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Almoravid Works on Defensive Architecture in Southeast Al-Andalus: Analysis of Their Remains and Proposal for Preventive Conservation

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Abstract: In the first half of the 12th century, several military works were developed throughout the territories under Almoravid rule, above all after 1126, both in the main towns and the rural areas of the Empire. Within this context, the aim of this paper is to present the results achieved in the framework of the PREFORTI R&D Project (BIA2015-69938-R) concerning the particular case of these military constructions built in the region of Southeast Al-Andalus (Granada and Almeria, Spain). To achieve this aim, we have studied their remains during field work, as well as documentation contained in archives, written sources and historiography, focusing on the risks that affect their conservation. The analysis of six cases of study has been included, where a sample of the systematic method based on preventive conservation measures has been detailed in two particular cases: the walls of the Alcazaba Qadīma (Granada) and the walls of La Hoya and Cerro de San Cristóbal (Almeria). The proposed method has been validated by the public bodies responsible for the protection of this heritage. Its importance lies in the guarantee to slow down the deterioration of this heritage, which facilitates the implementation of effective and economic strategies for its conservation.

Keywords: military constructions; Granada; Almeria; first half of the 12th century; Almoravids; risks of conservation

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1. Introduction

In the first half of the 12th century, during the Almoravid occupation of Al-Andalus, important military works were developed throughout the territories under its rule. These works took place above all starting from the year 1126, when the Almoravid emir Alī Ibn Yūsuf introduced the so called ta'tīb tax, the purpose of which was to construct or remodel the walls of the main cities of the Empire [1] (pp. 169–172). This decision was dictated by two main causes: the incursion of Alfonso I the Battler in Al-Andalus between 1125 and 1126, which devastated a large part of the territories in its path and caused serious damage to the fortifications of the Andalusi cities [2] (pp. 110–115); and the growing concern about the progress of the Almohads in North Africa, who had settled in southern Marrakech after the conquest of Tīnmal in 1124. Due to the threat of the conquering of the Almoravid capital [3] (pp. 27–29), it became necessary to provide it with a wall [4] (p. 316) after the first attempt at Almohad conquest in 1126 [1] (p. 173). Given this situation, in which an improvement in the defensive conditions of the Almoravid territories was imperative, it was also necessary to deliver some military works in rural areas, which, so far, have been scarcely assessed.

In this context, the aim of this article is to present part of the results obtained in the framework of the R&D Project *Sustainable methodology for the Conservation and Maintenance of medieval rammed-earth fortifications in the Southeast of the Iberian Peninsula. Assessment and prevention against natural and anthropic risks* (PREFORTI Project, BIA2015-69938-R), in which 229 medieval rammed-earth fortifications preserved in the territories of Granada, Almeria and Murcia (Spain) have been studied.

The fortified heritage of the above region is an exceptionally rich legacy given its historical condition as a frontier between kingdoms and civilisations. Such heritage is also a factor in cultural, tourist and economic development within the territory in which it is located. Many of its elements still stand as landmarks in the cultural landscape. Additionally, they bear witness to forms of territorial structuring, linked to a jurisdictional reality and its capacity to establish itself in the physical environment. It is intimately linked to the territory and to the population centres. On occasions, these assets come to constitute the first structures of, or have been constructed under the protection and defence of a population, constituting various typologies [5,6].

The fact that defensive heritage in Spain in general, as well as Almoravid heritage in particular, is subject to different alteration factors that constantly increase its state of degradation, having even more intense consequences when compared to other heritage typologies, needs to be taken into account. The state of degradation suffered by cultural heritage in general means that international organisations such as the United Nations, at the Climate Summits held in 2019 and 2021 (COP25 and COP26), have raised needs and objectives related to this concern, demanding direct action to protect heritage more effectively. Among the actions to be considered, those linked to the development of sustainability, the implementation of instruments, such as the 2030 Agenda and the application of the most innovative documents on this issue are included [7]. UNESCO is constantly monitoring and analysing the effects of climate change, which are threatening the sites on its World Heritage List [8]. ICOMOS, in the same way, seeks to engage cultural heritage in climate action by intersecting objectives with the Paris Agreement, including an increasing ambition to address climate change, mitigate greenhouse gases, enhance adaptive capacity and plan for loss and damage [9].

The commitment to cultural heritage and the effects that climate change risks can have on it have led to the development of numerous studies from this perspective. Subjects addressed in these studies include the protection of heritage against catastrophes [10], vulnerability and risk assessment of cultural heritage [11] and the review of conservation strategies from a territorial perspective [12], all of which have contributed to the improvement of adaptation plans as part of an iterative process. Moreover, it has led to the implementation of maintenance systems, or the analysis of these dynamics based on the results in the field of regional sustainable development [13]. More recent works have highlighted the gaps that still exist in the lack of holistic analyses that take into account the combined action of various hazards [14].

Despite the legal and patrimonial recognition of protection established in the last decades, and the tutelary attempts at safeguarding [15,16], Almoravid defensive heritage is currently in an uneven state of conservation and is at serious risk of losing its most essential values [17]. Although the conservation obligations that legally fall on their owners are mandatory, the archaeological nature of these ensembles, the complexity when assigning a contemporary function, their situation in the territory and the fact that the property rests with individuals or local administrations with scarce economic and material resources have generated great difficulty in the implementation of effective strategies that could remedy the situation [18,19].

Such a context of heritage degradation has materialised due to the impact imposed by the geological and climatological conditions of the territory [20]. In recent years, the use of technologies based on the spatial analysis capabilities of GIS (Geographic Information Systems), as a tool for evaluation, diagnosis and control in the field of conservation [21] from the perspective of territorial planning and risks, has grown considerably. This fact has made it possible to call for the integration of hazard maps into urban planning as a preventive measure [22], or to prioritise and design specific conservation actions when analysing the probability of risks and identifying areas susceptible to damage that threaten cultural heritage [23]. Environmental, climatological, geomorphological, fire and flooding factors, together with the high degree of seismicity that is widespread in the southeast of the Iberian Peninsula, contribute to the frequency of the manifestation of risks to heritage [24–26]. The

continuous seismic activity of the Tajo de San Pedro and associated faults [27] has resulted in the structures of the Alhambra (Granada) being damaged by the effects of different historical earthquakes. Geological studies of the site, as well as seismotectonic evaluation, analysis of its seismic shaking and the control of movements through different techniques, have constituted relevant studies that have revealed the seismic behaviour of the Torre de Comares [28].

Nevertheless, we must also add as key factors in the processes of heritage alteration those provided by the characteristics of the compositional material itself, as well as human action [29]. Concerning the first group, the most numerous studies have focused on the definition and knowledge of the material and its technical-constructive characteristics [30]. The work contributed by the experimental sciences has been linked to physic-chemical, mineralogical-petrographic and even biological studies, focusing on the knowledge of the physical, chemical and mechanical characteristics of the material, together with the diagnosis of the state of its conservation [31,32]. Thus, the main processes of the alteration of geomaterials have been determined [33], even making it possible to evaluate the environmental impact on the building material of biodeterioration [34].

Linked to anthropic risks, the most recent lines of research have focused on the study of restoration actions, which in some cases have also acted as a serious risk factor. In these studies, a critical evaluation has been made of the state of conservation, the criteria applied, the restoration techniques and their results [35,36].

Bearing in mind that the contemporary model of action on cultural heritage requires its tutelage, protection, conservation, safeguarding and use as a social asset and factor of sustainable development for its transfer to the future [37], and despite the lines of research developed, more efforts are needed in the field of preventive conservation [38]. A definition of effective and sustainable methodologies is needed to make the situation of vulnerability visible, together with the detection of the risks of deterioration affecting the structures, assessing the degree of their impact on the causes of damage in order to prevent deterioration and ensure more continuous and effective conservation and heritage management [39,40].

Among the fortifications analysed in the Project, considering the importance given to this type of structure during the Almoravid domination, six military rammed-earth constructions in the areas of Granada and Almeria, whose renovation works can be ascribed to the first half of the 12th century, have been selected as samples. The selected assets are as follows: (1) the walls of the Alcazaba Qadīma (Figure 1c); (2) the walls of the Alcazaba de Guadix (Figure 1a)—both in the province of Granada—(3) the walls of La Hoya and Cerro de San Cristóbal (Figure 1d); (4) the urban wall of Almeria (Figure 1b); (5) the Castillejo Castle in Abrucena (Figure 1e) and (6) the Castle of Bacares (Figure 1f), the last four of these being in the province of Almeria. These constructions, located both in urban centers and in rural areas, have been chosen to present a joint analysis of both territories, which has not been conducted thus far; the characteristics of the constructions, their conservation status and the risks by which they are affected have been included. Having approximated the methodology followed in the development of the Project, the list of the six constructions selected in this study, with their particular historical-artistic characteristics, as well as the historical risks that have jeopardized their conservation, is included. Following this, given their importance within Andalusi military heritage in the selected nuclei, the particular cases of the walls of the Alcazaba Qadīma (Granada) and the walls of La Hoya and Cerro de San Cristóbal (Almeria) included in the next section have been chosen. In this section, as a final thought, the proposal of a systematic preventive conservation method for this type of at-risk heritage, based on the obtained results of the Project, is presented.

Figure 1. Alcazaba of Guadix, Granada (**a**); remains of the walls of the rabaḍ al-Ḥawḍ among the houses, Almeria (**b**); walls of the Alcazaba Qadīma, Granada (**c**); walls of La Hoya and Cerro de San Cristóbal, Almeria (**d**); remains of El Castillejo, Abrucena (Almeria) (**e**); remains of the Castle of Bacares, Almeria (**f**). Source: PREFORTI Project.

2. Objectives and Methodological Approach

The purpose of this study is, on the one hand, to advance the state of knowledge of the Almoravid period and its material culture, both in urban and rural contexts; on the other hand, its purpose is to propose preventive and effective measures of conservation of these Almoravid constructions. Within this context, the main objectives of this work are:

1. To approach the historical-artistic analysis of the Almoravid works in the six preselected constructions.
2. To analyse the types of risks that have affected these constructions since medieval times.
3. To specify the pathologies that affect these assets.
4. To propose a systematic preventive conservation and maintenance method based on the developed analysis for the two following cases of study: the walls of the Alcazaba Qadīma (Granada) and the walls of La Hoya and Cerro de San Cristóbal (Almeria).

In order to achieve these aims, the selection of the six constructions was based on the chronological adscription of the foundation and renovation works developed in the first half of the 12th century, in the context of the assets included in the PREFORTI Project in the provinces of Granada and Almeria. Concerning the methodological approach, the first phase was based on a multidisciplinary analysis of the historical structures. The enhancement of its heritage characteristics has been particularly emphasized. The second phase consisted of the evaluation of impairment risks and the valuation and definition of priorities. Hereafter, the stay of conservation and the use and management of these assets have been observed. Subsequently, the relation among each hazard and the specific damages produced on each asset was established. Finally, monitoring and control methods were designed, along with the planning and design of preventive and maintenance interventions (Figure 2). This method was designed in the framework of the PREFORTI Project and was applied to samples of the defensive heritage. The obtained results demonstrate

that it is feasible to intervene in a specifically sustainable manner that is compatible with the heritage and material value of the assets.

