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Consolidation of a Bath Ruin in an Archaeological Site

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ABSTRACT

The study has focused on consolidation of a historical bath ruin in an archaeological site. Cevher Paşa Bath, which is located in Tabae archaeological site in Denizli, Turkey and dated to the 15th century, presents structural problems. The aim of the study is to propose a framework for planning consolidation of the ruins of Cevher Paşa Bath so that conservation work regarding similar masonry ruins in archaeological sites can be guided. Thus, methods of architectural restoration and civil engineering are combined in an interdisciplinary scope. Provision of temporary shoring as an emergency intervention, consolidation and presentation of the ruin within the scope of an interdisciplinary restoration project, and monitoring of the asset within the frame of a monument management plan are suggested, respectively. Structural analysis considering stress and overturning moment checks are performed. Consolidation work includes only supporting of arch remains. Some walls of the ruin are weaker than other parts. These parts need further detailed analysis, and if necessary, further consolidation and strengthening are to be carried out. The monument management plan points out the necessity of collaboration of local and central administrations, and also non-governmental organisations.

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1. Introduction

Archaeological sites dating to various ages have been subject to excavation in Turkey since the mid-19th century (Ünar 2014). However, current research focuses on Prehistoric, Protohistoric and Classical archaeology, while Middle age is less credited (Biçer 2009). Especially those focusing on early Turkish Period are very limited [Table 1]. Turkish Period ruins are characterized by a rubble stone masonry construction technique (Kurt 2018). On the other hand, implementations regarding the conservation, presentation and management of the excavated ruins are not satisfactory both in terms of quantity and quality (Ahunbay 2010). For example, Cevher Paşa Mosque dated to the 15th century (Çakmak 2016) in Kale archaeological site was reconstructed in 2006. However, both authenticity of the ruin was lost and also the integrity of the archaeological site is threatened with this single monument in its full height. Interdisciplinary collaboration is a must for betterment of the condition; for example, interaction of civil engineers and architect-restorers is indispensable for the planning of consolidation which is a frequent necessity to preserve ruins in archaeological sites with minimum intervention (Lausanne Charter, 1990, Article, 6).

Consolidation of historic monuments and related intervention types have been considered in a number of preliminary studies. In 1982, Feilden discussed structural elements and structural actions of historical buildings, causes of decay in material and structure, the work of conservation architect in terms of research, implementation, cost control, rehabilitation and presentation. In 1998, Feilden and Jokilehto underlined that conservation planning should be carried out with a multidisciplinary approach. For a management plan, values regarding cultural assets should be listed and priorities should be arrayed. There should be a committee consisted of different skills from academics, professionals and artisans. The management plan is evaluated as a continuing process which includes planning, programming and budgeting. In the management plan of Durham Castle and Cathedral in England, priority is given to conserving values of the site (Brown 2017; Gülersoy and Ayrancı 2011). The vision is conserving the site for the future. The aim of the management plan is sustaining, developing and conserving universal values. Some of the important targets of the plan are conserving distinctive characteristics of the site, understanding and presenting the processes and history of the site, and assessing the interest of the visitors and the

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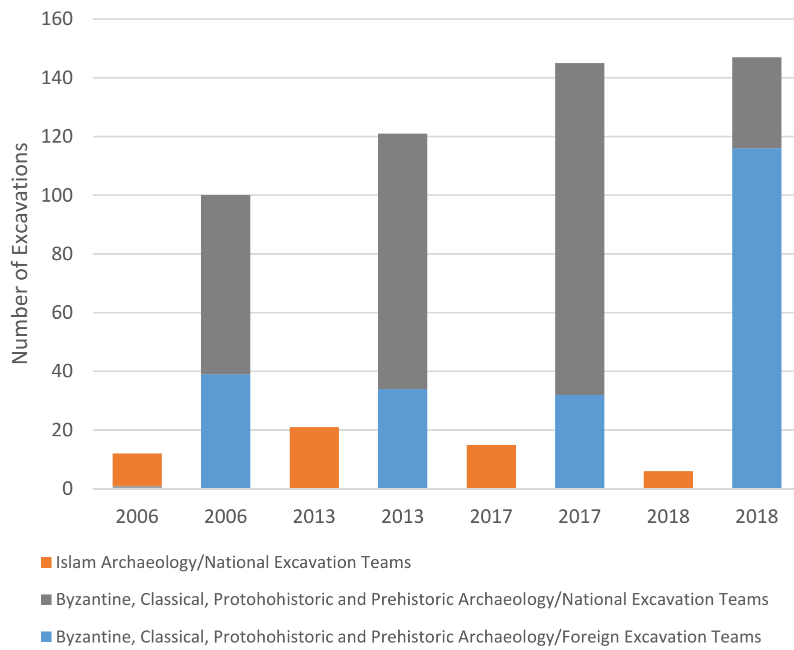
Table 1. Scientific excavations in archaeological sites of Turkey (Directorate general of cultural assets and museums, 2019).



characteristics of the local community for evaluating future use.

In 2007, Ashurst and in 2013 Australian Government Heritage Council questioned why ruins should be preserved and discussed conservation approaches for ruins: returning it to its former state, maintenance, letting nature take its course and removal when it is inevitable. Ashurst (2007) defined conservation philosophy and technology of ruins by different implementations: provide temporary supports and protection, treatment of wall tops, broken wall ends, cores and voids, stone replacement, stone repairs, repairing mortar, replacement of mortar materials and walls by defining its techniques. In 2007, Woolfitt argued that the common approach to the architectural remains in archaeological sites is to exhibit them with minimum intervention, but this approach results with unsatisfactory solutions. Therefore, if measures are inappropriate or resources are limited, ruins should be reburied or backfilled in the archaeological context. Protective shelters and reconstruction may be other solutions according to the quality of the ruin. In 2011, Güçhan suggested the new restoration model for immovable cultural assets in Turkey by evaluating the restoration project of the İlyas Bey Complex which is a ruin in the archaeological site of Miletos. A multilateral model is proposed for dealing with the implementation problems of restorations. Importance of scientific knowledge in preparation of restoration projects is pointed out. To guarantee a scientific implementation process; a model for management is defined.

In summary, consolidation of the historic structure with minimum intervention has been the first target in conservation of ruins. Nevertheless, this has been complemented with the search for presentation options of cultural asset values with user-friendly strategies. In time, the significance of management for a qualified and lasting implementation has been emphasized. This study has focused on conservation of a historical ruin in an archaeological site: Cevher Paşa Bath in Kale (ancient Tabae), Denizli, Turkey. The aim is to propose an interdisciplinary framework for consolidation, presentation and monitoring of the ruins of Cevher Paşa Bath so that conservation work regarding similar masonry ruins in archaeological sites can be guided. The way followed is combining the tools of architectural conservation with those of civil engineering.

The process includes an understanding of the distinctive characteristics of the case study, developing strategies for sustaining the historic structure, defining ways of presenting and managing it, as pointed out in the management plan of Durham Cathedral and Castle. For understanding the ruin, documentation was the first step undertaken. The point cloud gathered with

3D Laser Scanner (FARO, X330) was converted into an orthographic photo with Scene 6.2.4.30. To draft the measured survey, AutoCAD, 2015 was used. Visual analysis of spatial characteristics, architectural elements, construction technique and material usage, and alterations were carried out with conventional techniques. Then, the condition report (CEN 2012) of the bath was prepared in the form of tables. The conservation condition of different portions of the ruin was illustrated on conventional maps and stages (Arioglu and Acun 2006) of structural failures and material deteriorations were defined. In addition, the content of possible measures was identified according to condition classes and risk assessment. Condition class 1 refers to minor failures, while condition class 3 refers to major failures. Structural analysis was done according to current regulations (Turkish Earthquake Code, 2007; Earthquake Risk Management Guide for Historical Buildings, 2016). Analysis was carried out according to the collapse prevention level among performance levels. Nevertheless, they are limited with the capabilities of an architect. A comparative study was carried out in order to understand the significance of the ruin among the same period assets; and identify the original state of the building. Thus, the construction date (15th century) and function (bath) were the parameters in selecting comparative examples.

In order to sustain the historic structure, consolidation strategy was developed. This is a two-stepped process. First, emergency interventions are undertaken as an urgent precaution to re-establish safety. The related examples regarding the archeologic ruins in Turkey were evaluated. The second step includes comprehensive interventions realised as a part of a restoration project. These need to be planned together with the presentation strategy. In order to determine the restoration scope, which includes comprehensive consolidation and presentation, first international documents were checked: anastylosis is emphasized as a presentation approach for archaeological ruins (The Athens Charter, 1931, Article 6; Carta Del Restauro Italiana, 1931, Article 3; Venice Charter, 1964, Article 15; Ashurst 2007). However, the related implementations have revealed that it is appropriate for dry stone masonry, but the autonomy of rubble stone masonry does not permit an accurate anastylosis (Vacharopoulou 2006, 70). So, current restorations carried out in rubble stone masonry ruins (Ieva 2013; Bollack 2013; Revistaad; Revistaad 2018; Sierzputowski 2017; Tresoldi, 2018; Metalocus 2017; Divisare 2018a; Divisare, 2018b; Architizer, 2018a) do not consider anastylosis; but one of the options of only conservation, reintegration or reconstruction. These current restorations were evaluated in order to determine an appropriate restoration scope. In the selection of case studies; being a rubble stone masonry ruin has been taken as a parameter. The second parameter that plays a role in the presentation of ruins is their settings (White 2007). The ruins in urban settings, and in archaeological and/or natural settings necessitate different approaches (Ashurst 2007). For example, the rubble stone masonry ruins of Basilica Paleocristiana di San Pietro and the Church of Corbera d'Ebre both in historical centres were reintegrated to fill in the urban lacunae, while Alaca Mosque in the centre of Bosnia was reconstructed, which is realized with the aim of sustaining national identity after Yugoslav War (Anadolu Agency 2020). In this study, cases preferably in archaeological and/or natural settings were considered. The case studies were evaluated in terms of their documentary value (Madran and Özgönül 2005), distinguishability (Venice Charter, 1964, Article 12), integrity of context and building itself (Zimbabwe Charter, 2003, Article 1; Operational Guidelines, 2017, Article 88), compatibility of materials (Zimbabwe Charter, 2003 Article 3), consistency of implementation (ICOMOS 1931c, Article 15), accessibility (Burra Charter, 1999, Article 2.7) and re-treatability (Michiels 2015), Burra Charter (1999) article 15, Lausanne Charter (1990) Article 7 [Tables 2–3]. The effects of each restoration on the ruin were evaluated. According to this evaluation, the restoration proposal for the Cevher Paşa Bath was prepared.

