



Article

Eco-Sustainable Methods for Local Conservation of Built Heritage in Sistan's Castles

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Abstract: Built heritage has an important role in the development of the global tourism industry. Therefore, appropriate conservation methods are required to support cultural identities and the tourism industry. Within the Sistan region of Iran, there are a number of built heritage assets (such as castles) that were constructed in different periods of history. Due to climatic conditions, management issues, and unemployment issues, ineffective conservation measures have been implemented for these types of built heritage assets. Therefore, special conservation methods are required to address different performance issues. This study offers practical solutions for the conservation of Sistan's castles. An eco-sustainable model is proposed as a method to plan appropriate conservation interventions that consider economical, ecological, and labor-friendly characteristics of sustainability. We demonstrate that this approach to architectural conservation is responsive to local constraints and can be compatible with local requirements.

Keywords: heritage conservation; Sistan region; eco-sustainable approach; architectural conservation



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1. Introduction

Each society has had a relationship with its past, even those which have decided to ignore it, and it is maintained through understanding the significance and nature of what people tell each other about their past; such heritage studies have interactions with educational debates beyond the confines of present-centered cultural and tourism studies [1,2]. Heritage might be a technique for commitment, a demonstration of communication, and an act of making meaning in and for the present [3]. Built heritage has been, for all societies, one of their most precious assets because it brings along a series of values that make it essential for the development of social life [4]. Tourists' visits to places with culturally significant historic material and immaterial remains, additionally known as historic sites, are useful in terms of generating financial gain and employment opportunities for the local community and raising public awareness of the value of heritage [5–7]. Heritage resources such as built heritage, containing vulnerable and irreplaceable natural and human-made assets, need to be preserved and protected for current individuals and future descendants [8]. Heritage buildings, sites, arts, and collections present a variety of challenges for preventive conservation, particularly regarding environmental management. These challenges originate from the requirement to preserve the accuracy and physical entirety of the building and site, while simultaneously addressing the environmental vulnerabilities of the collections [9]. Conservation is not about the recovery of some original form but about the management of change, including endeavors to shape and control the future [10,11]. With the development of cities, some of these cultural assets have been forgotten or are being destroyed [12]. Heritage conservation is a method of incorporating three key components of heritage sites, namely, their physicality, fabrics, and the individual character of the local communities who live in and around the sites [13,14]. This procedure of continuous regeneration requires that the knowledge of architecture, construction, and relevant skills be preserved and passed down from generation to generation [11,15].

Sistan is titled the paradise of archaeologists. So far, many domestic and foreign researchers have studied in this region, and experts have identified about 1595 ancient works of various historical periods in this region, and 776 works have been registered in the list of national monuments. The existence of many ancient works in the Sistan Plain from different historical periods shows that this area has special importance. One of the most important heritage sites of this region is Sistan's castle. These castles generally have military fortifications, including battlements and ditches; some of them are governmental, some are residential, and others are governmental-residential. Of course, a complete sample of residential areas without a governmental sector is very rare [16]. This paper contains a critical discussion of heritage conservation at castles due to one of the valuable built heritage sites of Sistan. It focuses on the local and economic methods that can conserve castles to prepare them for tourists' visits. The first step toward finding clear and sustainable preventive conservation solutions for cultural sites requires a clear assessment of institutional context, goals, priorities, policies, geographical location, resources, and other limitations. This study investigated optimized and applicable methods of preservation for repairing old castles. Concerning large-scale castles, we considered the numerous number of them, local labor availability, and financial restrictions, and we chose integrated and similar methods of construction among scattered locations of castles to design optimized methods of preservation. Choosing materials is an important challenge that should be compatible with the main aims of research and sustainable approaches. For this reason, the main portion of materials was local and can be provided on-site, such as clay bricks and mud and straw covering materials. Other materials were chosen due to their availability and local market financial restrictions.

The method of this research contained two processes. One part of it involved the study of historical documents, and the other part was a field study that involved the mapping and documentation of vulnerabilities and damaged parts and areas, categorizing damages and destructions such as crack size, deterioration, and erosion issues.

2. Research Area (Strengths and Weaknesses of Sistan's Built Heritage)

The Sistan and Baluchistan province comprises two quite distinct regions of Sistan and Baluchistan, which are different in terms of historical, social, and cultural aspects [17]. Politically, Sistan is divided between Afghanistan, Pakistan, and Iran. The Sistan and Baluchistan province is in the warm and dry region of Iran, which is composed of two distinct regions of Sistan and Baluchistan [17] (Figure 1).