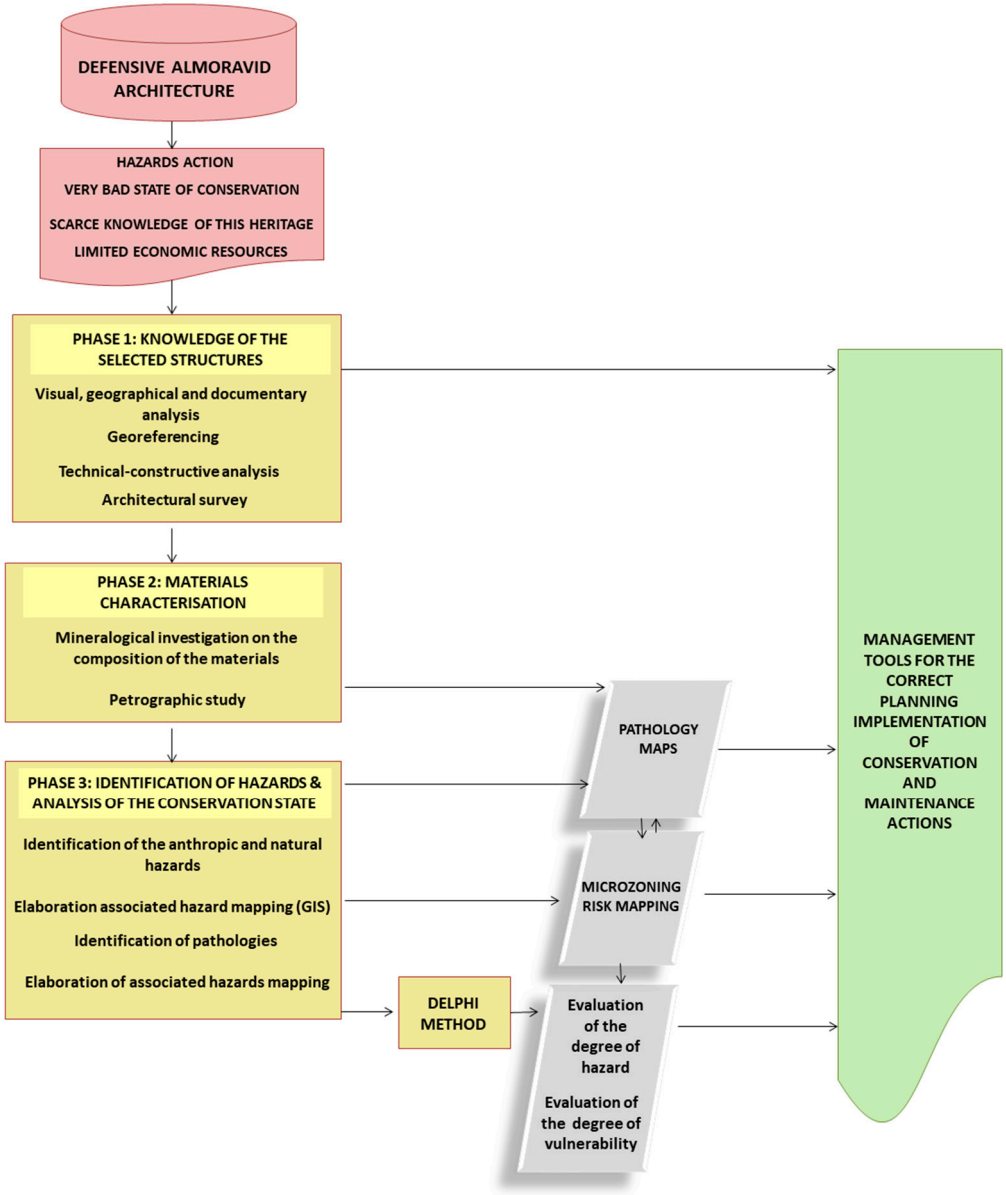

Figure 2. Flow chart showing the phases followed in the study. Source: PREFORTI project.

In the first phase, in addition to the direct observation of the preserved remains, documentation contained in the written sources of the medieval period has been consulted, which are contained in the archives of the Delegación de Cultura of the Junta de Andalucía in Almeria and of the Dirección General de Bienes Culturales y Museos of the Junta de Andalucía (Seville), as well as in the historiography. In some cases, the direct study of the cultural assets has been the one approach that has contributed the most data, since, in case of some constructions, hardly any references exist in the historiography, or no information regarding conservation or restoration interventions performed was encountered (as it is in the case of El Castillejo Castle in Abrucena, Almeria).

On the other hand, to develop the analysis of the risks that have affected the conservation of these constructions since medieval times, the references encountered in the archival materials and in the historiography have been fundamental in order to specify the historical risks, while the analysis of the current pathologies has been performed by means of direct observation of the conserved remains, making a classification based on the risks

systematized in the *National Emergency Plan and Risk Management of Cultural Heritage* [29] and the *National Plan of Defensive Architecture* [6]. In this context, linking the cultural assets to the territory has favored the determination of the main risks that affect them, as well as the incidence of each of them according to their geoposition, for which each of the cultural assets under study has been georeferenced [41,42].

Thanks to the different tools of analysis of the georeferenced assets of Geographic Information Systems (GIS), several risk maps have been elaborated for the two cases of study [43] (p. 4). As an example of these maps, we have selected a sample related to both the anthropic and the natural risks. Among the anthropic risks that may affect the territory around the walls of the Alcazaba Qadīma (Granada) and around the walls of La Hoya and Cerro de San Cristóbal (Almeria), cartographical material including the analysis of population density has been selected (Figure 3). Concerning natural risks, risk maps with the evaluation of fluvial (Granada) and maritime (Almeria) flood risk are included in Figure 4.

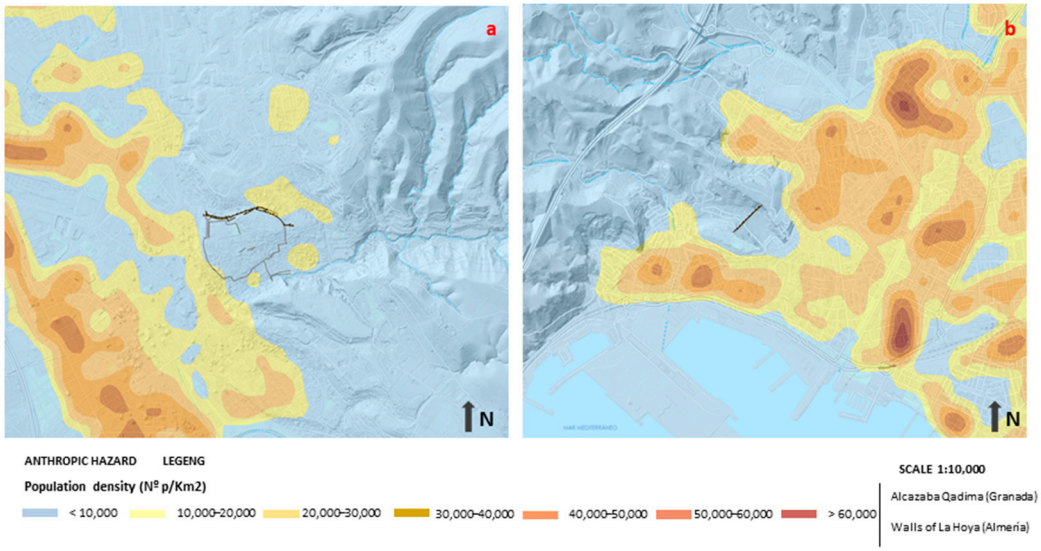

Figure 3. Risk maps of the anthropic risk caused by population density. (**a**) Walls of the Alcazaba Qadīma, Granada and (**b**) walls of La Hoya and Cerro de San Cristóbal, Almeria. Source: PREFORTI Project. E. Molero Melgarejo.

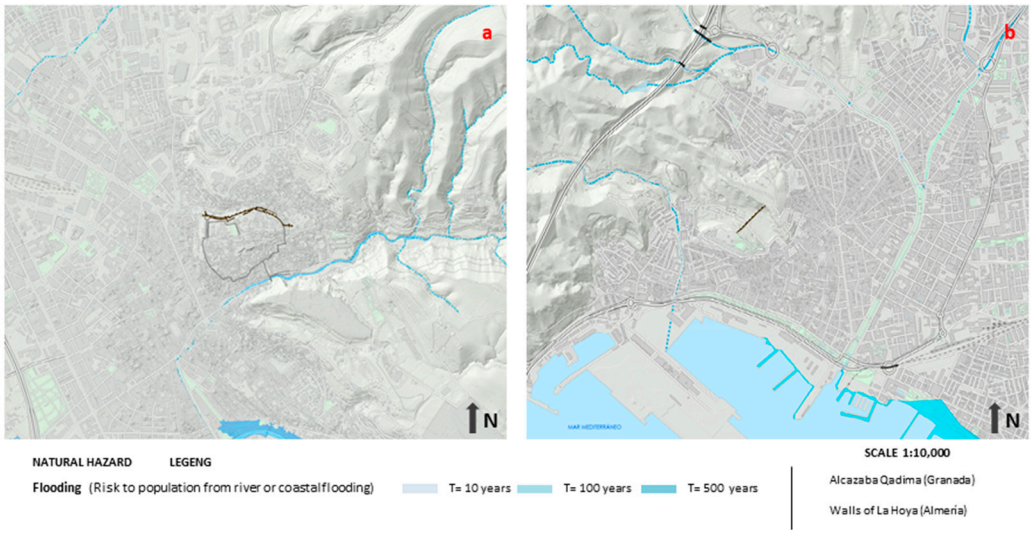

Figure 4. Risk maps of fluvial and maritime flood risks. (**a**) Walls of the Alcazaba Qadīma, Granada and (**b**) walls of La Hoya and Cerro de San Cristóbal, Almeria. Source: PREFORTI Project. E. Molero Melgarejo.

Beyond the elaboration of risk maps, GIS have been used in this work to analyse historical and strategic phenomena related to the two cases of study. In this way, maps including the analysis of visual basins from the walls of the Alcazaba Qadīma (Granada, Figure 5) and from the walls of La Hoya and Cerro de San Cristóbal (Almeria, Figure 6) have been also elaborated. In these maps, the visual basins are produced on a 2-m resolution DTM model generated from a Lidar point cloud (IGN 1º coverage). The maximum distance with high sharpness (500 m) is also included. In this way, the cartographical material uses a color scale to show a range of risks, from non-visible points to points of maximum exposure, taking the selected assets as the point of reference.