In order to determine the management scope for conservation actions, management plans for historic

Table 2. Evaluation of a similar case, Basilica di Siponto, Manfredonia, Italy.

Identification	Current Restoration	Evaluation
Location: Siponto, Italy **Construction Date**: Early Christian **Original Function**: Basilica **Original Structural System**: Masonry **Original Material**: Rubble stone, brick finished with plastering **Conservation State**: In ruin, lost third dimension	**Implementation** **Completion Date**: 2016 **Director of Project**: Ministry of Cultural Heritage and Activities and the Archaeology Superintendence of Puglia **New Function**: Museum **Architect**: Edoardo Tresoldi **Applied Parts**: The whole ruin **New Structural System**: Steel frame **New Materials**: Stainless steel covered with wire mesh; new walkways out of stainless steel finished with wire network **Award: -**	**Intervention Type**: Reintegration, consolidation, presentation **Documentary Value**: **Distinguishability**: **Integrity (context)**: **Integrity (building itself)**: **Compatibility of materials**: **Consistency**: **Accessibility**: **Retreatability**:

Table 3. Evaluation of a similar case, Doria Castle in Dolceacqua, Italy.

Identification	Current Intervention	Evaluation
Location: Dolceacqua, Italy **Construction Date**: - **Original Function**: Castle **Original Structural System**: Masonry **Original Material**: Rubble stone, finished with plastering **Conservation State**: In ruin	**Implementation** **Completion Date**: 2015 **Director of Project**: - **New Function**: Museum **Architect**: LD+SR **Applied Parts**: Partially **New Structural System**: Steel frame, new walkways out of steel **New Material**: Steel **Award: -**	**Intervention Type**: Consolidation, presentation **Documentary Value**: **Distinguishability**: **Integrity (context)**: **Integrity (building itself)**: **Compatibility of materials**: **Consistency**: **Accessibility**: **Retreatability**:

monuments in three world heritage sites, one in England and two in Turkey, were evaluated.

2. Conservation, presentation and management approaches in similar cases

In many cases, the ruin may require urgent intervention to avoid its collapse. As an emergency precaution, iron elements are often used to consolidate archaeological ruins in Turkey. However, rusting is a probable consequence (Figures 4 and 5). In some cases, timber is preferred for temporary support. Timber is compatible with historic stone (Figure 6). Thus, material preference is critical for short-range interventions as well as long ones.

On the other hand, long-range approaches focus on comprehensive conservation and presentation necessities as revealed in the four similar cases analysed. The cases are an early Christian church ruin (Figure 1) in an archaeological park of Siponto (Basilica di Siponto), Doria Castle ruin in Dolceacqua (Figure 2) in Portovenere, which stands on a rocky plateau with steep walls; and a monastery ruin (Figure 3) located in Santa Cataline Botanic Garden (Santa Cataline de Badaya). The ruin of Basilica di Siponto was reintegrated with contemporary building material. New and old are clearly distinguishable, but compatibility of steel in a long-time span should be monitored. The original volumetric effect of the monument is perceived, but the integrity of the archeologic site is ruined since it is the only ruin integrated to its full height. The ruin of Doria Castle and the monastery ruin in Santa Cataline were conserved as they were. The elements added for consolidation and presentation are out of contemporary material and technique. So, they are distinguishable. Timber as a compatible material is preferred, whenever there is direct contact with the ruin. However, steel elements in Doria Castle may corrode in the long term. Integrity of the archaeologic/natural sites is sustained. Accessibility and consistency of interventions are achieved in all examples, while re-treatability is only possible in the conservation only and re-integration examples. In terms of presentation tools such as balustrades for safety, walking paths and information panels for the visitors; Basilica di Siponto, Doria Castle ruin

Figure 1. Basilica di Siponto, after 2016 restoration (Il Post 2016).

Figure 2. Restoration of Doria Castle in Dolceacqua (Divisare 2018).

and Santa Cataline Botanic Garden are satisfactory examples.

The management plans of Durham Castle and Cathedral, England (Brown 2017); Süleymaniye Mosque Complex, Istanbul, Turkey (Kan, 2014); and Tumulus of Mount Nemrut, Adiyaman, Turkey (Nemrut Kommagene, 2020) define the monument management processes in similar ways. History of site, values, risks, definition of targets, actors, vision and action plans and monitoring are examined within these management plans. In the Management Plans of Durham Castle and Cathedral; first, the importance and meaning of the site was defined. Then, management objectives and processes of implementation and monitoring were defined. Management plan was prepared for 6 years plan in between 2017 and 2023 and work packages were planned in two classes an annual basis and continuously. There are many stakeholders such as the related religious administration, universities, the county council, a landscape master planning and design firm. In the Management Plan of Süleymaniye Mosque Complex, cultural components of the site, management plan, the related action plans and implementation processes were defined. Finance-budget units were created to ensure continuity of management. The stakeholders are the related religious administration, related waqf organisations, related universities, related preservation organisations, related culture and tourism organisations, local tradesmen, etc. Tumulus of Mount Nemrut Management Plan includes definition of site, vision, strategy, scenarios, operation and management model. The management plan was prepared for 20 years consisting of three different periods: period 1 and period 2 are 5 years long periods, while period 3 is 10 years long plan. The stakeholders are the related governorship, the related municipalities, related governmental units for public works, environment and transportation, the regional development agency, World Monuments Fund, World Heritage Centre, ICOMOS and Global Heritage Fund.

Figure 3. Restoration of Santa Catalina di Badaya (Revistaad 2018).

Figure 4. Rusting problem in a Roman (left) and Byzantine (right) ruin, Antiochia ad Cragum, Antalya, Turkey.

3. Understanding the case study

Geographical, historical and physical characteristics are introduced.

3.1. Geographical characteristics

The case study bath ruin is located on a butte jutting out of Tavas plain (Figure 7) in Kale district of Denizli Province, in the southwestern part of Turkey. This is a highly seismic region. The studied bath ruin is located at the northern part of the butte, on inclined ground and the inclination reaches approximately 60% at the east (Figure 8).

3.1.1. Historical characteristics

The case study is part of a multi-layered settlement ruin, which used to be a castle town (*Kale Tavas*), at the historic region named Caria (Etlacakuş and Turan

Figure 5. Supporting of the wall, the Basilica Bath in Hierapolis, Denizli, Turkey.

Figure 6. Consolidation of an arch (left), supporting of the walls (right) in the Bouleuterion, Metropolis, İzmir, Turkey.

2019; Robert 1954). The castle was conquered by Turks in the early 12th century and used for defence purpose. Starting with 1424, which is the beginning of Murat the second period in the region, it was inhabited by the nomadic Turkish communities (Baykara 2007; Etlacakuş and Turan 2019). In an archive document dated 1530, a single bath is recorded at *Kale Tavas*. Today, there is a single bath ruin from the Turkish period at the site. In the same document; the foundation charter of Cevher Paşa is referred to, although it is unclear who this *Paşa* is. In 1530; Cevher Paşa Mosque and dervish lodge had been sustained with the income of a village, a farm, a vineyard nearby, and also Cevher Paşa Bath (G.D.S. A., 1995; Kütükoğlu 2002). So, the case study was in use at the beginning of the 16th century. Comparison of architectural characteristics with other Ottoman baths in Anatolia points out that the case study dates to the 15th century (Table 4). Similarly, in the excavation report of the bath, it was dated to the 15th century (Çakmak 2016).

The settlement was abandoned in 1950 because of landslide risk. Then, the bath was used as a leather workshop (Ministry of Culture and Tourism 2016)[12] The layout of the concrete pools added during this workshop