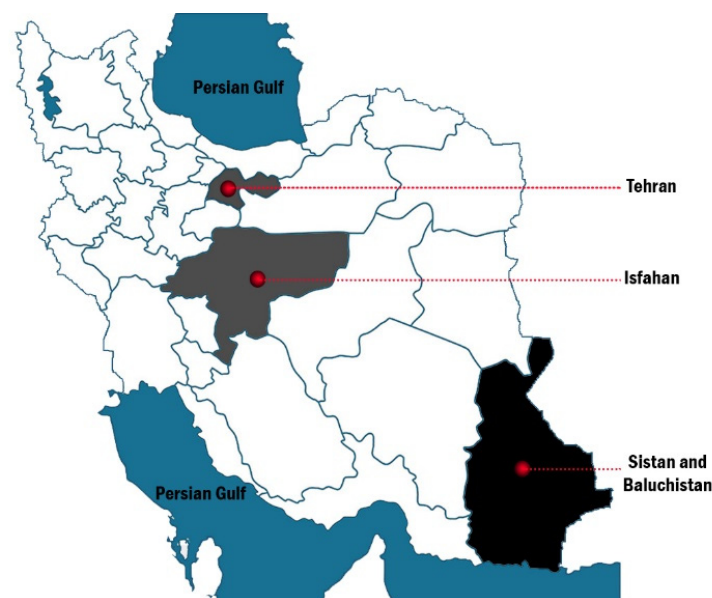


Figure 1. Location of Sistan in Iran.

In the past, Sistan was in the form of lands with hills of fluid sands and marine sediments, and a part of it was located on the river path; a reduction in river water led to the expansion of the surrounding lands, and therefore, a large village was formed [18]. During the Achaemenid time, Sistan was a region, and based on a Zoroastrianism book, Sistan was the eleventh country created by Ahura Mazda. Sistan has been called different names such as “Sak e stan”, “Sajestan”, and “Sivestan” [19] (Architecture in Sistan is based on the climatic conditions (hot and dry climate) of this area, so most of the houses in this land are made from indigenous materials, including water, mud, and clay, and they keep the heat and cold).

Sistan is one of the developing regions of the country in terms of economic growth and development, but despite the allocation of special credit and investment collections of recent decades, it still has the lowest economic and social indicators. Factors such as water, agricultural lands, and the traditional economic situation over the years, have made it more difficult to develop the region’s agriculture. In this province, industrial sector growth is little; now, the people of this province are provided with more consumer and industrial products from the provinces of Pakistan. generally, despite its heritage, including music, art, crafts, and architecture, and its high potential for attracting tourists as a means of resolving regional problems, Sistan has weak points, such as weather and climate conditions, a lack of specialists, a lack of financial resources, and the inequality and extensive regional dispersion of resources. Therefore, one of the economic solutions is attracting tourists to built heritage. One of the architectural heritage potentials of Sistan is its castles (Table 1). On the other hand, there is a need for the conservation and restoration of these buildings due to the economic problems of the region and specific weather conditions that require eco-sustainable conservation.

Table 1. List of historical castles in Sistan.

1	Mochi Castle	15	Spakeh Castle	29	Pashamag Castle	43	Kooh Kan Castle
2	Sekouheh Castle	16	Ganj Yaban Castle	30	Chat Sooldan Castle	44	Tamin Castle
3	New (NO’) Castle	17	Pishin Castle	31	Kazoor Castle	45	Chehel Dokhtaran Castle
4	Irandegan Castle	18	Gooran Castle	32	Parood Castle	46	Pil Boland Castle
5	Heydar Abad Castle	19	Sarbaz Castle	33	Raam Rood Castle	47	Batel Castle
6	Bampour Castle	20	Aashar Castle	34	Kohak Kahzad Castle	48	Tis Castle
7	Naseri Castle	21	Firooz Abad Castle	35	Saam Castle	49	Pirooz Gat Castle
8	Qale’e Berenji	22	Irafshan Castle	36	Bi Bi Doost Castle	50	Balooch Gat Castle
9	Qale’e Hadar	23	Pishin Castle	37	Tarqoon Castle	51	Noshiravan Castle
10	Sib And Suran Castle	24	Baftan Castle	38	Chapo Castle	52	Heidar Abad Castle
11	Kant Castle	25	Afshan Castle	39	Balan Castle	53	Rostam Castle
12	Nikshahr Castle	26	Barisk Castle	40	Hoz Dar Castle		
13	Bag Castle	27	Goodar Castle	41	Qasre Qand Castle		
14	Bent Castle	28	Zangian Castle	42	Narooi Castle		

3. Discussion: Eco-Sustainable Conservation Model in Sistan

Based on the information from Sistan, to develop an appropriate management plan for the eco-sustainable management of castles, it is necessary to determine what conservation is needed for built heritage in the area and then set goals as a first step. Therefore, efforts taken to conserve the built heritage in this area should have three general characteristics, including (a) economical, (b) ecological, and (c) labor-friendly. On the other hand, based on the region’s strengths and weaknesses, the following management objectives are presented in Table 2 for the conservation of castles in Sistan.