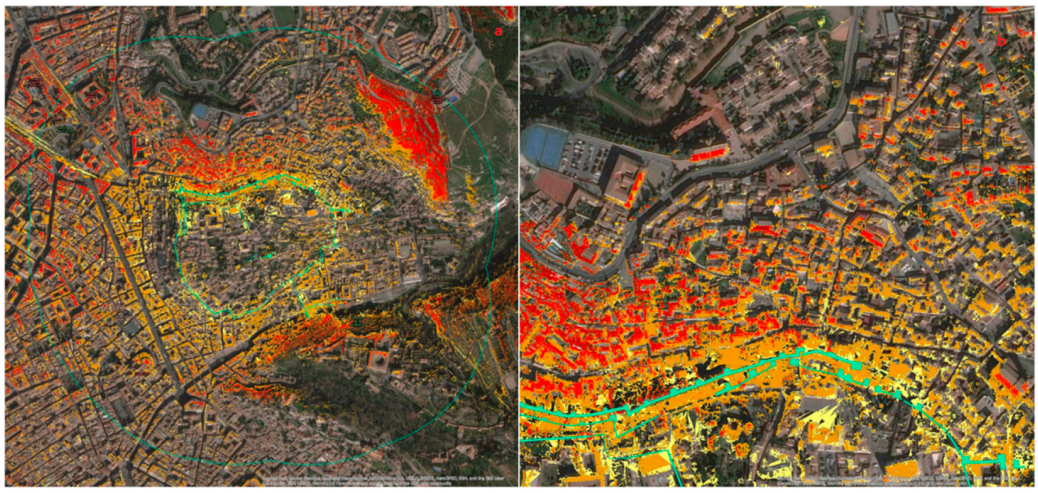

Figure 5. Maps of the visual basin from the walls of the Alcazaba Qadīma, Granada. (**a**) General map of the visual basin from the walls of the Alcazaba Qadīma, Granada; (**b**) Detail of the visual basin from the walls of the Alcazaba Qadīma, Granada. Source: PREFORTI Project. E. Molero Melgarejo. The light blue outline indicates the maximum distance with high sharpness (500 m). The color intervals indicate as follows: no color = not visible; yellow = low exposure (1 visible dot only); orange = medium exposure (up to 10 visible dots); red = high exposure (up to 30 dots visible); dark red = extreme exposure (more than 30 dots visible).

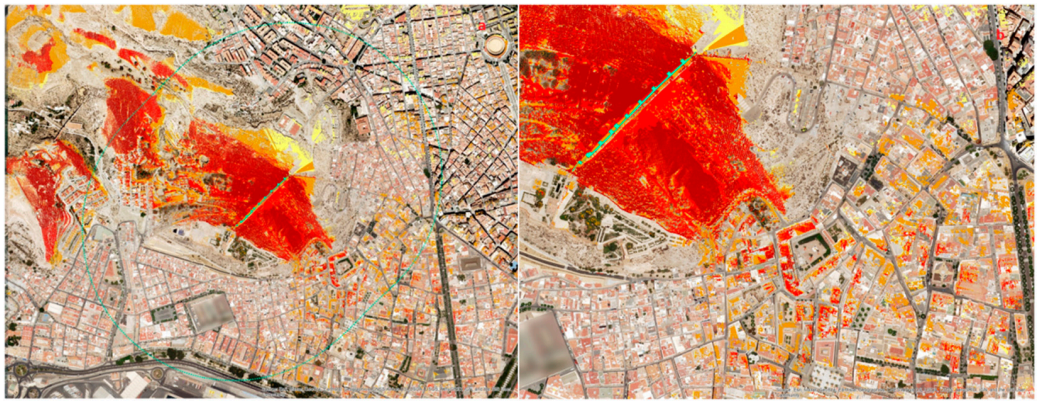

Figure 6. Maps of the visual basin from the walls of La Hoya and Cerro de San Cristóbal, Almeria. (**a**) General map of the visual basin from the walls of La Hoya and Cerro de San Cristóbal, Almeria; (**b**) Detail of the visual basin from the walls of La Hoya and Cerro de San Cristóbal, Almeria. Source: PREFORTI Project. E. Molero Melgarejo. The light blue outline indicates the maximum distance with high sharpness (500 m). The color intervals indicate as follows: no color = not visible; yellow = low exposure (1 visible dot only); orange = medium exposure (up to 10 visible dots); red = high exposure (up to 30 dots visible); dark red = extreme exposure (more than 30 dots visible).

In addition to the previous methodological processes, the Delphi method has been applied in this study in order to evaluate the impact of each risk on the selected cultural

assets, and to assess the vulnerability of those assets based on the effects that such risks produce on their structures [44–46]. For this purpose, a questionnaire that has allowed multidimensional evaluation has been generated. It has been distributed and completed by a multidisciplinary group of 15 experts from different disciplines relating to risks and conservation status of cultural heritage. The disciplines chosen have included Archaeology, History of Art, Architecture, Technical Architecture, Engineering, Geology, Chemistry, Restoration and Cultural Management. In this questionnaire, the variables of the probability of the risk occurring, the consequences it would generate and the possible measures that could be taken to minimize the effects of those consequences have been taken into account. For the assessment of hazard and vulnerability levels, each of the assessable items in the questionnaire has been assigned a numerical value between 0 and 5, where 0 means the absence of hazard and 5 means the highest level of hazard. (For a more detailed explanation of the Delphi method, see [44] (p. 6) and [47] (pp. 8–10)).

Concerning the methodological aspects of the analysis of materials and their pathologies, leaving aside the direct observation of the cultural assets, in the specific cases of the Alcazaba Qadīma in Granada and the Castillejo Castle in Abrucena, technical-scientific reports have been elaborated [48] (pp. 4–5), [49] (pp. 3–4), [50] (pp. 28–31) and a detailed study of the crust samples has been carried out. In the analysis, the X-Ray Diffraction (XRD) has determined the mineral composition of the material. It has been done with a BRUKER powder diffractometer D8 ADVANCE equipped with an automatic slit, using the crystalline sample interpretation software Xpowder for the interpretation of the data. Moreover, a petrographic study has been developed using microphotographs taken under a Zeiss Polarized Light Optical Microscopy (OM) with parallel nicols and with crossed nicols. In the case of the pathologies, they have been observed using a lens-videomicroscope.

3. Reforms in the Military Constructions in Granada and Almeria (First Half of the 12th Century)

3.1. Granada: Almoravid Capital of Al-Andalus

With the arrival of the Almoravids in the Iberian Peninsula in 1090, the first settlement that fell under their power was the city of Granada, which became the peninsular capital during this period [51] (p. 45). Given its important status, numerous works were performed in the city and its territory in the Almoravid period, as narrated in the written sources [1] (pp. 168–172); [52] (p. 42); [2] (p. 147), although almost none of these have been preserved. Among these constructions, those of a military nature stand out. This type of architecture reached a height of development during the Almoravid period, representing an important precedent for the great reforms of the poliorcetics implemented by the Almohads [4]; indeed, its development is linked to the very essence of that movement, which since its birth was based on territorial expansion and religious orthodoxy, the latter understood as Holy War [53] (p. 58). Among the reforms implemented during the first half of the 12th century in the works performed in rammed earth in Granada, as included in the catalogue prepared in the framework of the PREFORTI Project, the walls of the Alcazaba Qadīma and the city walls of Guadix stand out.

3.1.1. Walls of the Alcazaba Qadīma

Historical Approach

Thanks to the mentions collected in *al-Bayān al-Mughrib* by Ibn ʻIdhārī, we have references regarding the renovation works conducted on the walls of Granada. From 1126, the implementation of the mentioned ta'tīb tax subsidized these works, which were completed by the governor Inalū [1] (pp. 169–170). Thanks to this source, it is known for certain that the section between Bāb Ilbīra and Bāb al-Rambla was renovated at that time [1] (p. 171). In this context, it could be assumed that the section of the Alcazaba Qadīma responsible for protecting the palatine area of the city was also renovated at that time. (This area, in which the Banū Zīrī had established their original palaces and the Almoravids had the political center of their peninsular capital, was transformed during the first half of the

12th century, as recorded in al-Ḥulal al-Mawshiyya [2] (p. 147). This has been documented in the archaeological excavations at the Plaza de Santa Isabel la Real [54] (p. 199)).

Architectural Form

The best-preserved part of the walls of the Alcazaba Qadīma is the 390 m long section located to the north, on the Cuesta de la Alhacaba (Figure 1c). This section connected the Gate of Monaita (located in the northwest) and the Gate of Las Pesas (located in the northeast) (Figure 7). The section between these two gates can be divided into two clearly differentiated parts: to the west, a section with solid square towers on the inner side, smaller and standing much closer to each other than the towers of the other section; to the east, and behind the alteration in the wall line, a part with large semicircular towers next to other towers of quadrangular plan, which are larger than those located more to the west.

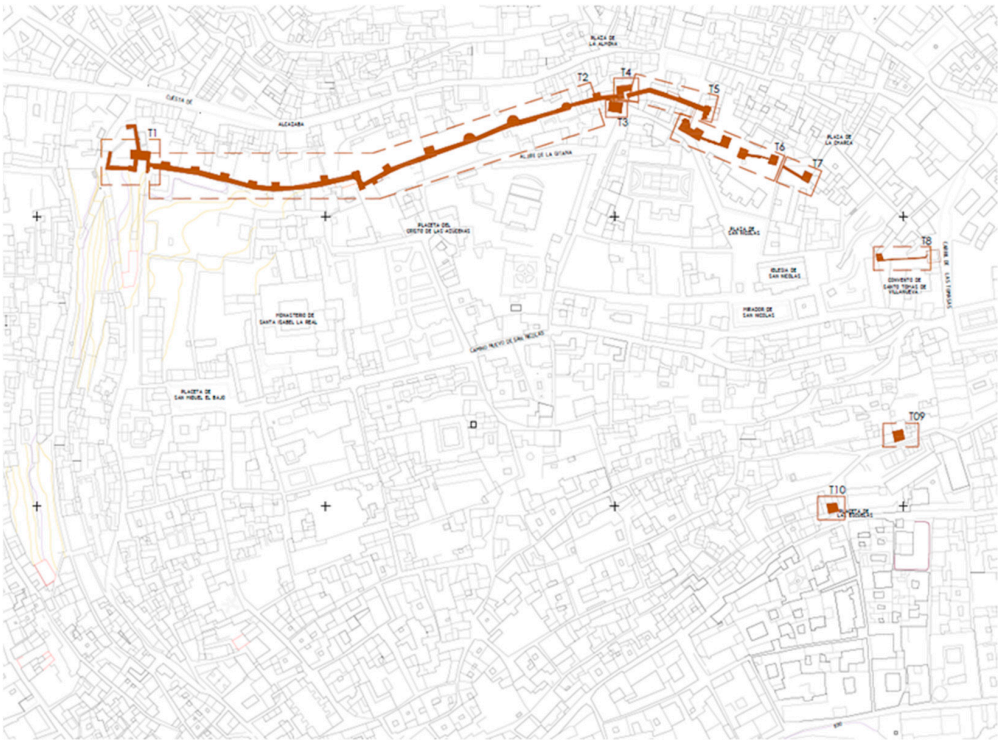

Figure 7. General map of the walls of the Alcazaba Qadīma, Granada. Source: Isabel Bestué Cardiel [55].

Building Structure and Materials

Although its chronology has been much discussed in historiographical debates, it was documented that during the archaeological interventions in the "Carmen de la Muralla" some of the Zīrī towers were heightened in the 12th century, as with the specific case of the tower that connected the internal enclosure wall documented in this site with another external stretch to which the preserved section belongs, where the large circular towers are located [56] (p. 1510). The issue of the chronology of this wall is related to the successive occupation of this area of the city at different points in time. The oldest remains of the wall located in this site correspond to the Iberian fence from the 6th century BC, as some of the Roman works had been documented in the 2nd century BC. Generally, the layout of this wall coincides with the posterior medieval layout (although it was extended on its south side), always conditioned by the topography of the hill on which it is located.