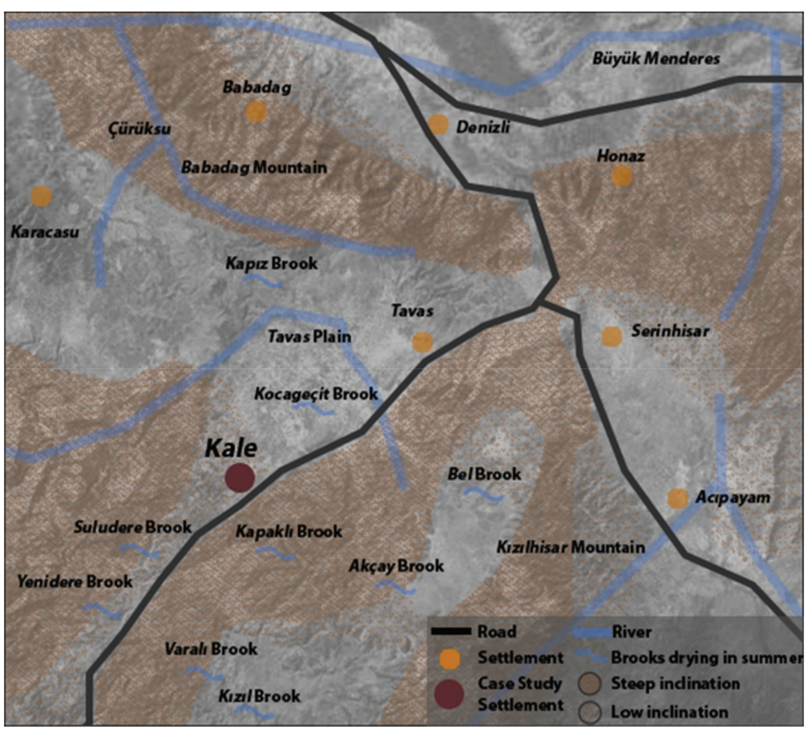
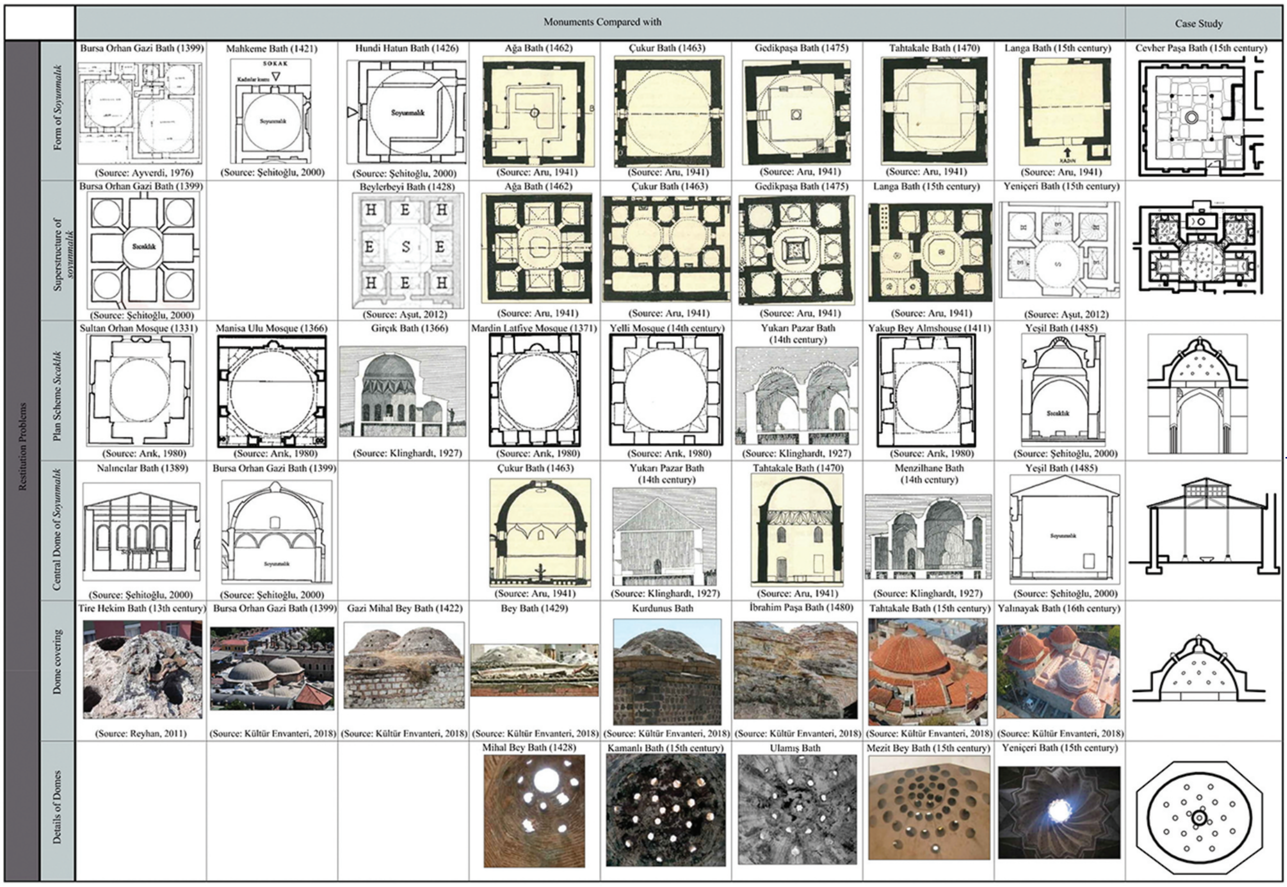


Figure 7. Geographical characteristics.

[1]It was proclaimed with the principle decision 880 by the Supreme Council for the Conservation of Cultural and Natural Assets..
[2]It was revised by Aydın Regional Council for the Conservation of Cultural and Natural Property in August 2010.

Table 4. Historical research and comparative study.



		Monuments Compared with								Case Study
Restitution Problems	Form of *Soyunmalık*	Bursa Orhan Gazi Bath (1399) (Source: Ayverdi, 1976)	Mahkeme Bath (1421) (Source: Şehitoğlu, 2000)	Hundi Hatun Bath (1426) (Source: Şehitoğlu, 2000)	Ağa Bath (1462) (Source: Aru, 1941)	Çukur Bath (1463) (Source: Aru, 1941)	Gedikpaşa Bath (1475) (Source: Aru, 1941)	Tahtakale Bath (1470) (Source: Aru, 1941)	Langa Bath (15th century) (Source: Aru, 1941)	Cevher Paşa Bath (15th century)
	Superstructure of *soyunmalık*	Bursa Orhan Gazi Bath (1399) (Source: Şehitoğlu, 2000)		Beylerbeyi Bath (1428) (Source: Aşut, 2012)	Ağa Bath (1462) (Source: Aru, 1941)	Çukur Bath (1463) (Source: Aru, 1941)	Gedikpaşa Bath (1475) (Source: Aru, 1941)	Langa Bath (15th century) (Source: Aru, 1941)	Yeniçeri Bath (15th century) (Source: Aşut, 2012)	
	Plan Scheme *Sıcaklık*	Sultan Orhan Mosque (1331) (Source: Arık, 1980)	Manisa Ulu Mosque (1366) (Source: Arık, 1980)	Girçık Bath (1366) (Source: Klinghardt, 1927)	Mardin Latfiye Mosque (1371) (Source: Arık, 1980)	Yelli Mosque (14th century) (Source: Arık, 1980)	Yukarı Pazar Bath (14th century) (Source: Klinghardt, 1927)	Yakup Bey Almshouse (1411) (Source: Arık, 1980)	Yeşil Bath (1485) (Source: Şehitoğlu, 2000)	
	Central Dome of *Soyunmalık*	Nalıncılar Bath (1389) (Source: Şehitoğlu, 2000)	Bursa Orhan Gazi Bath (1399) (Source: Şehitoğlu, 2000)		Çukur Bath (1463) (Source: Aru, 1941)	Yukarı Pazar Bath (14th century) (Source: Klinghardt, 1927)	Tahtakale Bath (1470) (Source: Aru, 1941)	Menzilhane Bath (14th century) (Source: Klinghardt, 1927)	Yeşil Bath (1485) (Source: Şehitoğlu, 2000)	
	Dome covering	Tire Hekim Bath (13th century) (Source: Reyhan, 2011)	Bursa Orhan Gazi Bath (1399) (Source: Kültür Envanteri, 2018)	Gazi Mihal Bey Bath (1422) (Source: Kültür Envanteri, 2018)	Bey Bath (1429) (Source: Kültür Envanteri, 2018)	Kurdunus Bath (Source: Kültür Envanteri, 2018)	İbrahim Paşa Bath (1480) (Source: Kültür Envanteri, 2018)	Tahtakale Bath (15th century) (Source: Kültür Envanteri, 2018)	Yalınayak Bath (16th century) (Source: Kültür Envanteri, 2018)	
	Details of Domes				Mihal Bey Bath (1428)	Kamanlı Bath (15th century)	Ulamış Bath	Mezit Bey Bath (15th century)	Yeniçeri Bath (15th century)	

period indicates that the bath was already in ruin before these additions. The pools are inharmonious with the original spatial layout in terms of their positioning, form and size. Their material and workmanship are also unqualified. Despite their negative effect on the aesthetic value of the monument, their preservation in terms of their contribution to the timeline of the monument could have been considered. However, the risk they create for salt crystallisation may be a threat for the historic building material (Ashurst 2007).

In between 2011 and 2013, an archeologic excavation was realised at Cevher Paşa Bath.[3] Consequently, capping and filling of joints with cement mortar were realised to prevent loss of historic material and collapse.

Figure 8. (a) Kale settlement, (b) Cevher Paşa Bath as viewed from west.

[3]Its scientific excavation was carried out by Prof. Dr. Bozkurt Ersoy in 2013. (Regional Directorate of Pious Foundations Archive, Aydın, 2017).

These interventions are incompatible with the historic building material as well.

3.2. Physical characteristics

The width of the bath ruin is 12.2 m in the south-north direction and its length is 21.3 m in the east and west direction. The highest level of the building is 5.5 m (Figure 9). The remains of a dome (Figure 10), squinches and an arch (Figure 11) provide information about the original superstructure. There are six original architectural elements sustained: a washbasin remains, horizontal pipes, vertical pipes, water channel remain, niches and stone floor covering. The concrete pools and the stone walls at the north-east are additions (Figure 13).

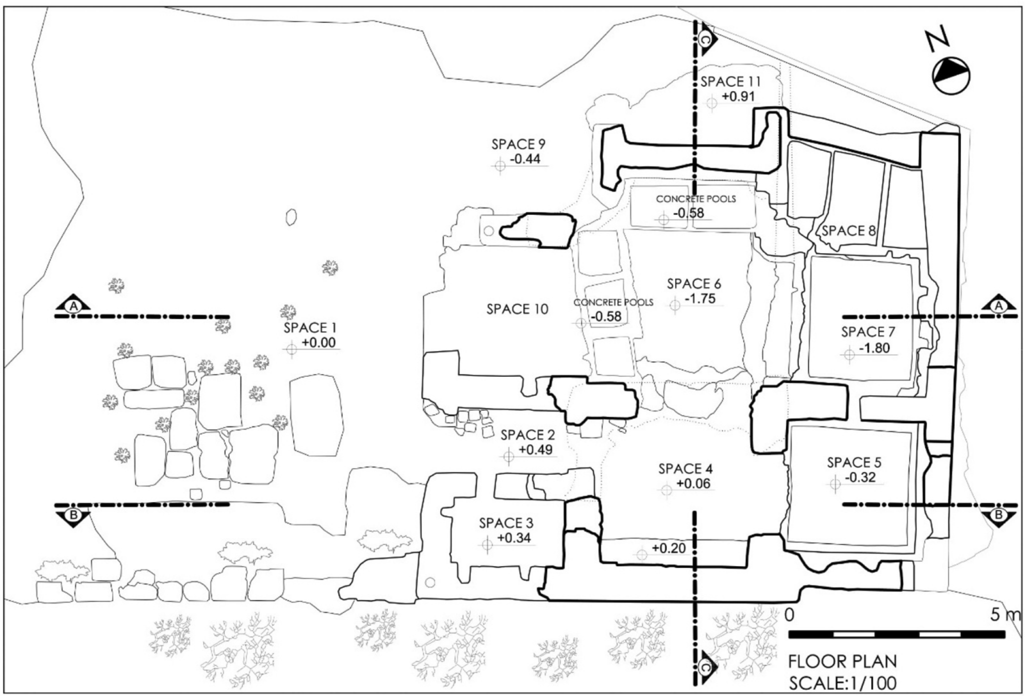


Figure 9. Ground floor plan from a measured survey.