Tourist attraction is a great chance to improve and increase local and international attention that can lead to an extra budget being allocated to conservation and restoration plans. The type of climate and geographical factors influence conservation planning management in historic buildings. Conservation planning for castles is generally similar, but regarding tourist attraction, financial resources, and the physical conservation requirements of castles, different approaches should be taken into consideration. Due to the vast area of

castles, it is essential to manage the budget on places that are remaining and can support the existing structure. The structure and total shape of a castle have a significant impact; therefore, the main priority in conserving these monuments should be concentrated on weak structures, less supported structures, and architectural elements that signify the kind and typology of Sistan castles. Figure 2 shows the needs and problems in eco-sustainable conservation in Sistan.

Table 2. Conservation management objectives for Sistan Castles.

Conservation management objectives for Sistan	Tourism attraction development	Representing specific monumental features Improve funding through the development of the tourism industry; Visual attraction;
	Physical conservation	Conservation of enclosed spaces; Conservation of visual and exterior features; Conservation of interior decorations.

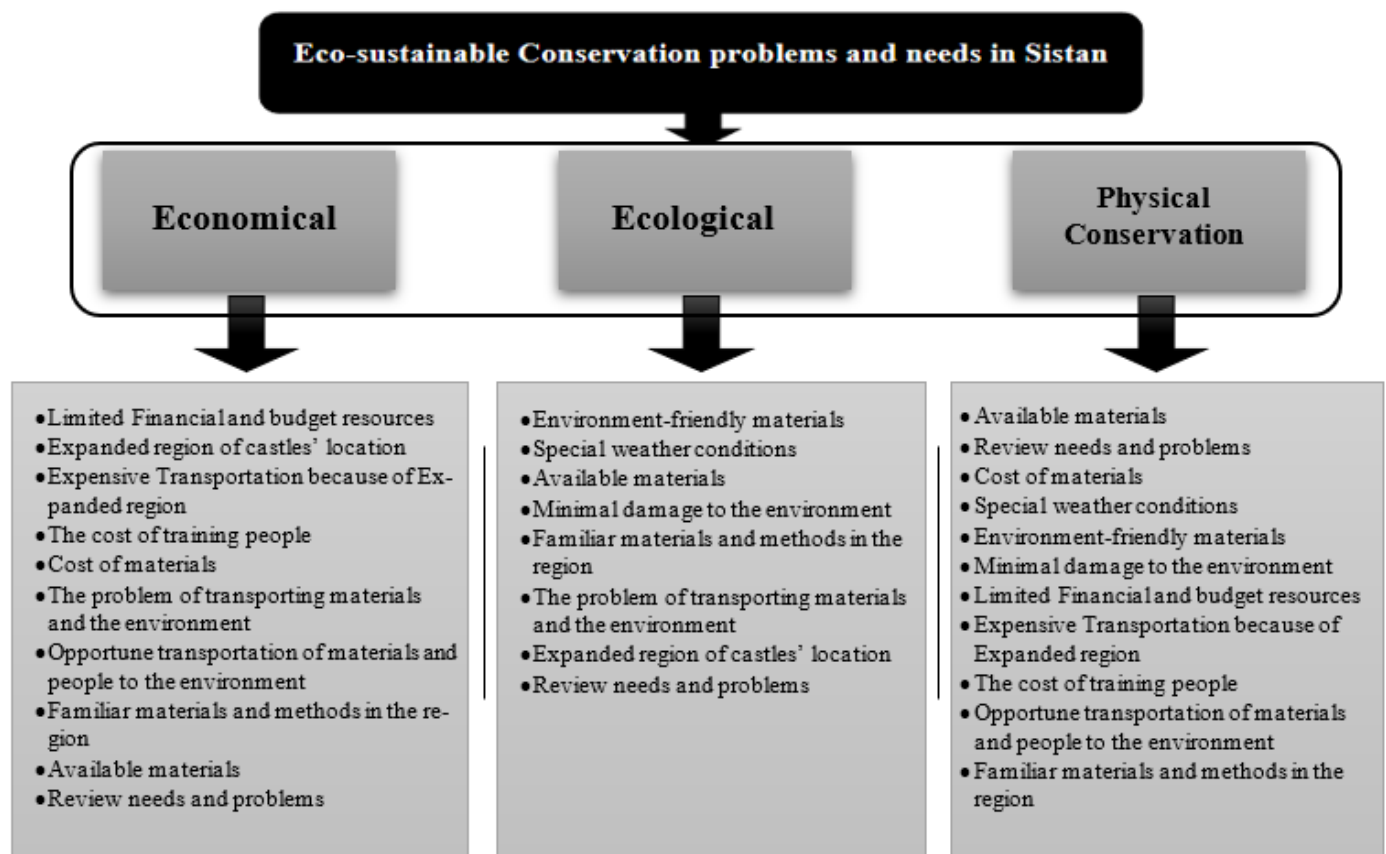


Figure 2. Eco-sustainable conservation problems and needs in Sistan.

According to Figure 2, the needs and problems overlap in different sections. Therefore, one of the approaches that has been achieved through the examination and adaptation of components is conservation based on the local architecture and techniques in the region. It is economically sustainable, which means it is friendly toward the environment because it is in harmony with the context and economy regarding the type and quality of materials used and their transport to the region. In addition, laborers are familiar with it, so the costs of training and moving experts to the area are greatly reduced (Figure 3).