Given the presence of two wall lines in the northern part of the Alcazaba Qadīma and the aforementioned increase of the tower connecting the two lines, with its proposed chronology in the 12th century, some authors have suggested that the external wall line corresponds to the Almoravid renovation works performed on the city fence starting in 1126 [57] (pp. 46–47), [51] (p. 199), maintaining the traditional hypothesis of Zīrī authorship

of the original Islamic wall, located on the internal line, of which a tower behind the Gate of las Pesas is also preserved. From that first period, the constructions of the Gate of Hernán Román and the Gate of Elvira were dated, both characterized by the use of stonework and stretcher and header bonds, the presence of carvings of Cordoban influence and an initial disposition in straight sections, using rammed earth with pebble aggregates joined together with mortar for the wall stretches and towers.

To the west of the inner tower, next to the Gate of las Pesas, a new section of the fence was documented following excavations of the "Carmen de la Muralla" in the 1980s, with three towers reinforced with brick and ashlar in the corners, built, as with the sections that joined them, of rammed earth made with limestone mortar. The same technique was found in the remains of the tower of the former Bāb al-Asad (Gate of the Lion), in the Carril de la Lona, in the Placeta de los Chinos nº 5 and in the "Carmen de las Maravillas", all of them from the Zīrī era.

As for the external wall, it continued approximately 70 m eastwards of the Gate of las Pesas, ending at the height of the hermitage of San Cecilio, from which it was separated 11 m to the north. In the hermitage of San Cecilio, another medieval gate in the fence was located, identified with the Castro Gate, which would probably belong to the internal wall line. From this place, the wall continued for approximately 80 m to the west; although part of its stretches and four towers were preserved, from this point traces of the double wall were lost, as only the remains of the oldest internal line were preserved. As for the material of this external wall line, in the preserved part of the Cuesta de la Alhacaba, it was built in rammed earth combined with other materials [57] (p. 54). This rammed earth is more resistant than that of the internal wall, as its composition is different [56] (p. 1509), being a lime-stabilized rammed earth; inside, there is less lime than in the case of the rammed-earth material of the internal wall line. Its external coating, however, is rich in lime, being a mortar of great resistance and impermeability [58].

Apart from the differences in construction materials used in the case of the two lines, other elements that have traditionally been used to propose Almoravid authorship of the external wall line include the use of semicircular towers (documented in military constructions conducted by the Berbers in North Africa) [4] (p. 321) and the presence of bend entrances, which became widespread at that point in military architecture, for example in the Gate of Monaita and the Gate of las Pesas [51] (pp. 202–205). However, despite the elements mentioned, no more details can be specified regarding the chronology of the wall of the Cuesta de la Alhacaba with the data currently available; in order to do so it will be necessary to await further analyses that may provide new data.

Anthropic Risks

In relation to the risks that have affected the conservation of these walls, the main risk is urban pressure, especially in recent times. As it can be seen in the risk map of the population density (Figure 1a), an area near to the wall in the northeast has a high population density (10,000–20,000 people/km^2), which is closely related to urban pressure and constitutes a risk to the asset. Along with this, the abandonment of some of the lands crossed by the wall has caused damages due to human activity (especially vandalism and graffiti) and natural causes.

Natural Risks

As for the natural damages that have affected the wall, erosion caused by thermal oscillations, which are very pronounced in Granada, has produced damages at some points of the wall. The micro-morphological study has shown micro-cracking in areas of the aggregate, especially in the area closest to the surface (Figure 8). This indicates the action of possible thermoclastic phenomena (i.e., physical fragmentation associated with intense temperature changes).

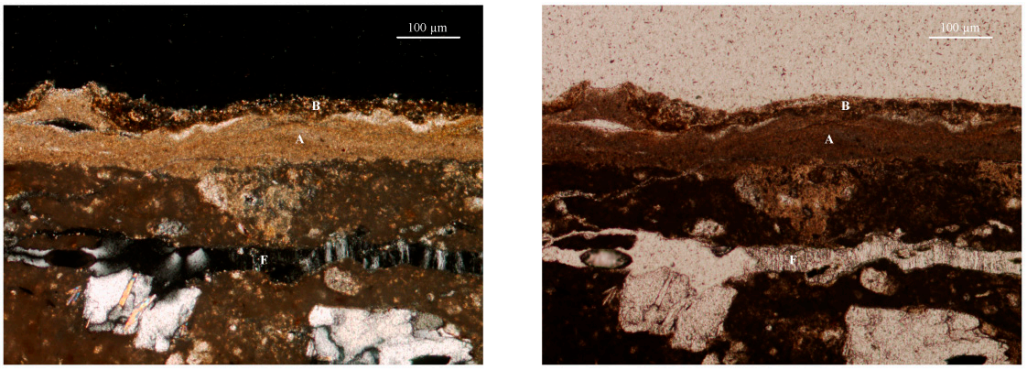

Figure 8. Detail of patina on the crust of the walls of the Alcazaba Qadīma (**left**: crossed nicols; **right**: parallel nicols). The patina of alteration on the lime mortar is made up of several layers: (A) patina of alteration composed of calcium carbonate and iron oxides; (B) layer of surface dirt. There are phenomena of cracking parallel to the surface (F) due to physical weathering processes associated with expansion-contraction phenomena possibly related to sudden changes in temperature [48] (p. 17).

The loss of materials has also been caused by landslides caused by the steep slope of the hill, as well as by landslides caused by urban pressure, the latter of which has also meant the presence of buildings attached to the fence, as well as some located on the fence at some of their points. At the same time, damage caused by water has been detected, relating specifically to dampness due to leaks and to capillarity, as well as to rainwater (Figure 9).

Figure 9. Elevation of pathologies of the Gate of Hernán Román. Source: PREFORTI Project. I. Bestué Cardiel.

In this context, the petrographic study has shown indications of partial recrystallizations of calcium carbonate associated with the circulation of water within the material, as well as other processes associated with the circulation of water inside the material and processes of precipitation inside pores and fissures [49] (p. 9) (Figure 10). At several points, the presence of vegetation that has affected part of the walls and has caused an increase in dirt has been documented. Finally, earthquakes have also affected its structural stability.

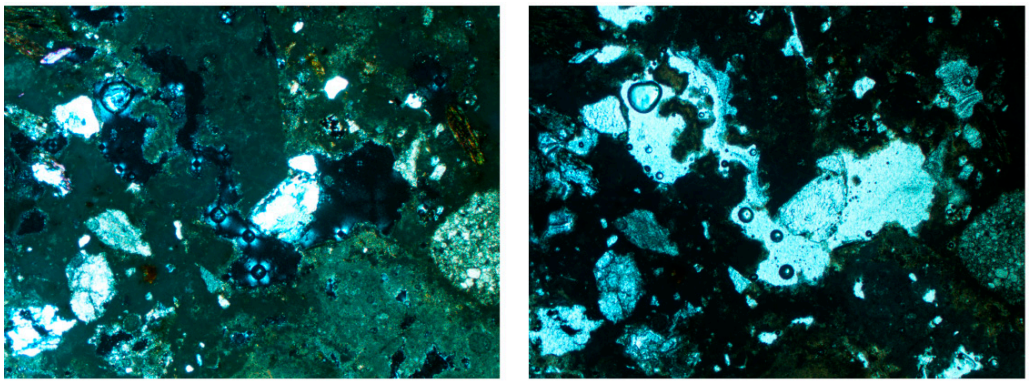

Figure 10. Indications of damages caused by water in the rammed earth of the walls of the Alcazaba Qadīma (area of the Gate of Hernán Román). 25× magnification. **Left**: crossed nicols; **right**: parallel nicols [49] (p. 9).

Conservation Status

The various sections of the walls of the Alcazaba Qadīma are in varying states of conservation. While some of them retain all their original strength and structure in almost perfect condition, other sections are preserved in a state of archaeological remains or have completely disappeared. All the sections that are preserved in height have been subject to intervention and restoration, in some cases modifying their original appearance and physiognomy. In general, we can say that the conserved sections are in a medium state of conservation, with some areas completely covered by restoration work.

The stable state of the structures preserved in height is predominant, with minimal structural damage visible and detectable. One exception should be made regarding the Hernán Román gate, which is currently undergoing restoration and has serious vertical cracks that make the whole unstable.

The entire wall is affected by urban pressure, which is at its maximum in many places. Additionally, the abandonment of some plots of land that include parts of the wall means that the general state of deterioration is at its maximum and the danger of damage from anthropic and natural aggressions is far greater.

3.1.2. Walls of the Alcazaba of Guadix

Historical Approach

The first mention of the Alcazaba of Guadix (Figure 1a) in written sources is found in the *Memoirs* of ʻAbd Allāh, last Zīrī king of Granada (late 11th century) [59] (p. 157). However, the oldest archaeological remains from medieval times documented during the first archaeological works date from the 10th century [60], being from the Zīrī era when the original caliphal construction became a citadel [61].

Architectural Form

The 11th-century construction would have been formed of a single enclosure. In the southeast there was a direct entrance (similar to the Zīrī entrances already mentioned, such as the Gate of Hernán Román and the Gate of Elvira in the Alcazaba Qadīma, Granada) between two small towers via a horseshoe arch. The main entrance was in a ramp between two bastions to the north, connecting the fortress with the madīna. Both were modified at the end of the Almohad or the beginning of the Nasrid period [61,62] (pp. 52–57).

After the first Zīrī phase, it seems that during the 12th century a second wall was built as a barbican, which surrounds the upper enclosure in the south. It has a central tower, along with another located on the west side. At that time the four towers of the previous wall were also renovated (Figure 11a,b). These transformations could be identified with those implemented at the end of the Almoravid period and during the second Taifas, mentioned in written sources [63]. In the middle of the next century, a tower was added to the east of the barbican, and the homage tower was built next to another, smaller tower,

which formed a new enclosure. It was in the Nasrid period when the Guadix fortress reached its utmost importance, being a royal property, in which members of the Nasrid court, such as Muḥammad V or Naṣr, took refuge [64] (p. 188).

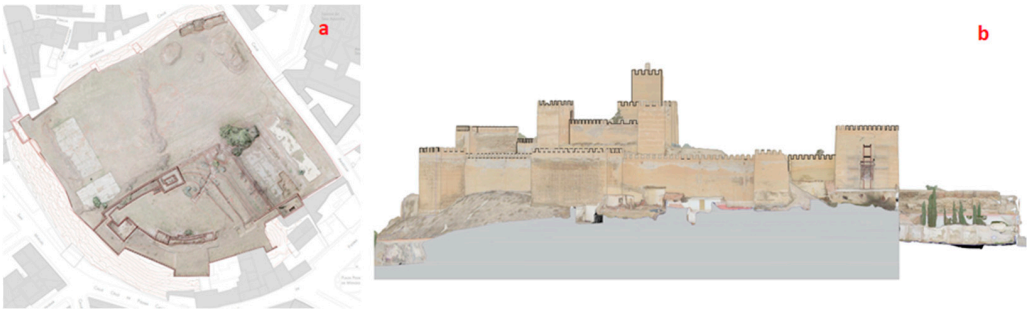

Figure 11. Alcazaba of Guadix. (**a**) Map and ortophoto of the Alcazaba of Guadix (Granada); (**b**) Ortophoto of the elevation of the Tower-gate. Source: PREFORTI Project. J. A. Benavides.