Figure 10. Dome remain as viewed from south.

Figure 11. Squinch remain as viewed from southeast (left), arch remain as viewed from north (right).

The arch remain (thickness: 89 cm, spanning distance: 3.7 m) and dome remain (thickness: 100 cm, spanning distance: 3.46 and 4.27 m at east-west and north-south axis, respectively) are composed of brick (5 x 17 cm) at their both surfaces, rubble stone and lime mortar in between. The squinch are at the four corners of the dome remain in space 4. Squinches were detected as bricks and lime mortar. The original load-bearing walls are three-leafed: rough-cut stone and lime mortar at the outer leaves and rubble stone and lime mortar at the interior (Figure 12). Rough cut stone with cement mortar is only seen at the lower portions of north-eastern wall, which was intervened just after the excavation. There are low and non-load bearing walls surrounding the concrete pools formed during the leather workshop period. At present, the floor is mainly covered with debris and partially screed, which also belongs to the leather workshop period. The remains of the original floor covering are marble blocks with different sizes (e.g., 0.9 m x 1.25 m, 0.63 m x 0.61 m).

Figure 12. Load-bearing walls: rough-cut stone at both surfaces, rubble stone and lime mortar in between (left), rough-cut stone with cement mortar.

Figure 13. Concrete pool.

3.2.1. Restitution

The Early Ottoman baths consisted of *soyunmalık, aralık, ılıklık, tıraşlık, sıcaklık*, water reservoir, furnace, *keçelik* (Erat 2006). The examples selected for comparison are the 15th century baths: Orhan Gazi in Bursa, Mahkeme in Bursa, Hundi Hatun in Bursa, Ağa in İstanbul, Çukur in İstanbul, Gedikpaşa in İstanbul, Tahtakale in Tire, Langa in İstanbul, Beylerbeyi in Edirne, Mihal Bey in Edirne, Kudurnus in Niğde, Kamanlı in Urla, Ulamış in Seferihisar, İbrahim Paşa in Edirne and Yukarı Pazar in Kocaeli. When the traces and remains of Cevher Paşa Bath are evaluated in light of historical research and comparative study, space 1 at the west is identified as *soyunmalık* since it is the first space entered and the largest space of the building. The transition space from *soyunmalık* to the small unit series is identified as *aralık* (3.7 x 1.48 m). The large space juxtaposing *aralık* is named as *ılıklık* (3.36 x 3.45 m) and the group of small spaces at the north of the *ılıklık* is defined *sıcaklık* (10.7 x 6.7 m as a whole). The ruins at the north of the composition belong to water storage (3 x 1.5 m).

Restitution problems are the form of *soyunmalık*, superstructure of *soyunmalık*, plan scheme of *sıcaklık*, central dome of *sıcaklık*, dome covering, and details of domes. In all of the comparative examples, *soyunmalık* is square planned [Table 4]. In turn, the form of *soyunmalık* of Cevherpaşa Bath is evaluated as a square. The superstructures of *soyunmalık*s could be timber-frame roof in the 15th-century baths (Önge 1995). Since the wall thicknesses of Cevher Paşa Bath at the *soyunmalık* portion are narrow (50 cm) just like three examples with 50 cm of wall thicknesses (Nalıncılar in Bursa, Yukarı Pazar in Kocaeli and Yeşil in Bursa), the superstructure was restituted as timber.

In all of the compared examples of the 15th-century baths, *sıcaklık* was located at the inner part of the composition. Main *sıcaklık* space is surrounded by iwans, at four sides of the space and *halvets* at the corners (Aru 1941). The superstructure of *sıcaklık* space in the 15th-century baths are mostly dome. The central dome of sıcaklık of the building, had ellipse shape as revealed in the dimensions of the central portion (4.29 x 3.9 m). In fact, elliptical domes are seen in Sultan Orhan Mosque (1331) in Bursa, Ulu Mosque (1366) in Manisa, Lütfiye Mosque (1371) in Mardin, Yelli Mosque (14th century) in Denizli, Fatih İbrahim Bey Mosque (14th century) in İzmir and Yakup Bey Almshouse (1411) in Kütahya of the early Turkish period (Arık 1980), but they have not been documented in baths so far [Table 4]. The dome was supported with squinches. The superstructures of *halvets* are domes. The superstructures of iwans are vaults. In the 15th century baths, domes were generally finished with plaster (Erat 2006). Therefore, the finishing

Table 5. Approximate strength of natural stone materials (Ünay 2002).

Type of Stone	Compressive Strength (mPa)	Shear Strength (mPa)
Granite	30–70	14–33
Marble	25–65	1–15
Limestone	18–35	2–6
Sandstone	5–30	2–4
Quartz	10–30	3–4
Serpentine	30	6–11

Table 6. Approximate compressive strength of walls (Türkçü 2017).

Type of Walls	Compressive Strength (mPa)
Rubble Stone	0.3–1
Pitch-faced Stone	0.4–2

Table 7. Approximate shear strength of walls.

Type of Walls	Shear Strength (mPa)
Hydraulic Mortar Rubble Stone Wall	0.33–0.57
Air-lime Mortar Rubble Stone Wall	0.13–0.34

of the superstructure of Cevher Paşa Bath is evaluated as plaster. There were oculi on the superstructure to provide daylight in the 15th-century baths (Erat 2006; Önge 1995). Thus, oculi are suggested in the restitution of the case.

3.3. Structural analysis

The structure is left with some walls that are partially or majorly collapsed in plan and elevation. This leads to a loss of integrity and resistance of the walls. Therefore, the vulnerability of the walls against the lateral loads such as earthquake and wind becomes an important issue.

However, detailed modelling of historical structures to assess them is complex, resource and time-consuming and expensive to create (Lourenço 2002). Because the material characteristics have to be determined without any harm to the structure; moreover, the construction materials do not show a homogenous and repetitive pattern. Hence, a practical structural analysis approach is necessary to evaluate the historical remains to prioritize the actions and use the resources effectively.

The masonry building that is intact may require detailed analytical or FE analysis for decision-making. However, the walls that are standing alone may be evaluated through a faster procedure for immediate action to avoid possible collapses. The evaluation is basically done by comparing the driving actions and resisting strength of the walls. For the calculation of driving forces, the codes on structural design may be a reference point; however, for the resistance, some conservative assumptions have to be made due to lack of knowledge on the mechanical properties of the structure materials.

Some parameters in the literature are referenced while making decisions on the structural condition of the remains. Table 5 lists the compressive strength values of the stones that are used in similar structures. Tables 6 and 7 provide the compressive strength and shear strength of walls made up from different stone types, respectively.

3.3.1. Load actions

The walls are exposed to vertical and lateral loads. The source of vertical loads are mainly the self-weight of the wall and any appurtenances on them. Knowing that the highest wall is less than 5 m, and the unit weight of the wall is around 23.5 kN/m^3, maximum compressive stress on the wall can reach to 5 × 23.5 = 120 kPa = 0.12 MPa that is far lower than the compressive strength of the wall material given in Table 6. Thus, the vertical capacity of the walls is below their capacity unless there is thinning due to material losses at the bottom parts of the wall.

On the other hand, the lateral loads are mainly seismic loads and wind loads. Seismic loads depend on the seismicity of the region and the self-weight of the wall since the load is a result of inertial forces due to ground acceleration. On the other hand, wind loads are proportional to the face area and the plan geometry of the wall.

3.3.2. Wind loads

As stated above, wind loads have a relation with the plan geometry of the wall. Such that, straight plan geometries and the curved geometries have different aerodynamic characteristics so the effective wind pressure too. TS EN 1991-1-4 defines the wind pressures that should be considered for different types of structures. The wind loads on detached walls are defined under section 7.4 of the code. c_{pnet} parameter is the resultant of windward and leeward pressures on the wall. Then, the wind force F_w is defined in Equation 1.

$$F_w = q_p * c_{pnet} * A \tag{1}$$

$$q_p = \frac{1}{2} * \rho v_b^2 * c_e(z) \tag{2}$$

$$\rho = 1.25 \frac{kg}{m^3}$$

$$c_e(z) = 2.5 \; for \; Terrain \; Category \, 2 \; at \; z = 10m$$

$$v_b = 30\frac{m}{s}\, assumed\ according\ to\ TS498\ (oldercode)$$

$$c_{pnet} = 1.2\ from\ section\ 7.4$$

Hence,

$$F_w = 1.69 * A\ kN \tag{3}$$

A: Area of the windward face of the wall (Height x Length)

The wind force is assumed to be acting homogeneously on all the wall surface and hence the resultant force may be acting at the mid-height for elevation.

3.3.3. Seismic load

Seismic load is calculated according to Turkish Earthquake Code 2007 (TEC2007). Response spectrum method is used to simply calculate the earthquake load on the walls. The base shear, the earthquake load acting on a member, is defined as;

$$V_t = \ W A(T_1)/R_a(T_1)\ \geq 0.10\, A_0 W \tag{4}$$

where

W: Weight of the member

T_1: First natural period of structure or member

R (T_1): Seismic load reduction factor. Two for historical masonry buildings (Earthquake Risk Management Guideline for Historical Buildings, 2016)

$$A\ (T)\ =\ A_0 I\ S\ (T) \tag{5}$$

A_0: Effective Ground Acceleration Coefficient (0.4 for Denizli province), I: Importance factor (taken as 1) S (T_1): Spectrum coefficient

Depending on the site class minimum T_A is defined as 0.1 and maximum T_B is defined as 0.9. The walls considered in this work are stiff due to their high thickness and relatively low height. Therefore, they are expected to correspond to the plateau of the spectrum, thus S(T) = 2.5 used in the calculation of earthquake load.

$$A(T) = 0.4 * 1 * 2.5 = 1 \tag{6}$$

Calculation of spectral acceleration coefficient *A (T)* is shown in Equation 6. A_0 is defined as 0.4 for first degree earthquake zone which Denizli province is within. *I* value is taken as 1 according to Turkish Earthquake Code (2007) and *S(T)* is accepted as 2.5 since the period of walls are predicted to be lower than T_2 which is defined in TEC 2007 by the soil properties at the site and shown in Figure 14.

$$V_b = \frac{WA(T_1)}{Ra(T_1)} \geq 0.10 A_0 W \tag{7}$$

$$V_b = 0.50W \geq 0.05W$$

Then, the base shear (V_b) of a member may be found as shown in Equation 7.

$$Weighofthewall = H * L * t * 24\frac{kN}{m3}$$

$$V_b = 0.5 * 24 * H * L * t = 12 * H * L * tkN$$

where

W: Weight of the wall, t: Thickness of the wall, H: Height of the wall, L: Length of the wall

The equivalent seismic load distribution is assumed to be inverted considering the first mode and the resultant seismic force acts at a height of 2 H/3 as shown in Figure 15.