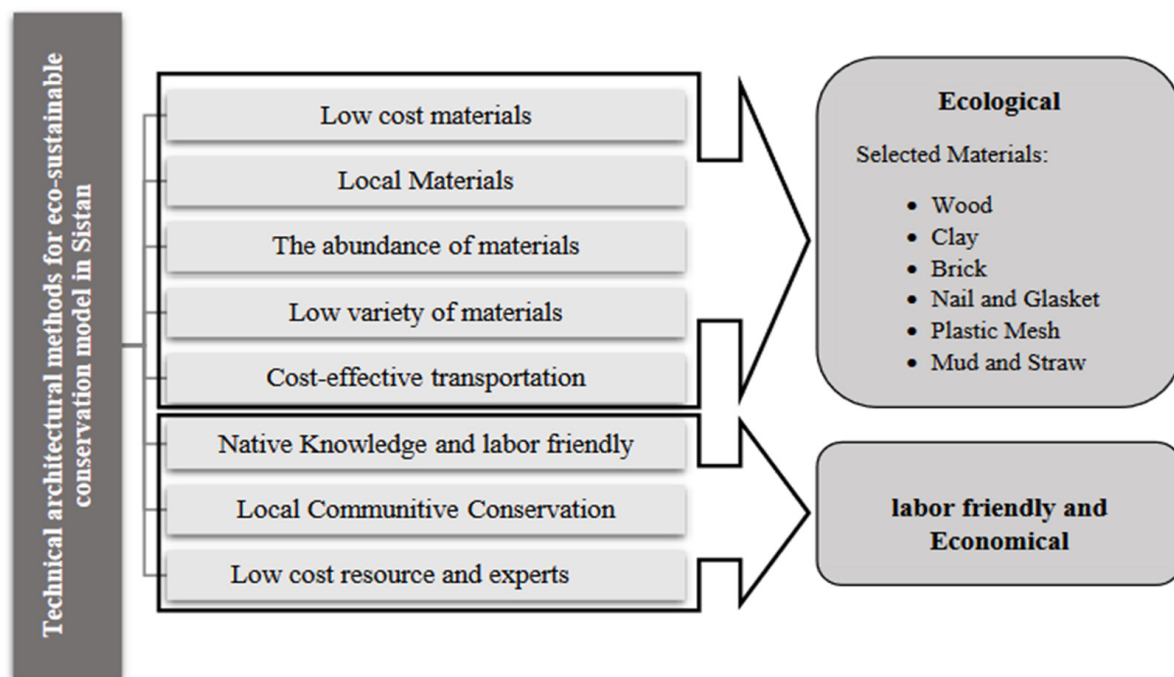


Figure 3. Technical architectural methods for eco-sustainable conservation model in Sistan.



4. Analysis and Findings

Due to the features of this region and the distribution of castles, three castles (Rostam Castle, Mochi Castle, and Sekouheh Castle) were selected and studied as case studies that have different architectural characteristics and need their compatible conservation plan to meet the conservation management plan requirements. For this reason, firstly, an upstream conservation plan was chosen, and then architectural conservation details were depicted for the castles. General damages were categorized on the basis of three factors in conservation planning. Considering that the cases studies, regarding their physical form, habitual placement of decorations, and ornamentation, have different architectural features, various conservation approaches were presented for a conservation plan. In this study, conservation strategies were determined for three case studies as follows: “Rostam Castle” was selected for exterior and visual features, “Mochi Castle” was selected for enclosed spaces, and “Sekouheh Castle” was selected for interior decorations. Before representing conservation approaches, the general documentation of damages of the castles was investigated. The conservation plan included entrance portals, walls (ramparts and parapets), and fortification ramparts, which are shown in Table 3.

Table 3. Investigation of general damages in case studies.

Rostam castle	<ul style="list-style-type: none"> - Rostam Castle has a vast area of residences, fortification walls, and the citadel; therefore, it has a huge amount of deterioration and erosion of building monuments. - Clay and straw finishing covers were eliminated over the years. - Parapets were destroyed in rooflines in the south and east sides. - The citadel has serious deterioration in the lower walls of the courtyard. - Domes and arches have fallen in some parts. - Some parts of the entrance portal were destroyed. - Fortifications have large cracks in the lower walls. - All of the interior/exterior walls have small cracks in $\frac{1}{4}$ of the wall height. - Some parts of fortifications were totally damaged on the northern side. 	
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Table 3. Cont.