Building Structure and Materials

In relation to the material used in the building of the enclosure, lime-stabilized rammed earth and rammed earth made with stone and lime mortar cement were mostly used, alongside other materials used in various repairs. In relation to the first of the materials mentioned, as in case of the rammed earth used in the building of the wall of the Alhacaba in Granada, it is poor in lime inside, although its coating is rich in lime, which guaranteed great resistance and impermeability [63]. In both cases, the thickness of this mortar ranges between 0.15 and 0.25 m, so that, given their similarity, one could apply the same chronology to the areas in which it was used.

Historical Risks

The Alcazaba of Guadix has been largely conditioned by the subsequent constructions carried out on the site, which is why the anthropic risks have been the most important. During the War of Independence, it was occupied by French troops, and a large part of the wall of the lower enclosure was thickened and repaired using poor quality materials. The reason behind doing so was to try to fill the gap between the stretches of the wall and the towers, distorting the original layout of the wall. Given its poor technical quality, numerous subsequent repairs were needed, which also lacked quality and distorted the image of the wall [63]. At that time, the interior was levelled with the debris from the landslides of the construction, and the two entrances were blinded, while a new one was opened southeast of the fortress [65] (pp. 289–293). After the Napoleonic occupation, this esplanade was used as a cemetery, distorting its appearance and function [66] (pp. 223–233). The subsequent fillings of the interior enclosure have caused rainwater-evacuation problems, which is why fiber cement pipes were placed in order to facilitate its evacuation.

Anthropic Risks

Subsequently, the bombings suffered during the Civil War affected the Alcazaba, which was repaired by the Dirección General de Regiones Devastadas using contemporary materials (Portland cement concrete and mixed concrete made of soil and cement), lifting all the walls of the upper enclosure. The walls of this enclosure are covered with graffiti [63]. After the restoration, the Alcazaba became the property of the Guadix Minor Seminary; at that time, a classroom, sports field and changing rooms were built in its place, alongside a garden area, which allowed passing to the interior enclosure, with a new entrance in the north side of the outer wall [65] (pp. 294–295). As far as this north stretch is concerned, it is covered outside by large slopes of earth, supposed to contain landslides, which, at times, leave only 1 m of the wall elevation visible. On the other hand, in the northwest corner, part of the wall has collapsed, causing a landslide, while in the southeast end of the wall part of its corner was lost, being repaired with no continuity with the rest of the fence. With

regard to the enclosure of the barbican built in the 12th century, this shows the following different degrees of deterioration: The southeast gate-tower is propped up and carved with a metal structure supporting the falling upper part of the tower, posing the threat of collapse. In addition to the structural danger it presents, the tower is partially clogged by a 19th-century dwelling, which blocks access to the Alcazaba. The urban pressure has caused the south part of the wall to be covered with several attached houses. On the other hand, the area to the southwest of the barbican has been completely rebuilt with crenelated ornaments with merlons of rammed earth and mortar, on which the antennas of the terraced houses, cables and other elements that distort the vision of the barbican are located. Besides these, large parts of the walls are covered with mortars, which contribute to the progressive deterioration of the original walls of rammed earth with lime.

Natural Risks

The landslides of the wall have caused damage in the area located west of the door-tower, since they have exposed the successive fillings of the land, and threaten landslides inside the Alcazaba and the plots located on a lower level. Likewise, the towers that border this space have lost their coating mortars due to environmental factors, exposing the mass of rammed earth with lime with which they are built, causing a progressive degradation, the mitigation of which was attempted using patches of brick in places where the loss of material was more significant. In some of the towers, numerous vertical cracks have appeared. Alongside this situation, the natural risks caused by the presence of vegetation in areas of the towers and walls are contributing to the degradation of the complex [63,67].

Conservation Status

Despite the significant deterioration of the materials in most parts of the Alcazaba of Guadix, it is expected that many of the pathologies detected will be remedied, given the imminent beginning of the work phase of the restoration project of the lower enclosure. Concerning the rest of the citadel, the staircase leading up to the Homage Tower is partially collapsed, with widespread detachment of the walls. The upper enclosure of the citadel shows the crenellated profile of the reconstructed merlons made of rammed earth and brick. The terraces are covered with vegetation. The perimeter towers are rendered with bastard mortar. The wall surfaces are partially eroded and graffiti is present on them.

3.2. Almeria and Its Port in the First Half of the 12th Century

After the conquest of Granada by the Almoravids in 1090, the rest of the territories ruled by the Taifas gradually fell under their power. In this way, Almeria and its region became part of the Almoravid Empire in 1091, the city exhibiting great splendor, which is echoed in written sources [68] (p. 36), [69] (p. 184 Arabic). This resulted in an increase in the importance of its port, the shipyards being built at that time [70] (pp. 23–25), with the port becoming the headquarters of the Almoravid fleet [71] (p. 646).

Given this great development, continuing of the importance acquired during the Taifa period, several renovation works were performed on the original city walls that had been erected in the times of Khayrān and Zuhayr. Among these, those of the surroundings of the Alcazaba and the Cerro de San Cristóbal stand out, which is why we will dedicate a special mention to the walls of La Hoya. The works performed in the Alcazaba during the Almoravid period were reduced to small repairs of the Taifa construction and to the construction of a complex of cisterns, consisting of three naves, with fountain attached, located in the first enclosure [51] (pp. 354–357). Despite this complex being part of the catalogue elaborated in the framework of the PREFORTI Project, its analysis will not be included, as it does not belong to the chronological time frame established in this work. Subsequently, we will analyse the reforms introduced in the remaining part of the city walls during the first half of the 12th century, due especially to the great development that the surroundings of al-Muṣallà and al-Ḥawḍ experienced during the first half of the 12th century [51] (p. 343). Finally, two fortresses located in rural areas, whose origin seems to

date back to the first half of the 12th century—El Castillejo of Abrucena and the Castle of Bacares—are included.

3.2.1. Walls of La Hoya and Cerro de San Cristóbal

Historical Approach

During the time of Khayrān, the first Taifa king of Almeria (1012–1028), the major part of the city wall was constructed, while the works were finished in the time of his successor, Zuhayr. Among the earliest works were the walls of Jabal Laḥam (currently Cerro de San Cristóbal) and La Hoya, whose function was to overcome the height differences between the Alcazaba and the hill, dividing the space into two differentiated areas [72]. In this way, the city wall was attached to the Alcazaba, together forming one of the best-defended complexes preserved in Al-Andalus (Figure 1d).

Architectural Form

The fence erected on the Cerro de San Cristóbal has several attached quadrangular-based towers, corresponding to the original Islamic works. Along with these are also four other semicircular towers built in ashlar, attached to the original construction made of rammed earth, breaking it partially. The stretch, which is approximately 3.5 m wide, is founded directly on the rock, with no wall footings on any of its points. The semicircular towers were built in 1147, after the conquest of Almeria by the troops of Alfonso VII of León [73] (p. 54). Later, as of 1157, with the Almohad recovery of the city, other defensive enclosures were constructed and attached to the original wall.

Building Structure, Materials and Topography

As for the wall located in La Hoya valley, it is made of lime-stabilized rammed-earth walls, 2.7 m wide and approximately 5 m high. As in the case of the stretch of the Cerro de San Cristóbal, some points of this fence are directly supported on the rock, while in the central part and in the stretch that ascends towards the Cerro de San Cristóbal it has wall footings of 1.5 m. The rock is 2 and 3 m deep in its central part, and covered with landfills due to its location on a dry creek [74] (p. 19). The walls on both sides were covered with a lime mortar, almost lost throughout its entire surface. On its west side, it has ten massive quadrangular towers, also built in rammed earth. The towers located in the lower part are larger (their dimensions are 5.6/5.8 × 4.55 m), while the towers located at the ends have smaller dimensions (4.7 × 4.7/5 m) [72]. Their average height is 12.75 m, and several of them have crenelated ornaments.

Historical Risks

With regard to the risks that have affected the walls of La Hoya and Cerro de San Cristóbal throughout their history, one of the most significant has been earthquakes, with the structural stability of the walls being damaged during the earthquakes of 1487, 1522 and 1529.

Anthropic Risks

As for anthropic risks, we can mention the construction of buildings attached to the walls of Cerro de San Cristóbal in the north and east, which has caused damage with the introduction of joists and fastening straps to the rammed earth. Also on this stretch, at some points on the part that descends towards the city, there are numerous pieces of graffiti and other distorting elements, alongside large amounts of garbage and debris. On the other hand, the H-1 tower (located next to the Alcazaba) is completely demolished, while the original configuration of the H-2 tower was distorted by the presence of a transformation center in its surroundings [75] (p. 11). On the other hand, although the recent restoration works of this wall have largely limited its pathologies, they have also caused the presence of rust stains in some points of the stretches, due to the use of corten steel in several towers, which is present, above all, on the walls near towers H-8 and H-10. A map showing the planimetric and graphic localization of pathologies in the walls of La Hoya can be

consulted in the project of restoration of this wall, with file number B043185 HP04BC in the Delegación de Cultura in Almeria [75].

Natural Risks

Alongside the aforementioned earthquakes, other natural elements that have affected the wall have been wind and, above all, water, which has caused signs of dampness in several of the walls, as well as cracks, fissures and buckles caused by the steam of filtered water in the walls, which have caused a progressive detachment of the materials. Most of these are caused by thermal variables, since the increase in temperature and the absence of structural joints have led to the opening and fracturing of the walls, sometimes even causing their granular disintegration. Also due to natural causes, the rammed earth used in the place of its union with the wall of the Alcazaba and with that of the Cerro de San Cristóbal is significantly deteriorated and disintegrated as a consequence of its own construction (especially as a large part of the lime plaster which protected the interior of the walls has been lost), due to the tensions produced at these points and to the water leaks caused by the lack of protection of the high parts of the wall, as well as due to existent ventilation problems in the interior. In addition, the presence of small plants, mosses and fungi is observed in the upper part of the walls and in the parapet walks, which, alongside the detritus caused by the action of birds, has deteriorated the wall's construction.

Conservation Status

The walls of La Hoya are in a good state of conservation as a result of the recent restoration that has been carried out on this structure. However, the main lesions are the stains caused by the rust of the Corten steel used in some of the towers.

The north and south elevations of the Cerro de San Cristóbal section also show lesions, such as the disintegration of its components, causing buckling, exfoliation, surface erosion and cracks in the lime coating, even to the point of detachment. There is dirt adhering to the walls, causing chromatic alterations. At the base of the south elevation, there is efflorescence. There is a loss of cohesion of the material, erosion and progressive detachment at the crowns.

Graffiti and distorting elements can be seen all over the wall of the Cerro de San Cristóbal, as well as rubbish and debris around it. In the northern and eastern areas, the effects of urban pressure are visible, with the presence of attached buildings.

3.2.2. Urban Wall of Almeria

Historical Approach

The city of Almeria was provided with a wall since its foundation by 'Abd al-Raḥmān III (955–956). This wall, of irregular quadrangular shape, encompassed the core of the original madīna, with access granted by various gates. The original fence, built in ashlar stone, was expanded during the Taifa period, during the rule of Khayrān, with the flourishing of al-Ḥawḍ surroundings (current district of La Chanca) and al-Muṣallà, in which four new gates were founded [76] (p. 82). Regarding the last district mentioned, on its eastern side, the walls were constructed outside the Caliphal madīna, with a fortified irregular quadrilateral plant, in the place occupied by the ancient cemetery known as Maqbarat Sha'ria Qadīma [51] (p. 346). With regard to al-Ḥawḍ, referred to as the "great suburb" by al-Idrīsī [68] (pp. 36–37), it was located in the western part of the city. Its walls, built during the Taifa period, according to archaeological evidence, were renovated during the Almoravid period, in the framework of the works developed by Ibn al-Fahmī thanks to the ta'tīb tax [1] (p. 170). Those walls were connected with the enclosure of the Alcazaba through their western flank.