Once the seismic moment is found it may be compared with the moment created due to the wind loads

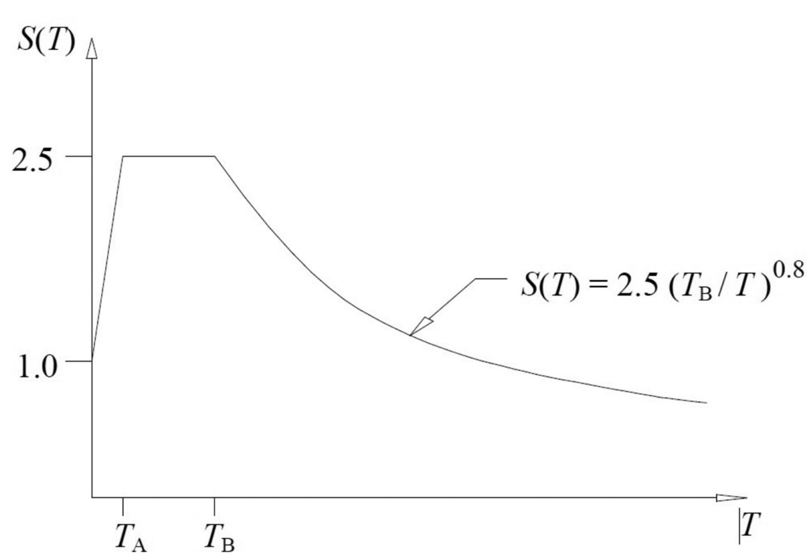


Figure 14. Elastic earthquake design spectrum.

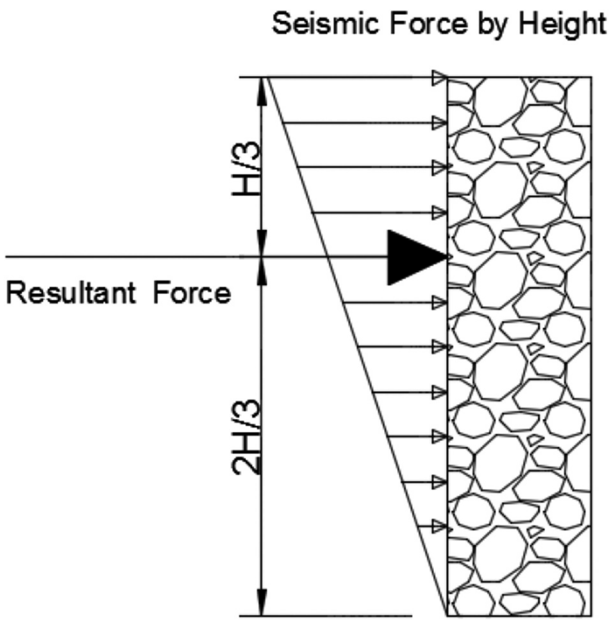


Figure 15. Seismic load distribution through the height.

and the evaluation may continue according to critical action. While doing a comparison of seismic moment with wind-induced moment, the reoccurrence periods of maximum wind and earthquake should be equal. In the codes, for 50 years of design period, the wind loads are factored by 1.5 or 1.6. Whereas the spectrum is created for 50 years of design life, thus no additional factor necessary. Then, the comparison leads to Equation 8;

$$\frac{(SeismicMoment)}{WindMoment} = \frac{\left(12 * H * L * t * \frac{2H}{3}\right)}{1.6 * 1.69 * H * L * \frac{H}{2}} = 6 * t \quad (8)$$

This suggests, for the cases that a wall is thicker than 0.17 m, seismic force is dominant.

3.3.4. Resisting moment

A self-supporting wall has three fundamental failure modes. These are bending, shear and overturning. Bending mode failure happens when the section stresses due to bending moment exceed the material strength within the section. In other words, total of external and internal axial stresses within the section should be in equilibrium. However, since the current condition is not known, the tensile strength of the mortar is neglected. Then, the bending mode failure is getting closer to overturning mechanism. Therefore, only the shear and global overturning check is considered for the evaluation.

It is known that masonry walls are vulnerable to out of plane failures more than the in-plane failures. Therefore, during an earthquake excitation, the walls that are orthogonal to excitation direction will be likely to fail. For example, an earthquake excitation in the direction of North, North East–South, South West would be critical for wall A4 since its direction is orthogonal to earthquake direction. Whereas A3 and the east side of A5 will be working in their strong direction and support the A4. Then, the stability of A4 wall is sustained by the shear resistance two shear planes with neighbouring walls and the base. Similarly, the overturning moment will be resisted by the self-weight of the wall and the resultant shear force at its shear planes. The lateral deformations on a wall would be larger at the higher points of the wall. Then, the shear resultant location would probably be higher than H/2. However, due to the deteriorated condition of the walls, the resultant is assumed to be acting at H/2 in the calculations. An illustration for a wall with two neighbouring walls is provided below.

Resisting moment may be calculated by using Equation 9;

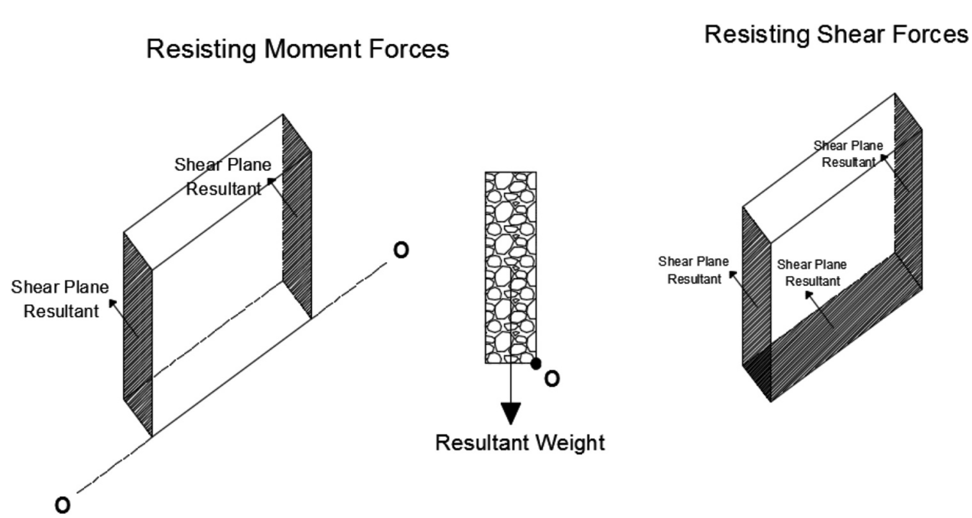


Figure 16. Load resistance mechanism for a middle wall.

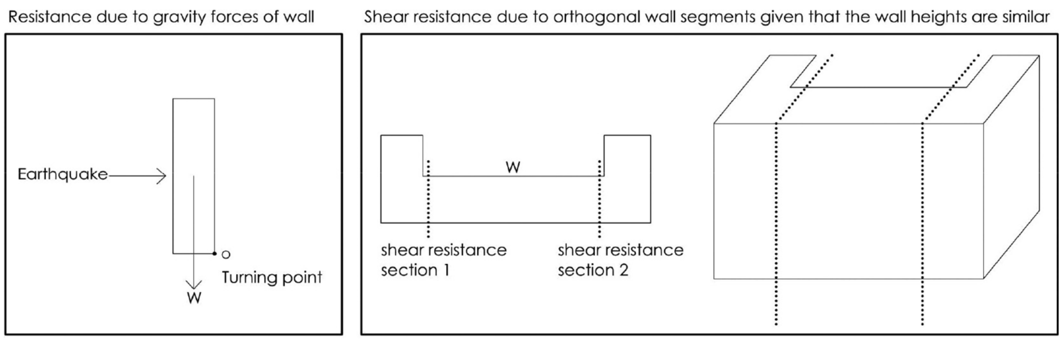


Figure 17. Calculation of overturning resistance.

$$M_r = W * \frac{t}{2} + \tau*(\mathrm{H} * \mathrm{t})*\mathrm{s}*\frac{\mathrm{H}}{2} \tag{9}$$

Resisting shear may be calculated by using Equation 10;

$$V_r = (s * t * H + L * t) * \tau \tag{10}$$

τ: Shear strength

s: number of shear planes

Consequently, the safety factor for overturning and the shear failure may be written as below.

$$FS_{overturning} = \frac{M_r}{M_{EQ}} \tag{11}$$

$$FS_{shear} = \frac{V_r}{V_b} \tag{12}$$

The safety factor for each wall segment is tabulated in Table 8. It should be noted that the weight of the structure is calculated by multiplying the plan area of the wall with the average height of the wall. The area and unit weight of the wall is obtained from the CAD drawing while the thickness is the minimum that is observed through its length. Moreover, it may be observed that A3 to A5, B1-B2 and B3-B4 wall segments may be grouped due to their similar heights. Hence, group analysis is done for these walls which might be the failure mechanism. Their height and thickness are averaged for calculation.

4. Evaluation

Cultural asset values, conservation condition and risks are evaluated. Structural system, construction technique, material, spatial characteristics and architectural

Table 8. The geometric properties of walls and safety factors for overturning and shear failure.