Mochi castle	<ul style="list-style-type: none"> - Sagittal domes and arches have fallen in some sectors. - The citadel has serious deterioration in the lower walls where the walls meet the ground, especially in the courtyard. - Gypsum plastering was destroyed or scraped over the years. - Clay and straw finishing covers were eliminated over the years. - Parapets were destroyed on wall tops and fortifications. - Cracks were caused by the thrust of domes. - There were traction cracks on domes meeting the pillars. 	
Sekouheh castle	<ul style="list-style-type: none"> - The destruction of arcade finishing. - Weakening of the load-bearing arcades and arches. - Destruction of top lines of domes caused by the weight of clay and straw and exposure to annual rain. - Small cracks in walls and decorations. - Most of the coverings of the citadel were eliminated or wiped out. 	

4.1. Architectural Conservation Plan for Three Case Studies in Sistan Castles

The financial limitations, vast area of castles that needs conservation, and the physical characteristics of castle buildings for the Sistan castles are represented in Tables 4–6.

Table 4. Exterior and visual features (Rostam Castle).


Architectural spaces and elements	Parapets	<ul style="list-style-type: none"> - Clay and straw covering of parapets eliminated for restoration. - Restoring and rebuilding parapets in the entrance front and the side that is close to the entrance location. - Reconstructing the parapets and openings with indigenous materials depicting and modeling parapets and wall top openings. 	
	Entrance portal and fortifications	<ul style="list-style-type: none"> - Restoring the lower parts of deeply damaged entrance pillars with prepared 41 × 41 cm clay bricks. - Using 41 × 21 × 7 brickwork in the facade and exterior walls, which does not affect the foundations of the walls. - Restoring the sidewalls of entrance arches. - Repairing entrance arch brickworks with new clay bricks and gypsum as mortar. 	
	Walls	<ul style="list-style-type: none"> - Eliminating old and destructed clay and straw covering; then, renovating and recovering the facade and clay bricks of walls with new mud and straw finishing. - Restoration and rebuilding of south and north walls with large cracks. - Supporting Ivans' main arches with wooden beams. 	

Table 5. Conservation plan for physical spaces (Mochi Castle).

Architectural spaces and elements	Thatching Roof	<ul style="list-style-type: none"> - Sagittal domes and arches restored with brickwork and gypsum mortar in interior spaces and interior walls. - Dome damages and destruction rebuilt and reinforced with rebar (steel rods).
	Interior spaces	<ul style="list-style-type: none"> - In Lord Residence: restoring the gypsum underlying clay brick materials and completing the patterns and preparing the plastering. - In Servitors Residence: restoring the mud and straw composite for finishing interior walls. - Decoration considering the type of remaining ornamentation in interior spaces; models and patterns of ornaments were copied and documented for expansion of conservation progress.
	parapets	<ul style="list-style-type: none"> - Clay and straw covering of parapets eliminated for restoration. - Restoring and rebuilding parapets in the entrance front and the side that is close to the entrance.
	Walls	<ul style="list-style-type: none"> - Eliminating old and destructed clay and straw. - Covering and then renovating and recovering the facade and clay bricks of walls with new mud and straw finishing. - Restoration and rebuilding of south and north walls with large cracks. - Supporting Ivans' main arches with wooden beams.

**Table 6.** Conservation plan for physical spaces (Sekouheh Castle).

Architectural spaces and elements	Entrance portal and fortifications	<ul style="list-style-type: none"> - Damaged parts of entrance arches restored with baked bricks and gypsum mortar. - Fortifications decorated with arcades and facades reinforced with clay brickwork and covered with mud and straw finishing.
	Arches	<ul style="list-style-type: none"> - Damaged parts of entrance arches restored with baked bricks and gypsum mortar plaster at interior surfaces.
	Interior decorations	<ul style="list-style-type: none"> - Documenting the placement of decoration in interior places and the patterns of arcade ornamentations. - In some cases, with a low level of damages, some parts of the motifs were scrapped and restored with a plastic coating.
	parapets	<ul style="list-style-type: none"> - Parapets restored by complicated arches with clay brick and gypsum mortar and overlaid with mud and straw finishing. - Restoring and rebuilding parapets in entrance front and the side that is close to the entrance location.
	Walls	<ul style="list-style-type: none"> - Restoring the facade and exterior body of the buildings with the same block size used in walls and exterior surfaces. - Old coverings were cut out and replaced with new mud and straw finishing in the exterior part and gypsum plaster.



4.1.1. Conservation Plan for Exterior and Visual Features (Rostam Castle)

Rostam Castle conservation includes massive gates, raised portals, and high-rising and voluminous walls. The row-shaped diminutive openings at the tops of the walls of huge fortifications have a special visual identity. Due to the damages and remaining monuments, conserving these architectural characteristics was the main priority in the conservation of the castle (Table 4).

4.1.2. Conservation Plan for Physical Spaces (Mochi Castle)

In the conservation management plan for the Sistan region, regarding castles and the remaining roofed areas, interior plastered arcades, and decorations, restoring physical interior space was the main priority of the conservation plan (Table 5).

4.1.3. Conservation of Interior Spaces of Sekouheh Castle

Considering the placement of decorations in interior places, the models and patterns of the arcade ornamentations were documented digitally; then, the conservation operations were established for the castle (Table 6).