Architectural Form

Although in most parts of the city the walls were destroyed in the nineteenth century due to the urban growth of Almeria, in some places remains of this defensive system can

be still seen [73] (p. 51). Thanks to archaeological activity and textual references, new sections and some of its old gates have been documented. The main entrance to the city was Bāb Bayyāna (Gate of Pechina, called Gate of Purchena after the Christian conquest of the city) [73] (p. 53). Close by in the vicinity, thanks to the archaeological works on what is now Antonio Vico Street, remains of the wall built by Khayrān in the 11th century, as well as evidence of the subsequent renovation works delivered during the Almoravid period were found. Two lines of the original fence were documented: the first line was attributed to the works of Khayrān; the second one has been assigned to the first half of the 12th century. This stretch of wall belonged to the fence in charge of protecting the so-called al-Muṣallà suburb [77] (p. 29). The continuation of the wall that ran through Antonio Vico Street was documented in other archaeological works carried out on what is now Rambla Obispo Orberá Street. On the corner of Navarro Rodrigo Street, a stretch of the Taifa wall which is 2.8 m wide and approximately 0.6 m long appeared [78] (p. 13). Other remnants of the Taifa wall in al-Muṣallà suburb have been documented on Méndez Núñez Street and Rueda López Street [78] (pp. 13–14).

From Rambla Obispo Orberá Street, the wall went down until Nicolás Salmerón Park. This wall, located by the sea, was connected to the original Caliphal fence of the madīna. As for the primitive Caliphal wall of ashlar and masonry [79] (p. 22), a part of its remains was located at the crossing with Reina Street [80]. Additionally, a section was located during the works in the Inés Relaño School [81]. Alongside what appeared to be one of the old city gates, a rammed-earth wall appeared, which could be attributed to the renovation works carried out on the fence after the ta'tīb tax was introduced, though it could also correspond to a later point in time.

In relation to the al-Ḥawḍ suburb, there are some stretches of wall and towers (Figure 1b) related to the Almoravid renovation works on the original Taifa construction [51] (pp. 345–346), located among the urban network of La Chanca. The largest remains correspond to two rammed-earth towers in the northern part of the wall, located on Del Mar Avenue. They are 14.5 m high and 5 m long, despite being in a state of neglect.

Building Structure and Materials

The two lines of the original fence documented in Antonio Vico Street have different materials used in their manufacturing process: the first line is built in coastal sand and without foundation; the second one is made of rammed earth, between 1.80 and 1 m thick, and is cemented, possessing a more reddish tone. The stretch of the Taifa wall on the corner of Navarro Rodrigo Street is built in mortar and earth [78] (p. 13). In the wall in Nicolás Salmerón Park, several stretches built in ashlar combined with mortar were located, along with other stretches built in bricks combined with compact earth and mortar, and others built in mortar and small stones. In one of the stretches built in mortar and compact earth located in this park, a complex structure appeared next to a quadrangular tower. The tower had very compact walls, built in earth, combined with stone and mortar, all of which was covered by a compact mortar and ashlar [78] (pp. 14–15).

Historical Anthropic Risks

Of all the risks that have affected the conservation of the urban walls of Almeria, the major ones have been those of human-induced nature. Starting from the 17th century, the abandonment of the wall occurred, especially on its west side, as Gate of the Sortida was closed at that point in time [82] (p. 457). In the next century, the artillery of the Anglo-Dutch attacks of 1703 provoked new damage in the fence [83] (p. 162). From that moment on, the landslides of its stretches started, beginning with the stretch located next to the Gate of the Sea in 1749 and continuing with the destruction of part of the nearby madīna in 1776, 1854 and 1862 [83] (p. 166, 174). To all this, we have to add the destruction of a large part of the urban wall starting from May 26th 1855, when Queen Isabella II authorized its demolition for reasons of urban pressure, destroying the Gate of Pechina [73] (p. 53). In 1858, the

Gate of the Sea was destroyed, and in 1891, by order of the City Council of Almeria, the rammed-earth wall that ran along Torreones Street was also destroyed.

Historical Natural Risks

Despite the prominence of anthropic risks, the Almeria fence has also been affected by natural risks. The earthquake of 1522, which reduced its perimeter on its east and west sides and destroyed the parapet walks, stands out [83] (p. 155).

Anthropic Risks in Modern Times

In the cases of the towers located among the urban network of La Chanca, some of these were reused as houses, which had a great impact on their constructions.

Conservation Status

As has been mentioned before, most parts of the city walls were destroyed in the nineteenth century due to the urban growth of Almeria. Despite this fact, in some places in the town remains of this defensive system have been documented thanks to archaeological interventions, and some of these have been recovered. Some of the towers of the al-Ḥawḍ suburb can be still seen, but they are in a state of neglect.

3.2.3. El Castillejo Castle, Abrucena

Historical Approach

El Castillejo Castle in Abrucena is located on the highest part of an elevated hill, known as "dirty stone", on the right bank of the Nacimiento River, in the region of La Dehesa [84] (p. 2334), [85] (p. 59). According to ceramic remains found on-site, the occupation of the hill has been documented since the Neolithic era. Subsequently, there was an Iberian village, where the Romans settled, forming the ancient Lauricena [73] (p. 273). On its remains, a fortress was constructed in the Islamic period, which formed part of the defensive system between Granada and Almeria, alongside the Alcazaba of Fiñana and El Peñón de las Juntas Castle of Abla [82] (p. 421).

Traditionally, El Castillejo had been assigned to the Almohad period. However, this place is mentioned in the work *Uns al-Muhaj wa Rawḍ al-Furaj* by al-Idrīsī under the names of Lawrisāna and Lawrishāna [86] (p. 318), as a castle between Fiñana and Abla, on the way from Guadix to Berja and from Guadix to Abla [82] (p. 420). As this work was written in the mid-12th century, this suggests that El Castillejo could be considered an earlier work, of sufficient importance to be mentioned, built during the Almoravid period, although undergoing important transformations during the Almohad period [84] (p. 2335). Most probably, its construction is related to the reinforcement works of the Andalusi fences after the incursion of Alfonso I the Warrior in 1125–1126, who crossed the territories near Guadix, located close to this zone, on his way to Granada [2] (pp. 110–115).

Architectural Form

Only part of its wall built in rammed earth, four towers (some of them very damaged) and a cistern have been preserved from El Castillejo of Abrucena. After the analysis of these remains and the documented ceramic material, up to five construction phases can be differentiated, dating from the 11th to the 13th century [82] (pp. 420–421). The largest tower is quadrangular, is massive in its interior and is 7.70 × 6.90 m long. Next to the largest tower is a large corner tower, measuring 6.90 × 7.50 m, also massive. This bastion was attached to the tower located in the western part of the enclosure, and was smaller than the towers previously described (4.50 × 5.20 m). The towers are joined through a wall of about 7.50 m, which is reinforced by another exterior wall that, due to its disposition, maintains the tower in line with the wall [87]. These types of towers, quadrangular and massive inside, are the most characteristic of the Almoravid military constructions, although they were also used in several Almohad enclosures [51]. On the south side of El Castillejo, only a smaller tower is located (3 × 5.20 m). In the wall, an aperture has been located whose

function is unknown, which leads to a ramp, and is interpreted as a possible entrance to the enclosure.

With respect to the interior constructions, the remains of a new tower, hollow in its interior and measuring 4.50 × 4 m, are preserved on a small rock ledge. In the center of the enclosure, a single cistern oriented to the North has been preserved, which ensured the storage of the water to supply the fortress [85] (pp. 68–70). It had a great capacity thanks to its dimensions (8.70 × 3.10 m). As for its upper closure, it was covered with a barrel vault of 0.30 m thick with a wide aperture, possibly used for the extraction of water, as is often the case in this type of construction [84] (p. 2336).

Building Structure and Materials

The corner tower attached to the bastion located in the western part of the enclosure is made of stone and lime rammed earth on a masonry base. The smaller tower located on the south side is built completely in masonry and has several layers of lime plaster. Regarding the preserved remains of the wall, its construction was built in stone and lime rammed earth on a masonry base, with its stones cemented with gravel or slag, joined with mortars rich in lime and earth [85] (p. 73). These materials were mostly used in the military constructions of the ʻAlī Ibn Yūsuf period [4] (p. 318).

On the other hand, the tower in the interior enclosure is built in lime-stabilized rammed earth. Its construction is of mortar rammed earth on a base of masonry. As for the thickness of its walls, it ranges between 0.75 and 1 m [87]. The walls of the cistern are built in rammed earth at the base, up to a height of 1 m and a thickness of 0.50 m, at which point they are transformed into a superposition of a platform made of slate, a material often used in the area.

Anthropic Risks

The main risks that have affected El Castillejo of Abrucena have been ones of an anthropic nature. Its current state is abandonment and ruin. The enclosure has been greatly affected by the agricultural activity of the area, which has produced a great deterioration as a result of the removal of the earth and slope terracing, as well as the loss of materials of its walls [82] (p. 423). On the other hand, during the last decades its cistern was used as a livestock refuge [87]. Additionally, one of its towers has been affected by vandalism, since on its base it has a white piece of graffiti.

Natural Risks

Natural environmental risks have also caused damage to the site. On the preserved walls there is a clay patina with fungi and lichens, and there is certain deterioration due to the formation of salts, as has been observed in the lens-videomicroscopic analysis [50] (p. 28, Figure 32a,c). In addition to the dirt, there has been a significant surface erosion that has affected the walls, which has led to a loss of their mass (sometimes parts of rammed earth have disappeared), which has affected the stability and cohesion of the material and is still affecting the loss of the perimeter due to the disintegration of the rammed earth. The loss of material has increased the intensity of degradation damage, especially water saturation and thermal differences, as has been shown in the petrographic analysis [50] (p. 28, Figure 34). The damages caused by water have had a crucial impact in the degradation process, outlined as follows: The lack of protection of the high parts has caused the entrance of water by filtration, which has resulted in the disintegration of the rammed earth and the accumulation of salts, as well as favoring the formation of lichen, moss and fungi (Figure 1e). Additionally, the presence of birds has generated a significant amount of detritus, which has reacted with the material, resulting in its deterioration.

Conservation Status

Structurally, the whole complex is significantly affected. The towers have important undermining at their bases that jeopardizes their stability, and vertical structural cracks and

fissures that affect their coating at different points of the preserved remains can be observed. Moreover, they have a noticeable level of soiling. The *mechinales* are very deteriorated due to the disintegration of the rammed earth.

In the lower parts and crown of the walls, there are lesions that have caused a loss of cohesion in the material and a progressive detachment of more superficial material. The loss of grouting between the courses of masonry is frequent. Various wall faces have suffered chromatic alteration. Efflorescence is visible, being more prominent in the interior of the cistern. This construction is semi-ruined, with debris and vegetation inside as a result of the partial destruction of the vault that covered it.

The effects of neglect, vandalism and lack of maintenance are noticeable. There are numerous incisions, paintings and white graffiti at the base of the massive western bastion. Agricultural activity has led to the removal of the terrain and the terracing of the hillside, with retaining walls presumably made of material from the fortress.