Wall Code	W: Wall Weight (kN)	t: Wall thickness (m)	L: Wall Length	V_b *Base Shear (kN)*	H: Wall Height (m)	Shear Plane	Shear Strength (Mpa)	SF Overturn	SF Shear
A.1	14.97	1.05	1.81	7.48	0.4	1	0.10	10.86	31.01
A.2	93.60	0.73	2.85	46.80	1.7	2	0.10	6.16	9.75
A.3	90.02	0.74	1.47	45.01	3.51	0	0.10	0.42	2.42
A.4	203.05	0.77	3.46	101.52	3.06	2	0.10	5.14	7.27
A.5	232.44	1.12	3.51	116.22	3.36	1	0.10	3.90	6.62
A.6	101.24	0.68	1.09	50.62	3.03	1	0.10	4.52	5.53
B.1	7.00	0.52	0.79	3.50	1.75	1	0.10	26.59	37.74
B.2	265.12	0.61	1.49	132.56	2.67	1	0.10	1.69	1.91
B.3	91.41	0.66	1.72	45.71	3.5	2	0.10	10.48	12.59
B.4	280.27	0.81	5.46	140.14	3.11	2	0.10	4.12	6.75
C.1	92.84	0.55	3.10	46.42	2.11	2	0.10	5.52	8.67
C.2	346.88	0.58	4.50	173.44	4.2	2	0.10	3.09	4.31
C.3	24.35	0.54	0.43	12.18	1.5	2	0.10	14.02	15.21
C.4	63.46	0.78	1.19	31.73	2.9	0	0.10	0.54	2.93
C.5	11.82	0.72	0.98	5.91	0.75	2	0.10	20.19	30.20
C.6	5.36	0.82	0.88	2.68	0.38	2	0.10	27.55	50.13
D.1	92.83	0.77	2.99	46.41	1.5	2	0.10	6.00	9.94
D.2	30.28	0.57	2.16	15.14	0.9	1	0.10	4.65	11.52
D.3	170.67	0.83	1.99	85.34	4.45	0	0.10	0.37	1.94
D.4	253.39	0.57	1.54	126.70	4.45	1	0.10	2.26	2.69
D.5	62.44	0.86	2.28	31.22	3.05	1	0.10	8.97	14.68
E.1	60.00	0.73	2.16	30.00	1.7	2	0.10	9.13	13.53
E.2	71.88	0.84	1.45	35.94	2.35	1	0.10	6.21	8.88
A3-A5	525.51	0.88	8.44	262.75	3.31	0	0.10	0.53	2.82
B1-B2	272.12	0.57	2.28	136.06	2.21	1	0.10	1.43	1.86
B3-B4	371.69	0.74	7.18	185.84	3.305	0	0.10	0.44	2.84

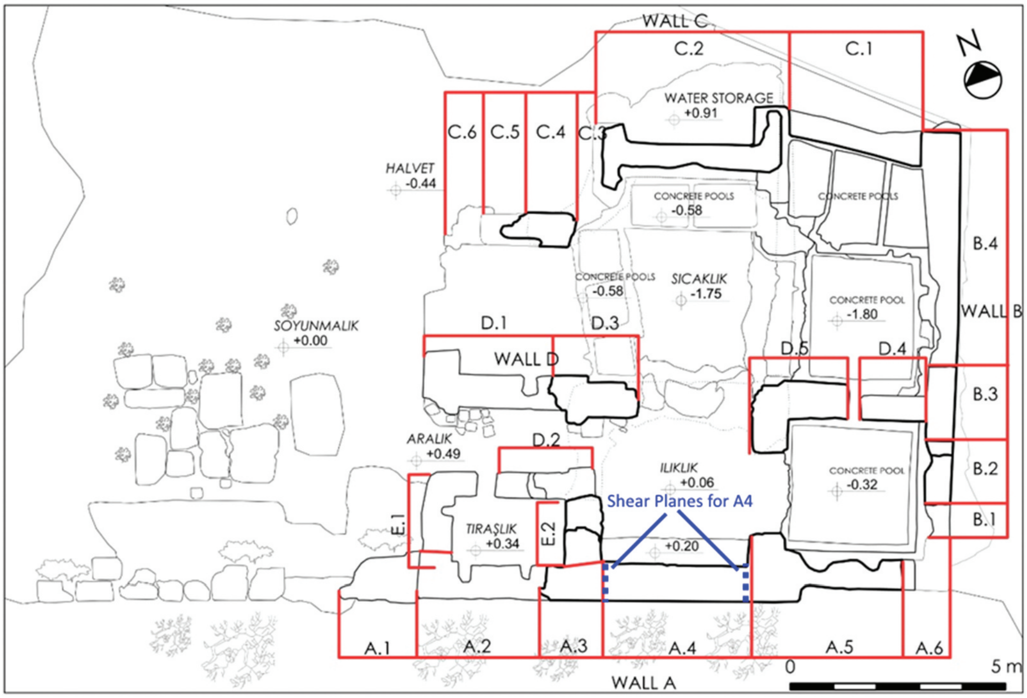


Figure 18. Portions of walls defined according to their heights.

elements of the building have sustained characteristics of the 15th-century Turkish bath. In terms of these characteristics, the building has documentary value. There are some unqualified additions such as concrete pools observed in the building. However, the overall authenticity of the monument is sustained. The form of the partially preserved central dome of *sıcaklık* attributes rarity to the monument. However, there is no presentation strategy for the visitor to understand the ruin.

Major structural failures observed at the upper zone of the ruin are evaluated as condition class 3 (Figure 19). The remains of the dome, the squinches and arches here [3.2] need urgent actions against seismic vulnerability risk. The structural analysis of the walls has revealed that A3-A5, B1 to B4 and C1 and C4 portions (Figure 18) ave a low safety factor. B4 is a long unsupported wall against overturning considering seismic forces, while C1 has a free (unsupported) end. So, they may show bulging behaviour under out of plane loading. They are

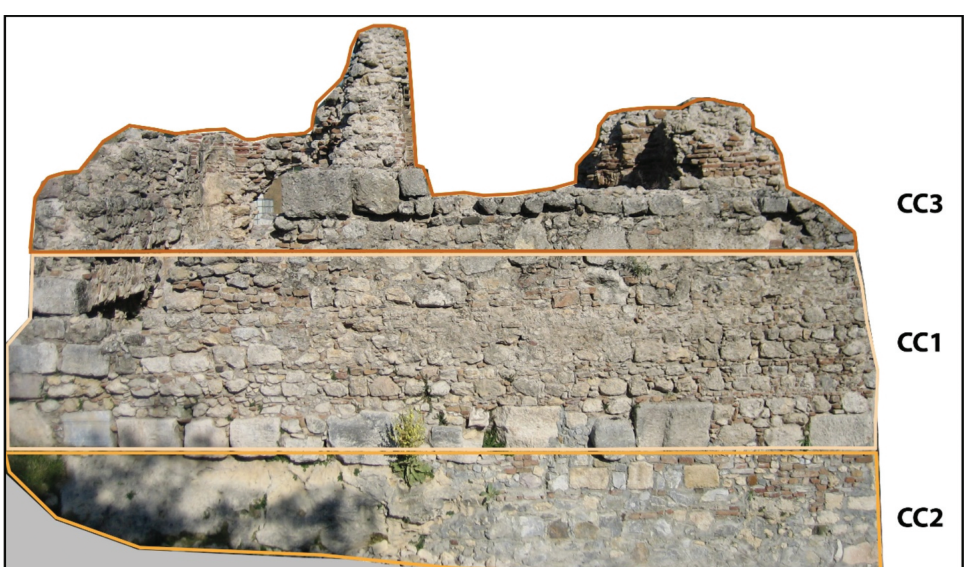


Figure 19. Condition classes.

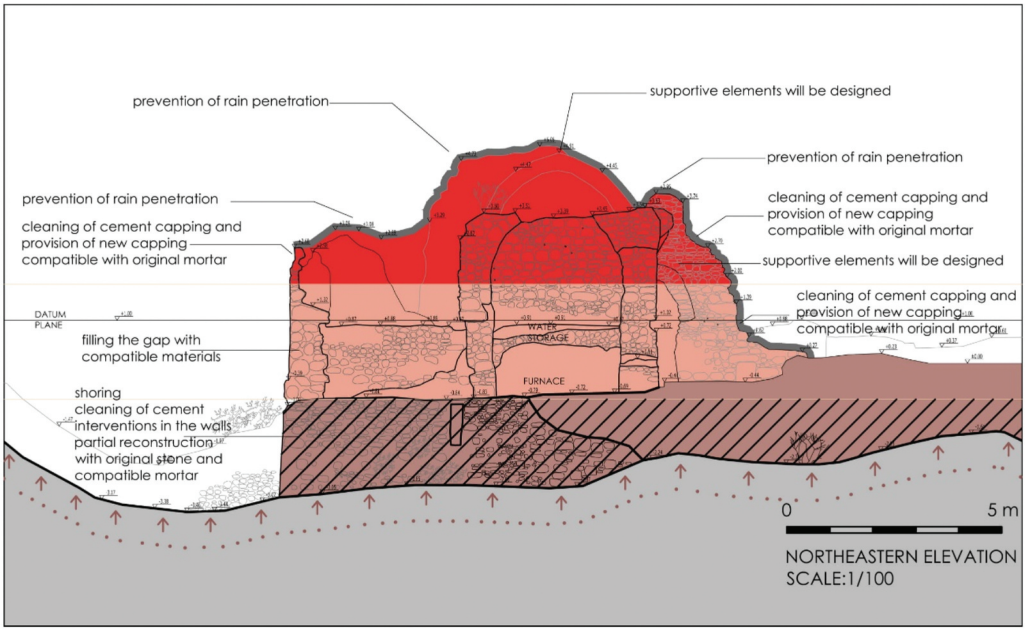


Figure 20. Condition classes, north-eastern elevation.

evaluated in condition class 2 and their consolidation may be planned within the comprehensive restoration. At the lower zone of the ruin, there are local cracks; and potential deterioration of original material due to cement interventions and salt crystallization due to cement mortar and plaster (Figure 20). This zone is also evaluated as condition class 2.