4.2. Architectural Details in the Conservation of Sistan Castles

There are many trends in different places and architectural elements which require specific architectural and structural details in the conservation process of Sistan castles. In this article, the main examples of conservation details applied in Sistan castles were represented. These architectural details were used due to the compatibility of materials with the physical characteristics of castle buildings. For instance, wooden blocks were used for tension reinforcements of different sizes of wall cracks, which is more compatible with mud and straw mortar humidity in the finishing and mortar. In addition, plastic mesh was used to cover the surface of crack restorations to resist the humid layers of mud and straw mortar. The other conservation details, such as reinforcing materials, humidity absorption, and critical details, are represented below (Figure 4).



Figure 4. Rostam entrance portal (before and after conservation).

Figure 5 illustrates the architectural details for conserving walls with large cracks. In this image, wooden block is used for its compatibility with mud and straw mortar and coverings. To protect the wood from termites, the wooden block is coated with lime grout. As the height of the cracks increases, multiple wooden blocks are used as beams to conduct the pressure of upper mortars to the ground. Plastic mesh is a better option than metal nets to create an integrated surface. Two layers of plastic nets are applied at different levels to cover the wall surface. Clay bricks are used for filling the lines in crack spaces.

Regarding the proposed method and previously used materials, it should be considered that in most cracks that have not affected structure damage, or are not deep, previous methods of repairing with the same materials were used for preservation procedures. To repair the largest-scale cracks and to find optimized options for preservation, three factors should be considered that are also adaptable to sustainable approaches: technical factors, the local community, and economic restrictions.

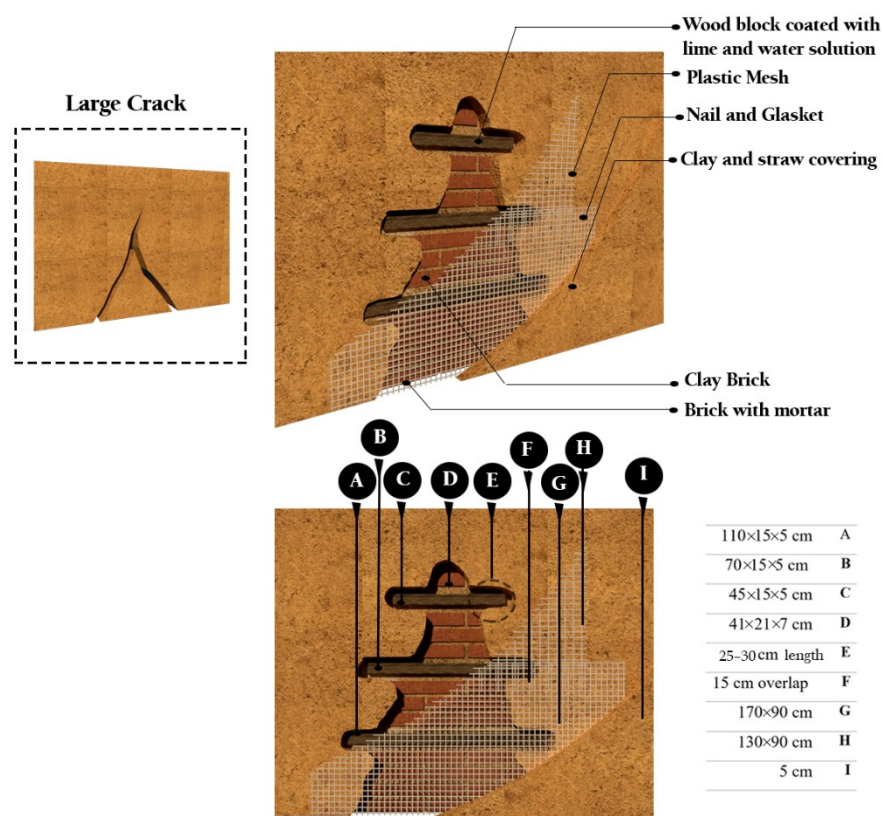


Figure 5. Example of architectural detail for conservation of a large crack in the wall (for instance, 80 cm width).

Technically, regarding the scale of the castles and similar ways of construction, integrated types of details could be applied to refurbishments. For local community considerations, using the most known and routine methods of repairing create a better opportunity for local masons and workers to be hired in repairing projects. Due to economic restrictions, there should be low-cost materials chosen to repair the projects. As wooden lintel is available in the region, and also clay bricks are a local soil type, these are available and low-cost transportation materials for a restoration project. The only material which is not a nature-based material is a plastic mesh that is one of the routinely available building materials in the local market.

In the case of Moshi Castle, conservation is presented in Figure 6.



Figure 6. Mochi Castle conservation.

Figure 7 shows the conservation details for small cracks that were seen in all parts of walls, fortifications, and interior spaces. The crack should be cleared and prepared for the placement of wooden block. Block length should extend in walls about a half crack length. Plastic mesh and then mud and straw finishing were used for covering the crack.