3.2.4. The Castle of Bacares

Historical Approach

The Castle of Bacares is located on top of a hill on the slope of the Sierra de los Filabres, next to the Bacares River, east of the urban center [73] (p. 344). It seems that this fortress, of Berber origin, was part of a more complex defensive system, located next to Velefique Castle and other castles in the same region. The aim of this complex was to control the Filabres route between Baza and Almeria [88] (p. 137). The original construction is dated between the 11th and 12th centuries, as it was first mentioned in the texts of al-Idrīsī, under the name of Bakārish [86] (p. 325). During the 13th century, it underwent significant modifications due to the great political instability at the end of the Almohad and the beginning of the Nasrid period [89]. This modification was surely related to the incorporation of Almeria into the first Nasrid kingdom of Muḥammad I in 1238.

Architectural Form

This fortress is formed by an irregular enclosure of about 25 × 25 m that adapts to the orography of the land. Its wall has six towers, five of them being quadrangular, while the last one is larger and has a rectangular plan [90] (p. 71). Several of these towers are located at the corners of the enclosure, a model widely used in this region during the 13th century [89], in direct relation to the aforementioned renovation works carried out on the original Berber construction. The best-preserved tower is the one located on the north side of the enclosure, which is 8 m high. As for the western one, it was probably hollow inside, and still retains part of its original plaster, while the rest of the bastions were massive inside (at least up to the preserved height) [82] (p. 467). This typology was typical of the military constructions of the first half of the 12th century.

Inside, remains of the rooms between the towers have been preserved. The one located to the south was two floors high. Beneath, there seem to be remains of other buildings, which, however, are walled up. In the courtyard there are the remains of a small rectangular cistern, attached to the west wall of the north tower [84] (p. 2340).

Building Structure and Materials

With respect to the construction system of the fortress, its walls of remarkable size (between 0.91 and 1.15 m wide) [90] (p. 71) are built in lime-stabilized rammed earth on a masonry base, made of slate stones joined with cement mortar, forming courses. The towers have a barely preserved plaster [89] (Figure 1f).

Historical Risks

The construction was abandoned in the 16th century, and was very close to disappearing, as archaeological analyses have indicated.

Anthropic Risks

The most important risks that have affected the Castle of Bacares have been those of human-induced nature, especially those related to abandonment, which in turn has increased the pathologies associated with natural risks. A restoration project was implemented in 2008–2009 [91], and the walls were consolidated using colored concrete based on rich lime. Alongside abandonment, another human-induced risk that has been detected in this fortress is the presence of graffiti on one of the walls on the way up to the castle on the southeast side.

Natural Risks

Before the intervention, the rammed-earth walls had holes produced mainly by rainwater. However, there are still some areas where the rammed earth is damaged, presenting cracks and fissures, as in the interior room located to the south. On the other hand, water leaks have eroded the walls, causing detachments of their coatings. Both in the room situated in the south part and in the north tower, there are also whitish stains, results of the accumulation of salts on the surfaces. The upper part of the walls is damaged due to the lack of adhesion, which is causing detachments due to the consequent entry of moisture. Additionally, throughout the whole complex there are mosses and fungi, as well as low vegetation in the walls and in their crownings.

Conservation Status

Since the restoration project implemented in 2008–2009, the current conservation status of the Castle of Bacares is relatively good. However, there are still some areas where the rammed earth is damaged. Small cracks and fissures can be seen in the south wall of the room inside the complex. The filtrations generated have created erosion and progressive detachment of the cladding, leaving the wall more vulnerable. Efflorescence can be seen on this same front and on the inside face of the north tower.

In relation to the work carried out on the remains of the rammed earth, we can observe the lifting of the protections of the crowns of the walls, due to the lack of adherence, causing exfoliations and detachments that favor the presence of gaps and the entry of damp.

4. Synthesis of the Results

This section summarises the results obtained from the analysis of the six military rammed-earth constructions in the areas of Granada and Almeria included in this study. The results have been synthesized in Table 1, where the names of each asset, its location and the chronology of the different historical works have been included. The works developed during the first half of the 12th century have been specified in a separate column. In addition to this information, the types of historical rammed earth and the anthropic and natural risks of conservation have also been compiled in the table.

Table 1. Characteristics, materials and risks of conservation in the 12th-century military constructions in Southeast Al-Andalus.

Name	Location	Chronology	Works on the First Half of the 12th Century	Types of Historical Rammed Earth	Risks of Conservation	
					Anthropic	Natural
Walls of the Alcazaba Qadīma	Granada	Zīrī (11th century) Almoravids (first half of the 12th century)	Reparations in the walls and towers	Rammed earth with pebble aggregates joined together with mortar Rammed earth with limestone mortar Lime-stabilized rammed earth with less lime inside and resistant lime mortar outside	Urban pressure Abandonment Vandalism and graffiti	Thermal oscillations Dampness due to filtered water Dampness due to capillarity Rainwater Vegetation on the wall Earthquakes Landslides
Alcazaba of Guadix	Guadix (Granada)	Zīrī (11th century) Almoravids/2nd Taifas (12th century) Nasrids (13th–15th century)	Barbican	Lime-stabilized rammed earth with less lime inside and resistant lime mortar outside Rammed earth with stone and lime mortar cement	Occupation as a military quarter during the War of Independence Repairs using poor quality materials and contemporary materials (Portland cement concrete and mixed concrete made of soil and cement) Use as a cemetery of the interior esplanade Bombings during the Civil War Graffiti Sports facilities in the interior enclosure Urban pressure	Environmental factors Vegetation on the walls
Walls of La Hoya and Cerro de San Cristóbal	Almeria	Zīrī (11th century) Almoravids (first half of the 12th century) Christians (1147) Almohads (from 1157)	Reparations in the walls	High hardness lime-stabilized rammed earth	Urban pressure Graffiti Garbage and debris Use of corten steel in a recent restoration	Earthquakes Dampness due to filtered water Rainwater Wind Thermal oscillations Small plants, mosses and fungi in the upper part of the walls Detritus

Table 1. *Cont.*

Name	Location	Chronology	Works on the First Half of the 12th Century	Types of Historical Rammed Earth	Risks of Conservation	
					Anthropic	Natural
Urban walls of Almeria	Almeria	Caliphal (10th century) Zīrī (11th century) Almoravids (first half of the 12th century)	Reparations in the walls and towers	Rammed earth of coastal sand Mortar and compact earth Mortar and small stones Ashlar combined with mortar Bricks combined with compact earth and mortar	Urban pressure Abandonment Artillery of the Anglo-Dutch attacks of 1703	Earthquakes
El Castillejo	Abrucena (Almeria)	Almoravids (first half of the 12th century) Almohads (12th–13th centuries)	Original construction repaired in the Almohad period	Rammed earth with stone and lime mortar cement on a masonry base Lime-stabilized rammed earth	Urban pressure Abandonment Agricultural activity Use of the cistern as livestock refuge Vandalism and paintings	Surface erosion Clay patina Presence of mosses, fungi and lichens Water saturation Thermal oscillations Dampness due to filtered water Detritus
Castle of Bacares	Bacares (Almeria)	Almoravids (first half of the 12th century) Nasrids (13th century)	Original construction transformed in the Nasrid period	Lime-stabilized rammed earth on a masonry base	Abandonment Graffiti	Rainwater Dampness due to filtered water Presence of mosses, fungi and low vegetation

5. Discussion: Proposal of a Preventive Conservation Method for Two Case Studies

The multidisciplinary analysis based on the Delphi method of the cultural assets included in this work has shown that anthropic and natural risks have jeopardized their conservation in most of the cases. On the one hand, concerning the anthropic risks, those referring to urban pressure, abandonment and vandalism can be highlighted, beside the lack of maintenance and/or the lack-of-criteria restorations. Concerning the natural risks, earthquakes and risks related to water are also present in most of the cases of study. The walls of the Alcazaba Qadīma (Granada) and the walls of La Hoya (Almeria) have been selected as case studies in this section because they are the most representative ensembles among the cultural assets included in this work. Furthermore, the preventive conservation method proposed below for both case studies can be extrapolated to the other assets of this study, as has been proved within the framework of the PREFORTI Project for other similar cases. For this reason, the compared analysis of the incidence of anthropic and natural hazards in the cases of the Alcazaba Qadīma (Granada) and the walls of La Hoya (Almeria) is presented as a discussion, together with the vulnerability index of both assets.

In regard to the incidence of anthropic hazards (Figure 12), in both cases the most significant hazards are urban pressure and the disappearance of the original use/incompatible use (with an incidence of 5 in a scale from 0 to 5), followed by the alteration of environmental conditions/infrastructures and negligence (with an incidence of 4 in a scale from 0 to 5). In the specific case of the walls of the Alcazaba Qadīma, vandalism is also particularly significant (with an incidence of 5 in a scale from 0 to 5), as well as the lack of maintenance (with an incidence of 4 in a scale from 0 to 5). On the other hand, in the case of the walls of La Hoya, restoration errors can be highlighted (4 in a scale from 0 to 5).

Figure 12. Graph of the incidence of anthropic hazard. **Left:** walls of the Alcazaba Qadīma, Granada; **right**: walls of La Hoya and Cerro de San Cristóbal, Almeria; 1: Lack of historical, graphical or archaeological documentation; 2: Alteration of environment conditions/Infrastructure; 3: Negligence; 4: Lack of maintenance; 5: Vandalic acts, sabotage and thefts; 6: Conflict; 7: Restoration errors; 8: Disappearance of original use, incompatible use; 9: Urban pressure. Source: PREFORTI Project.

In the case of the incidence of natural hazards (Figure 13), these hazards have a higher impact in the walls of La Hoya, above all in the cases of the action of capillarity and floods (with an incidence of 5 in a scale from 0 to 5). In both cases, they are followed by the incidence of seismic activity (with an incidence of 4 in a scale from 0 to 5). In the particular case of the walls of the Alcazaba Qadīma, the impact of the action of fire and temperature are significant too (with an incidence of 4 in a scale from 0 to 5), while in the case of the wall of La Hoya the impact of seaquakes is also high (with an incidence of 4 in a scale from 0 to 5).

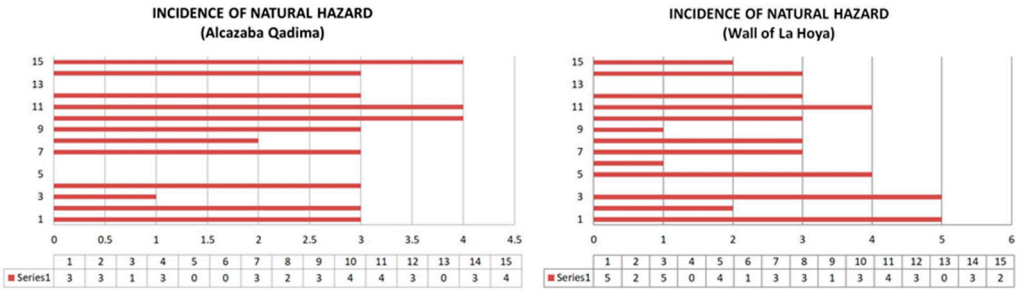

Figure 13. Graph of the incidence of natural hazards. **Left:** walls of the Alcazaba Qadīma, Granada; **right:** walls of La Hoya and Cerro de San Cristóbal, Almeria. 1: Action of capillarity; 2: Environmental humidity and rain; 3: Floods; 4: Snowfalls; 5: Seaquakes; 6: Hurricane; 7 Winds; 8: Lightning; 9: Ice; 10: Temperature; 11: Seismic activity; 12: Landslides; 13: Clay expansivity; 14: Steep slopes; 15: Action of fire. Source: PREFORTI Project.