The middle zone is characterized by local structural failures such as gaps in the walls, and material deterioration caused by cement capping in some portions. Potential loss of historical material due to climatic and seismic effects is possible here. It is evaluated as condition class 1 (Figure 19).

The absence of a conservation action plan for Cevher Paşa Bath, which should have been part of a site management plan, is the major risk against its sustainability. After the completion of the excavation, necessary structural interventions have not been fully undertaken or there are inappropriate interventions. Similarly, the ruin has not been monitored.

5. Proposal

Intervention types are defined with regard to the European Standard EN 16,096 as emergency interventions and restoration. The restoration approach is developed by comparing possible options: reconstruction, reintegration or only consolidation. The safety factors that express the structural stability of the walls were a decision parameter on the decision of intervention type. A quantitative categorization is done thanks to the calculated safety factors (SF) and intervention type is assigned accordingly. Necessary supportive structures are designed. A management plan clarifying the actors of Tabae archaeological site, financial support possibilities and priority of interventions is presented.

5.1. Emergency interventions

Emergency interventions are short-term interventions, realized prior to the implementation of the

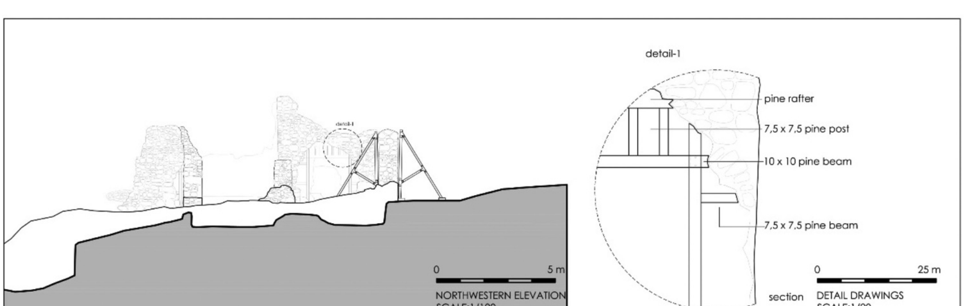


Figure 21. Emergency interventions.

Table 9. Management plan of the bath.

	TARGET	ACTION	AGENT	DURATION
PRELIMINARY ACTIONS	-Taking precautions against further damage	-A preliminary committee will be constituted in coordination of Kale Municipality. -Temporary shoring will be prepared as an emergency intervention. -The tender of Environmental Organization Project will be made.	-Kale Municipality -RT Ministry of Culture and Tourism -Civil Engineering Department of İzmir Institute of Technology -Architectural Restoration Department of İzmir Institute of Technology - History of Art Department of Ege University -A construction firm specialized in restoration -RT Southern Aegean Development Agency	Short term
	-Providing sustainable management of the bath and the site	-A Consultation Council will be formed. A head for the monument and members of the Control and Coordination Council will be selected. -In depth interviews will be realized for assessing the interest of the visitors of the site and the characteristics of the local community that was replaced in a near-by site. -Environmental Organization Project (The Law numbered 5226, 2004) in 1/500 and Management Plan for the Site scale will be prepared for the site. -The project will be submitted for the approval of Regional Directorate of Pious Foundations and RT Ministry of Culture and Tourism	-Kale Municipality -RT Ministry of Culture and Tourism - Regional Directorate of Pious Foundations -Directorate of Excavation -General Directorate for Cultural Heritage and Museums -Pamukkale University, Department of Sociology.	Short term
	-Provision of financial resources to preserve and to promote the building and the site	-Funds will be increased.	-RT Ministry of Culture and Tourism -Denizli Metropolitan Municipality -Kale Municipality -Pamukkale University -Regional Directorate of Pious Foundations - Aydem Electricity Distribution Corporation in Aydın, Denizli and Muğla cities	Medium term

(*Continued*)

Table 9. (Continued).

	TARGET	ACTION	AGENT	DURATION
RESTORATION	TARGET	ACTION	AGENT	DURATION
	-Preparation of the bath for restoration	- The tender of restoration and restoration project will be made within the scope of Environmental Organization Project. - Civil engineer and ground engineer will study for site scale for restoration project.	-Kale Municipality -Directorate General of Foundations -A construction firm specialized in restoration -Directorate of Excavation -Aydın, Conservation, Implementation and Inspection Office -General Directorate for Cultural Heritage and Museums	Short term
	-Preparation of restoration project for the bath accordance with 660 Principle Decision	-The project will be prepared by contractor. -The project will be submitted for the approval of Regional Directorate of Pious Foundations and RT Ministry of Culture and Tourism.	-Kale Municipality -A construction firm specialized in restoration -Directorate of Excavation -Aydın, Conservation, Implementation and Inspection Office -General Directorate for Cultural Heritage and Museums	Medium term
	-Consolidation of the bath	-Mechanical cleaning of plant will be done. - Cement capping will be cleaned and new capping compatible with original mortar provided. -Drainage system will be done. -Walls will be consolidated with injection. -Temporary shoring will be removed and permanent shoring will be installed.	-Kale Municipality -A construction firm specialized in restoration -Directorate of Excavation -Aydın, Conservation, Implementation and Inspection Office -General Directorate for Cultural Heritage and Museums	Medium term
	-Presentation of the bath	-Information panels will be added. -Binocular and balustrades will be added. -Timber floor will be applied. -Specific presentation strategies in order to emphasize the distinctive characteristics of the replaced local community and to fulfil the expectations of the visitors will be developed in accordance with the values of the ruin.	-Kale Municipality -A construction firm specialized in restoration -Directorate of Excavation -Aydın, Conservation, Implementation and Inspection Office -General Directorate for Cultural Heritage and Museums	Medium term
	-Opening of the bath for visitors	-There will be a ceremony for opening of the bath for visitors.	-Kale Municipality -Civil Engineering Department of IZTECH -Architectural Restoration Department of IZTECH - History of Art Department of Ege University -A construction firm specialized in restoration	Medium term
MONITORING	TARGET	ACTION	AGENT	DURATION
	-Regular maintenance of the bath will be made.	-Monitoring scheme of the bath (Table 10) will be implemented.	-Kale Municipality -Directorate of Excavation -Aydın, Conservation, Implementation and Inspection Office -Regional Directorate of Pious Foundations	Continually

restoration project. They will be applied to the elements which have seismic vulnerability risk: the remains of the dome, squinches and arches. Moreover, the walls that have a safety factor for shear or overturning below a threshold of 3 are taken into this category. These are, namely, A3 to A5, B1 to B4 and C1 and C4. These vulnerable elements should be consolidated with temporary shoring immediately so that their structural integrity is re-established. As an emergency intervention, pine timber supports are proposed which is compatible with original material and re-treatable (Figure 21).

5.2. Restoration approach

For the presentation of rubble stone masonry ruins in archeologic/natural sites, reintegration or reconstruction are not appropriate options since they threaten the integrity of their sites with their scales. Reconstruction is totally inappropriate since the documentary value of the authentic ruin is lost. In terms of distinguishability, contemporary techniques and material seem to be advantageous. However, compatibility of stainless steel, which is an often-preferred intervention material, should be monitored regularly since it has rusting risk. Timber, in this sense, has better performance. Preference of only conservation aimed interventions, including consolidation of the historic structure and treatment of historic material, is an appropriate approach since the aesthetic value of the ruin image in the archaeologic/natural setting is sustained. Re-treatability of consolidation elements is a positive attitude. If a better intervention is planned in the future, they may be dismantled. Provision of limited presentation tools such as balustrades for safety, walking paths, information panels and binoculars for the visitors is indispensable since a balance between conservation and visitor satisfaction is to be established. As a result, the restoration approach for Cevher Paşa Bath is a consolidation of the historic structure, conservation of historic material and addition of contemporary elements for guiding and safety of the visitors.

5.3. Implementation details

Firstly, the mechanical cleaning of plants will be done. Prevention of rain penetration will be provided with hard capping. There are 10 different concrete pools with different sizes. One of the sizes of pools is equal to the dimension of the related space. Five of them are located in another space with different dimensions. In the northern part of this pool, there are three pools which are adjacent to each other. Some of the walls of concrete pools consist of brick and stone pieces with cement plasters. These concrete pools provide historical value to the timeline of this building during the leather workshop period. Most of them are adjacent to the original wall of the ruin. There is no salt crystallization observed in these

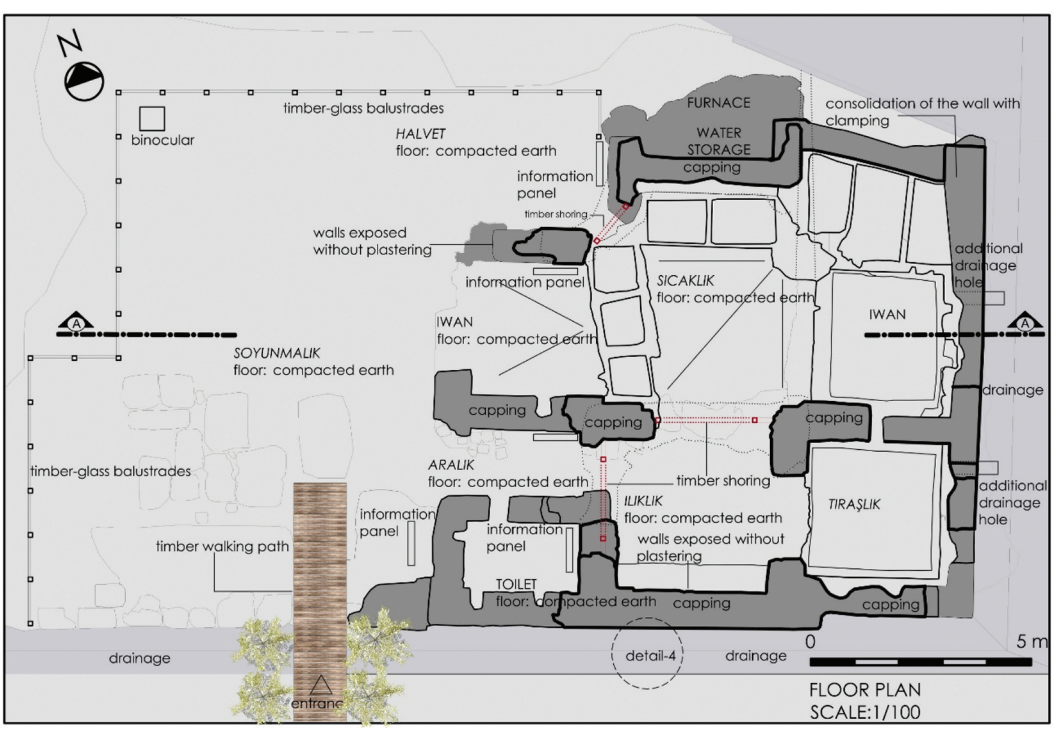


Figure 22. Restoration.