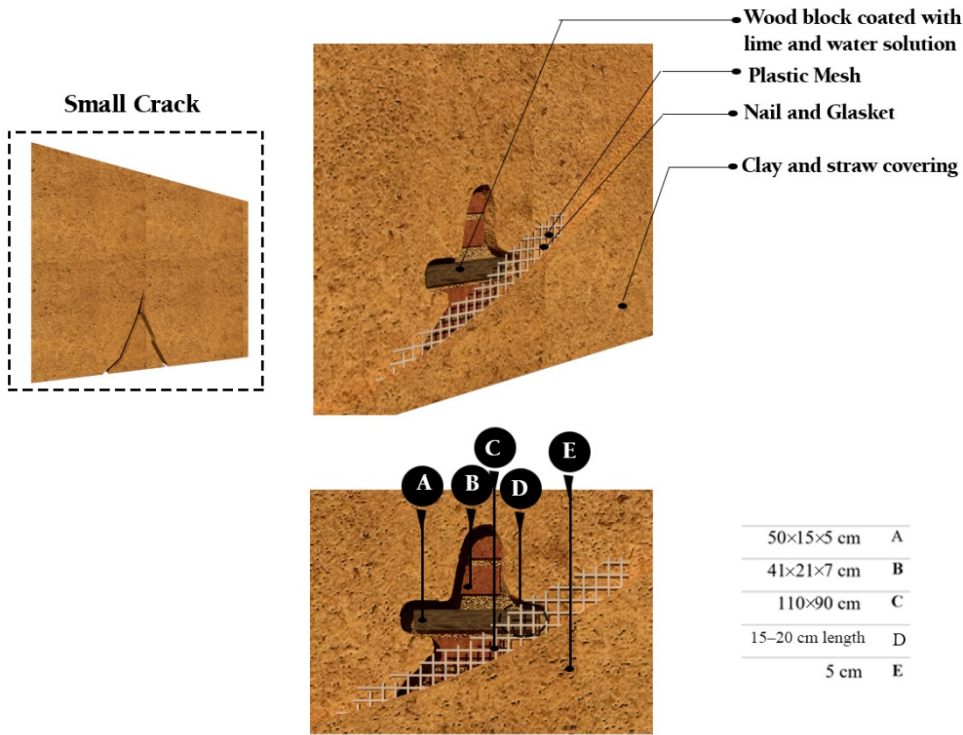


Figure 7. Example of architectural detail for conservation of a small crack in the wall (for instance, 40 cm width).

In parapets, as the openings are weak for load bearing, a wooden block coated with lime grout is placed at top of the parapet’s opening. For adhering and integrating mortar, some plastic mesh is used on different sides and nailed with gaskets to the walls (Figure 8).

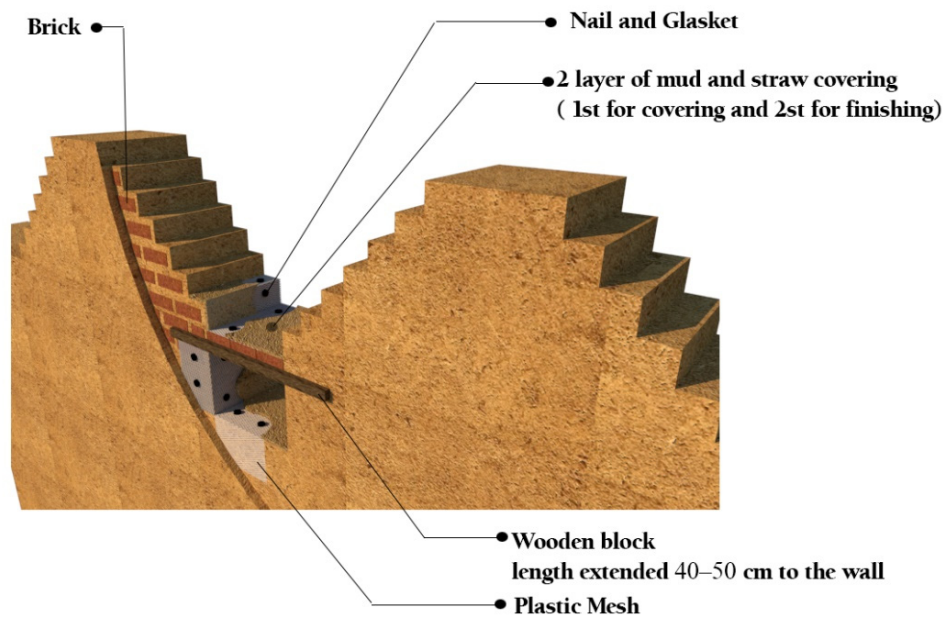


Figure 8. Example of architectural detail for conservation of parapets.