Concerning the vulnerability index (Figure 14), the situation of the walls of the Alcazaba Qadīma is worse than the walls of La Hoya, where the impact of pathologies has an incidence of 3 in a scale from 0 to 5. Among these pathologies, material disaggregation/loss of cohesion; cracks and fissures; settlement/stability issues; stains caused by runoffs and humidity by capillarity/filtration can be highlighted. On the other hand, in the case of the walls of the Alcazaba Qadīma, the impact of moderate and excessive vegetation is the most significant (with an incidence of 5 in a scale from 0 to 5), followed by dirt/superficial deposits; lichens and fungi; detritus and nesting and cracks and fissures (all of them with an incidence of 4 in a scale from 0 to 5). The pathologies of the walls of La Hoya are at the same level, being material disaggregation/loss of cohesion; stains caused by runoffs and humidity by capillarity/filtration; besides the detachment/loss of mass and volumetric loss (all of these with an incidence of 3 in a scale from 0 to 5).

Figure 14. Graph of the impact of pathologies on the studied items. **Left:** walls of the Alcazaba Qadīma, Granada; **right:** walls of La Hoya and Cerro de San Cristóbal, Almeria. 1: Superficial erosion/lack of rendering and pointing/Exfoliations; 2: Detachments/Loss of mass and volumetric loss; 3: Material disaggregation/Loss of cohesion; 4: Dirt/Superficial deposits; 5: Lichens and fungi; 6: Moderate and excessive vegetation; 7: Detritus and nesting; 8: Black crust; 9: Chromatic changes; 10: Efflorescence; 11: Cracks and fissures; 12: Settlement/Stability Issues; 13: Displacement; 14: Discard; 15: Rock fracture/Disintegration of soils; 16: Slides, hillslides; 17: Stains caused by runoffs; 18: Humidity by capillarity/filtration; 19: Calcareous concretions; 20: Calcination. Source: PREFORTI Project.

According to the developed analysis, the systematic method based on preventive measures of conservation and restoration proposed from the PREFORTI Project are intended to mitigate the damages caused by these specific risks. The universality of the proposed method has been experimentally validated in other assets analysed within the framework of the PREFORTI Project (for example, in the case of the Lojuela Castle (Granada) and the castle of Velez de Mula (Murcia)). All these assets are affected by natural and anthropic risks of different types and with diverse level of degradation, and they have been intervened in for several years. In these groups, it has been possible to carry out the phase of

experimentation and validation after it has been submitted and approved by the public bodies responsible for their protection. The application of the method has been parallel with the development of intervention works funded by state, regional and/or local administrations. Moreover, in these cases, the necessary time to evaluate the benefits of the application of the proposed methodology has passed, and it has been confirmed that the preventive measures are working and that the appropriate control strategies have been established. (The method has been presented to bodies such as the Institute of Cultural Heritage of Spain, which belongs to the Ministry of Culture, and the General Directorate of Cultural Heritage of the Andalusian Government. Both institutions are competent in the management of cultural heritage, and both have shown their interest and support.) As for the model of supervision and control of the assets in the future, the absence of specific protocols of preventive conservation for the earthen defensive architecture has been verified. Considering the doctrinal and legal obligation of its design and implementation by the owners, and in order to contribute to this end, the PREFORTI project has conducted an analysis of the diachronic behavior of the series of interventions carried out on the assets of the sample under study in the aforementioned project, evaluating how they have responded to the damage produced and to the repeated risk agents over time.

In analyzing the cultural assets mentioned above, and in order to extrapolate and disseminate the method, the walls of the Alcazaba Qadīma and the wall of La Hoya and Cerro de San Cristóbal have been chosen because they are part of the sample selected in the PREFORTI project, and because they are in a phase of diagnosis of the state of conservation and risk assessment. In both cases, specific measures to be taken into account for preventive conservation have been included. These measures have the advantage that they can be easily applied in other cultural assets with similar characteristics, with minimal economic investment.

5.1. Systematic Measures for the Walls of the Alcazaba Qadīma (Granada)

The recent interventions of integral character that have been carried out on these structures from the year 2011 until the present day have required the adoption of emergency measures as well as conservative and restorative strategies, following the criteria compatible with the heritage values of the fortified complex. This means that the solutions to be taken into account in future include designing maintenance strategies as well as a monitoring plan that can ensure preventive conservation of the monument and its surroundings and minimize the aggression of external agents [55].

The adequacy of the solutions and their duration time has been considered in this systematization, and they have been divided into solutions that could be performed with the following two different levels of frequency: on a short term basis (annually), aiming to control cultural assets and control restoration and conservation interventions; and on a long term basis (five-year and ten-year periods), which will allow the assessment of long-term pathological processes and the planning of more permanent measures. In this way, the objective of these assets being viable and sustainable will be fulfilled.

Among the maintenance tasks essential for the proper conservation of the wall that should be carried out annually are the following: visual inspection of the state of each section of the wall; recording of external conditions including external alteration factors—environmental (temperature, humidity, elimination, atmospheric pollutants), biological (microorganisms, insects, rodents and birds, vegetation), natural disasters (earthquake, flood, fire) and anthropic action (vandalism, terrorism, inappropriate handling)—that have been observed throughout the annual control period; assessing and recording risks, having determined to what extent a cultural asset suffers due to external alteration; assessing and recording the damage, always in relation to the origin of the risk that produces it, dividing damages into permanent, new and previous damages and recording and assessing restoration interventions.

As for the long-term maintenance protocol, it will be based on the annual records compiled in the previous phase, in order to establish a ten-year control of the pathological

processes that affect the wall, which will allow for the organization of the corrective measures of minimum impact that can be applied at low cost and in a systematic way. At the same time, the ten-year control assumes that the minimal duration of the undertaken actions is five years, in order to avoid the alteration of the optimal conditions of conservation of the monument after the intervention. These actions include:

- Cleaning and clearing of vegetation in the environment of the wall.
- Manual removal of invasive vegetation that could be deposited on the wall, having previously applied non-aggressive herbicides on the rammed-earth walls.
- Spraying most disintegrated surfaces of the walls with lime water.
- Brushing the upper part of the walls in order to eliminate earth deposits.
- To the above-mentioned measures, the following must be added:
- If necessary, and as determined by annual checks, conducting chemical laboratory tests that can determine the condition of the material stability of each section of the wall.
- The annual control of the structural stability systems of the walls, both their foundation and the structure itself.
- Revising the catalogue of elements every ten years in order to detect possible punctual disappearances of sections of the wall and the incorporation of new sections.
- Increasing public awareness, so that the local population can gain suitable knowledge of the presence and condition of the walls and be the first to collaborate in the inspection and control processes in order to detect problems that arise during the conservation.

In case of the sections of the fortification being state or local property, local authorities will be in charge of carrying out maintenance. In case of these sections being part of private properties, the owners will be responsible for the control and maintenance of their material integrity, and the local authorities will be responsible for the ultimate supervision of the proper development of this work through technical support when requested by the owners.

5.2. Systematic Measures for the Wall of La Hoya and Cerro de San Cristóbal

Having analysed the risks that have affected the conservation of the wall of La Hoya and Cerro de San Cristóbal, in the framework of the PREFORTI Project, different systematic conservation actions that should be undertaken in order to preserve this stretch of wall have been indicated. The most urgent measures that should be carried out, being given priority 1, are the following: repairing cracks in the walls in order to prevent water entry and filtration and corresponding erosion, as well as consolidating the upper part. It is necessary to reintegrate the lost masses that affect structural stability. On the wall of the Cerro de San Cristóbal, underpinning of the base of the bastions and the walls is necessary. On the other hand, regarding the La Hoya stretch, applying a cleaning treatment in order to eliminate rust stains caused by the corten steel used during the last restoration is a priority.

Secondly, the following preventive measures were proposed and given priority 2: consolidation of the walls, as well as punctual consolidation of the crenelated ornaments, parapets and gaps; stability replacement; sealing of cracks and fissures and the replacement of the masonry with traditional mortar at the points where it had been lost. To preserve the stretches of wall from water damage, it is important to solve moisture problems, protect the upper part of the walls, introduce waterproofing measures, protect and install rainwater evacuation systems and ensure drainage at the base of the walls, in order to reduce the presence of dampness due to capillarity. Finally, measures of restoration of the walls have been proposed and given priority 3, the most important of these being general cleaning of the structures by natural means in order to eliminate vegetation and accumulated organic remains, as well as a deep cleaning in order to remove the adhering dirt, dust deposits and the paintings and graffiti that affect, above all, stretches of the wall of the Cerro de San Cristóbal. Likewise, cleaning of the parapet walks is proposed, and covering of the exit gaps. Also, it is important to replace the lost materials and reintegrate scabs with traditionally manufactured mortars, as well as to cover the putlog holes. On the other hand, it would be desirable to clean, consolidate and replace the flooring of stairs and rooms, as

well as to adapt, clear and clean the environment, which has been invaded by vegetation, in order to enhance its value. This cleaning would help to perform an archaeological study of the environment, and ensure that the area is adapted to its new use. The adaptation of the protective environment is essential, as especially the area of Cerro de San Cristóbal is noticeably degraded, full of garbage and graffiti. In the case of the area of the wall of La Hoya, the recovery of the environment throughout the creation of the park "Jardines Mediterráneos" is projected and planned for the year 2023 [92]. It will be a valuable opportunity to carry out the preventive measures proposed in the PREFORTI project.

6. Final Remarks

The methodology of the PREFORTI Project is based on a multidisciplinary and comprehensive study of the rammed-earth fortifications in Southeast Spain, carried out in order to gather a better knowledge of their history and constructive characteristics, as well as the impact on cultural assets of natural and anthropic risks, the different actuations on these and their state of conservation, in order to identify the preventive actions of conservation and restoration most compatible with their material and nature as pieces of heritage. The universality of the proposed method has been experimentally validated within the framework of the project in the cases of assets affected by natural and anthropic risks of different types and with diverse levels of degradation, which have been intervened in for several years. The application of the method has been parallel with the development of the intervention works funded by state, regional and/or local administration. In these cases, the necessary time to evaluate the benefits of the application of the proposed methodology has passed, and it has been confirmed that the preventive measures are working and that the appropriate control strategies have been established.

The proposed preventive measures acquire especial relevance in the case of the cultural assets included in this study, due to the scarcity of archaeological remains from the first half of the 12th century in the Iberian Peninsula, despite the importance given to this type of structure during the Almoravid domination, as explained above. These assets are currently in an uneven state of conservation and are at a serious risk of the loss of their most essential values, especially in the cases of the assets located in rural areas. For this reason, the systematic method based on preventive measures proposed in the PREFORTI Project constitutes an important contribution to the conservation of these assets, as well as a great advance in safeguarding this at-risk heritage, above all taking into account that the ownership of such assets, in many cases, rests with local administrations with scarce economic and material resources. In this way, preventive measures guarantee to slow down the deterioration suffered by this heritage, which facilitates the implementation of effective and economic strategies for its conservation.

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