural artefact, the following were realized:

- For the canal and its immediate vicinity, physical interventions have been planned.
- Implementation proposals for the consolidation and stabilization of the rocks to provide the preservation of Ferhat Water Canal were programmed, considering human security.
- A new function for the canal and its vicinity was defined, within the logic of a historic preservation proposal.
- Rehabilitation of the entry of the town of Amasya on the Tokat road, which runs parallel to the Ferhat Water Canal, was planned.

When considered from the point of social benefits; the values the preserved canal and its impact area represent will enable a rise in collective cultural education and a new awareness among the townspeople, providing a recreational and social site which everyone could enjoy. These potentials brought back to life would serve development of valuable cultural media sustaining the presence of a remarkable cultural entity for future generations. However, the construction of the project had no opportunity to be implemented until now. It is hoped and expected that this article would initiate a new milestone among administrators and townspeople, who are the potential actors in re-activating a future preservation program, to take steps in line with the realization of this project proposal.

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Anahtar Sözcükler: Amasya; Ferhat, Su Kanalı; belgeleme; koruma.

BİR ANTİK SU YOLU BELGELEME YÖNTEMİ: FERHAT SU KANALI, AMASYA

Ferhat Su Kanalı, Amasya kentinin su gereksinimini karşılamak üzere Geç Helenistik - Erken Roma dönemleri arasında bir tarihte, kayaların oyulması, dere yataklarında ise taş tonozların inşası ile yapılmıştır. Onsekiz km uzunluğunda bir su yolu olan kanalın, bugün 6 km'si şehir yerleşiminin altında kalmıştır. Kentin Batı yönü girişinde bulunan Ferhatarası Mevkii'nde, Amasya - Tokat karayolunun kenarında kıvrımlar çizerek şehre doğru uzanan 675 m'lik kısım yer üstündedir ve tescil edilerek koruma altına alınmış bir taşınmaz kültür varlığıdır. Kanalın bu kısmında, Amasya Valiliği, Amasya Belediyesi, Amasya Müzesi ile Gazi Üniversitesi'nin işbirliği ile Amasya "Ferhat Su Kanalı Koruma Önerileri ve Çevre Düzenleme Projesi" gerçekleştirilmiştir. Makalede, bu antik su yolu için belgeleme, sorunların saptanması, koruma önerileri ve çevre düzenlemesini içeren bir uygulama projesinin yöntemi aktarılmıştır. Proje, planlama, çalışma grupları ile belgeleme, rölövenin elde edilmesi, hasar tespiti, jeolojik etüd, kaya mekaniği / stabilizasyon projelerinin hazırlanması, kazı çalışmaları, elde edilen analiz sonuçlarının

değerlendirilmesi, sentez süreci, koruma önerileri ve çevre düzenleme projesinin hazırlanması aşamalarını içermiştir. Yapılan çalışma, benzer sorunları barındıran kültür varlıkları için yol gösterici bir yöntem uygulaması olması nedeniyle önem taşımaktadır. Bu projenin hayata geçirilmesi ile, Geç Helenistik - Erken Roma dönemi su yolu planlaması, tekniği ve malzeme kullanımı özelliklerini sergilemesi açısından dünya kültürel mirası içinde enderlik değeri olan bir kültür varlığı gelecek kuşaklara aktararak önemli bir kültürel hizmet yerine getirilmiş olacak; sıkışık kent düzeni olan Amasya'nın Tokat yönü çıkışında dinlence ve sosyal etkinlik işlevleri için karşılanacak alanlarla ferahlık yaratılarak, kentin ve kentlinin nefes alması sağlanacaktır.