Figure 9 shows architectural details for repairing and restoring the ground-level walls in interior and outdoor spaces. The main point was to protect the wall from ground-level humidity. Hence, a water-resistant layer such as mosaic tiles and lime mortar was used as a wall bed. In addition, a mixture of soil and lime with one part lime to two parts soil constituted the bed level on the ground and a cornice covered with brickworks. Gypsum plaster was used for finishing indoor walls, and mud and straw were used for outdoor walls.

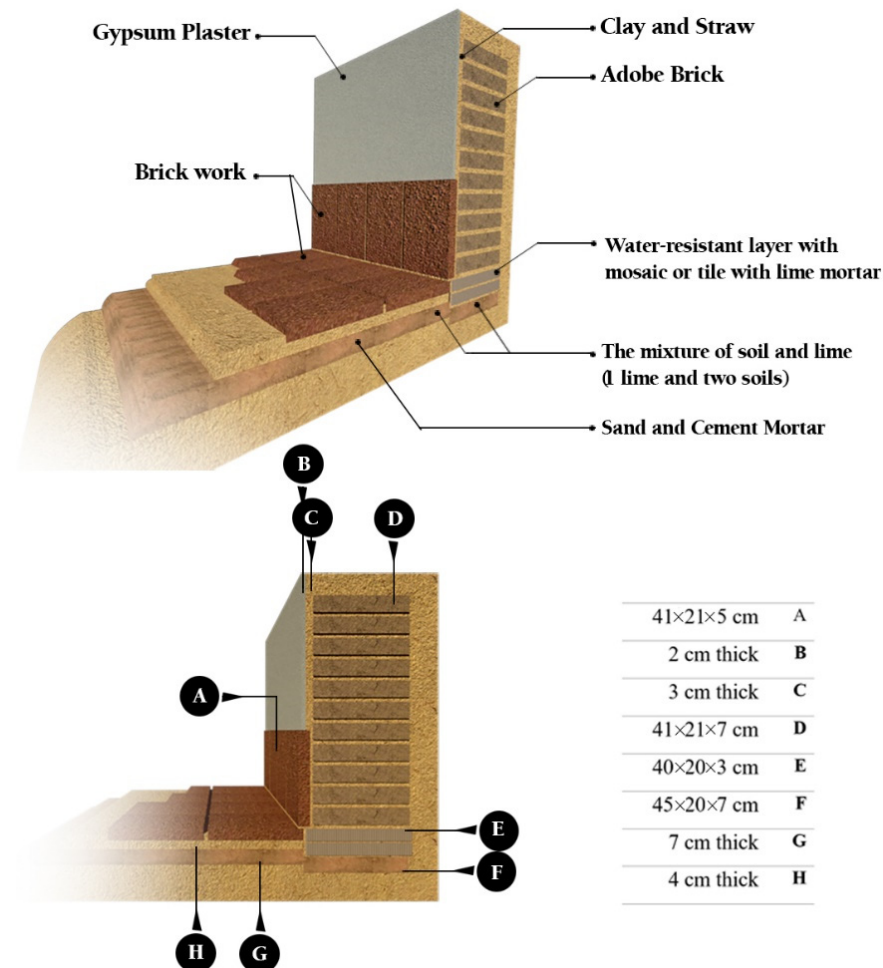


Figure 9. Example of architectural detail for conservation walls meeting the ground level.

4.3. Materials

Considering the restrictions in the preservation process such as the high rate of unemployment and the scattering of numerous castles in the region, this study aimed to consider sustainable approaches in choosing materials. Therefore, we tried to choose labor-friendly materials that can be used easily without special training. Concerning financial restrictions, the availability of materials on-site or at the local market was the main factor that was considered to decrease the transportation cost of providing materials.

On the topic of environmental issues, it should be considered that most of the materials are extracted from local resources. Using plastic mesh was inevitable because of availability in the local markets and economic issues. However, mud and straw and clay bricks were all extracted from local soil types and natural resources.

Due to its geography, the Sistan region benefits from hot and dry climate conditions, and the changing climate makes this region drier and hotter. For this reason, natural materials were used to be compatible with climate change, and the rest of the materials were specifically chosen so that they are not affected by higher temperatures and less humidification.

5. Conclusions

Every castle is a fortress building built with specific architectural features that confronts climate and environmental challenges. Sistan castles, due to particular environmental characteristics and climate conditions, have specific building types and are affected by erosion and deterioration in the physical body of buildings. Restrictions in our conservation management plan were caused by financial limitations and deterioration in many areas; this conservation plan aimed to decrease costs by using indigenous and local materials and human resources, and it concentrated on critical conservation priorities and visual features in access ways and outdoor perspectives. Restoring decorations and enclosed spaces can be beneficial in two ways: it completes the form and shape of the castle, and it conserves interior architectural decorations and ornamentations. For further study, there are plenty of castles in the Sistan region that are located in historic and ancient places such as Shahr-e-Sukhteh “Burnt City” (from 3200 to 1800 BC), are still populated, and have had multiple settlements over time; these places provide a chance to work on different historic architecture and various styles of conservation for historic buildings.

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