Table 10. Annual monitoring scheme of the bath.

Annual Monitoring Scheme		Months											
		January	February	March	April	May	June	July	August	September	October	November	December
Work	Packages	Check											drainage system
	Check material deterioration of concrete pools												
	Cleaning of biological growth												
	Check retaining walls												
	Clean out drainage channel												
	Removal of fallen leaves												
	Remove debris												
Repair capping													

original parts adjacent to cement parts. Therefore, these walls will not be removed. However, there is a risk of crystallization in these walls. If salt crystallization will be observed, removal of these walls might be proposed. Possible material deteriorations should be monitoring regularly a planned in the management plan. If deterioration will be observed in the future, in order to prevent further material deterioration, removal of concrete pools will be carried out (Table 9).

Existing cement capping will be cleaned and new capping compatible with original mortar will be implemented. A drainage system will be added. After the consolidation of walls with injection, temporary shoring will be removed and permanent shoring with spruce timber supports will be placed. The stainless-steel plates will be applied for vulnerable elements with rubber isolator to prevent rusting. These elements will be supported with timber shoring. Consolidation of the wall with clamps will be carried out at the north-eastern corner which was determined as the weakest wall of the bath. Timber floor will be provided at the original entrance. Information panels and binocular and balustrades at the cliff side will be added (Figure 22). The permanent shoring is also re-treatable. It does not damage historical building elements. The vulnerable elements will be wrapped with stainless-steel plates and rubber isolators and this new structure will be carried by timber shoring (Figure 23).

For the walls that need urgent lateral capacity increment, namely A3 to A5, B1 to B4 and C1 and C4, may be supported as in (Figure 21) given that the supportive structure contribution will bring the safety factor above 5 for both shear and overturning. This support shall be employed at both sides for stand-alone walls to ensure safety in two ways of weak direction.

5.4. Management plan

A monument management plan for the bath is prepared in order to define actors, financial resources and priorities (Table 9). The aim of the monument management plan is to ensure that the implementation is carried out in accordance with the legislation and the project; to enable the evaluation of the new data obtained during the implementation by the project designer and the consultants; and to make possible the revision of the project; to ensure completion of the work safely and to provide regular maintenance after implementation of the project. The plan is to be a pilot application for the whole site. The theme of the monument management plan is cultural tourism. Monument management plan consists of three phases. First stage is related with preliminary actions before the implementation of restoration. A committee in coordination with Kale Municipality will be constituted and temporary shoring will be applied as an emergency intervention. A Consultation Council will be formed, and members of the Control and Coordination Council will be selected. Then, Environmental Organization Project in 1/500 scale and Management Plan for the site will be prepared. Funds will be increased by the mentioned agents. In the second stage, the target of the restoration and the workflow is defined. The third phase is related with the monitoring of the bath after the implementation. Monitoring aims to provide regular maintenance (Table 10) to the bath. In case of weakening of the east portion (wall B in Figure 13), a supportive structure will be provided (Figure 24).

6. Discussion and conclusion

The management of rubble stone ruins in archaeological and natural sites should take into consideration its understanding, the actors and budget of conservation, and the process of restoration and monitoring, just like in any other monument management plan. Nevertheless, it is important to keep in mind that anastylosis is not a suitable restoration approach for rubble stone masonry ruins, but structural consolidation process should be detailed in the action plan. The

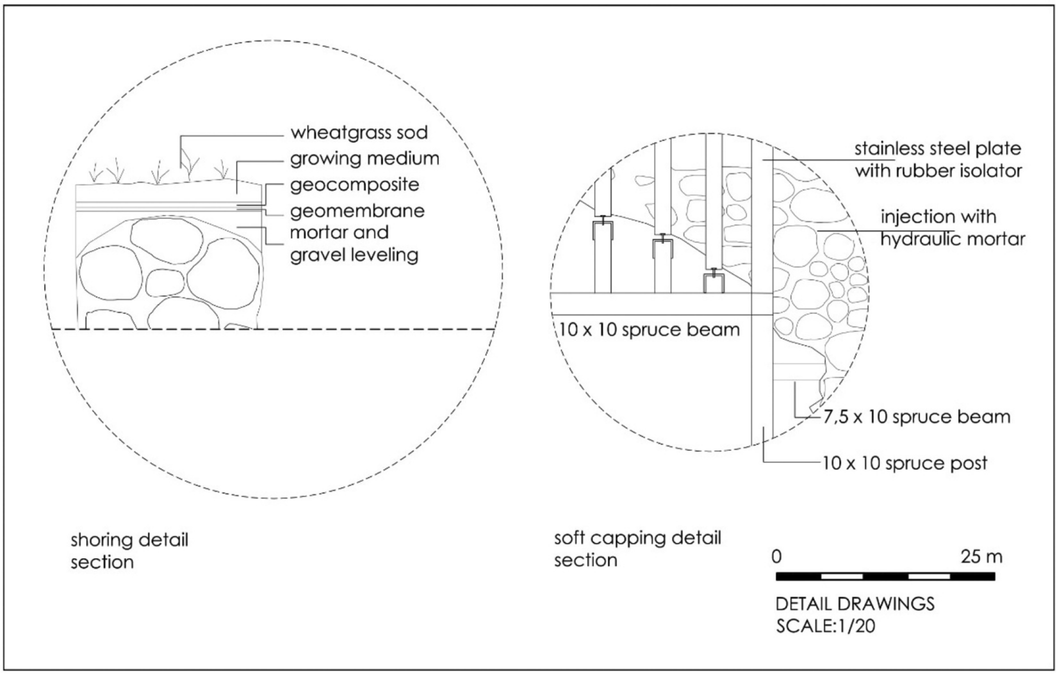


Figure 23. Restoration.

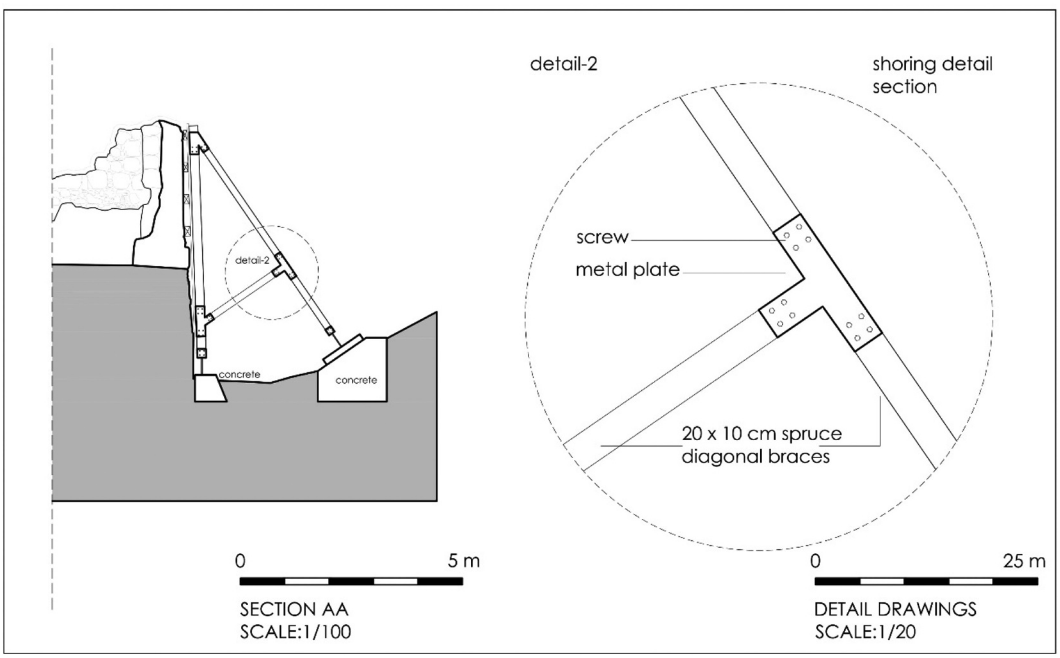


Figure 24. Supportive structure.

planning of consolidation should take into consideration the safety factor of wall portions, which are grouped according to their heights and thicknesses, and re-establishment of the integrity of portions of superstructure elements. The urgency of interventions to wall and superstructure portions should be determined. First, emergency interventions such as supporting vulnerable superstructure and wall portions should be realized with compatible material, e.g. timber. Then, comprehensive planning of the restoration process should be made. This includes understanding the history and values of the ruin, as well as its conservation problems. It is important to preserve contributions of different historic periods, but risks of the incompatible material additions should be carefully evaluated. The restoration scope should include a sustainable consolidation strategy, as well as presentation of the ruin considering the safety necessities, viewpoints of the locals, and expectations of the visitors. Reintegration and reconstruction, as a restoration scope, may have a negative impact on the authenticity of the archaeologic and natural setting.

An interdisciplinary work of architecture and structural engineering is conducted for the determination of walls' lateral resistance capacity that leads to the urgency for intervention. At the structural evaluation phase, resistance of the walls against wind and earthquake loads are considered. A simple and conservative approach is employed due to lack of information on the material properties of site and the proposed framework is built on a number of assumptions. The tensile contribution of the mortar is neglected. Because at some points, erosion of the mortar is observed and the mechanical test data for the mortar were not available. The width of the walls are varying through their length and height; however, to calculate the shear plane areas, the end widths at the plan view height are used. Other conservative assumptions are made due to uncertainty and complexity of the microstructure of the walls which are stated in sec 3.2.2. It should be noted that more complex failure mechanisms may occur. For the wall for safety factor less than 2, more detailed analysis would be carried out before finalizing the intervention decisions on them.

Disclosure statement

No potential conflict of interest was reported by the authors.

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