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FRAGOKASTELLO SFAKIA: RESTORATION AND CONSERVATION THROUGH COMPATIBLE ARCHITECTURAL, STRUCTURAL AND CONSTRUCTION MATERIALS

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Abstract. *Castello San Nikita, called Frangokàstello by the inhabitants, which was built by the Venetian authorities, between 1371-1374 in southeaster Crete, today exhibited a great decay state. The principles of restoration and conservation taking into account the uses and meanings of such construction during the six centuries of its presence, along with the requirement of compatibility between original materials and technical solutions for the restoration and conservation of the whole structure are of the main objectives of this study. In the architectural interventions, fingerprints of time specifically incorporated on the towers and the walls, in correlation with value as symbol of freedom and independency for the local communities, have been considered as main criteria to work with. Emphasis was given on the analysis of original plasters before the design of the conservation mortars, compatible to the original ones and paying particular attention to enhance their resistance to the environmental loading. The structural behaviour of the masonry castle, were studied by the finite element method, taking into account the pathology of the structure which affects its mechanical response and finally the required actions for the reinforcement of the structure.*

1 INTRODUCTION

Castello San Nikita, called Frangokàstello by the inhabitants, was built by the Venetian authorities between 1371-1374, on the plain in front of the villages Patsianós and Kapsodàsos in the mountainous area of Sfakià, in southeast Crete. On 10 February 1371, it was decided to build a fortress in order to deal with pirate raids and local insurrections. The relevant document mentions the existence of a spring of drinking water and a good anchorage at the site "*ubi est bonus portus at aqua fontane...*", but there is also a reference to the low cost of construction, "*faciendo quam minors expensas potuerint pro bono comunis*" (Archivio di Stato di Venezia (A.S.V.), *Senato Misti, XXXIII*, 93). A newly discovered document sheds more light on the issue: it is the order of the Duke of Crete to the artisans who had declared their availability to work on this new building site, commanding them to leave Chandax (Heraklion) immediately: *"The government intends to erect a castle on the site of San Nikita. All the builders, masons and workers already called upon, with their tools, are ordered to depart the next day for the area"*, 1 May 1371 [1].

After its construction, the next mention of Frangokastello comes two hundred years later, when the General Proveditor of Crete, Nicoló Doná (1593-97), refers to the building being in ruins due to its abandonment. The removal of the wooden beams from the floors of the towers and rooms is also mentioned repeatedly in other historical periods. In 1634, the Venetian Proveditor Lorenzo Contarini intended to implement repair work on the fortress but this was not carried out. In 1644 Andrea Corner assumed responsibility for repairs, but again they were never completed due to lack of funds.

The castle was abandoned for several periods during the Venetian rule of Crete, meaning that it was probably never fully completed. The last interventions are owed to the Ottomans, in 1833-1836, when the castle was transformed into a *koulés*, a typical fortification with rifle embrasures in the lower part of the walls. This intervention weakened the walls of the three small towers by reducing their width by half, in order to pierce them for embrasures more easily and prevent the thickness of the walls hindering the aiming. The walls affected were coated in light ochre plaster with characteristic trowel-marks (*sardelota*, or "sardine pattern"), while the upper walls over a height of four metres were left untouched. The piles of rocks and soil from the collapse of the upper floors allowed soldiers easy access to the new battlements, which were limited to the ground floor of the building [2, 3].

It consists of three small towers and a third bigger with height equal to 9 and 15 m accordingly and four perimeter walls. Today the fortress presents a picture of great decay, in its structures, construction materials and restricted use by local communities. Given the progressively decaying state of the building over the past 40 years, intervention is necessary because there is a high risk of partial collapse, due to deterioration of the existing deep cracks and crumbling masonry, particularly of the three small towers. Meanwhile, the use of the building in the summer months, although low, is not subject to any safety measures. The protection and promotion of the monument, and subsequent intervention based on an integrated view, is the only way to ensure its continuing existence.

The proposal for the restoration and reuse of the castle was elaborated by our scientific team, in collaboration with the Ephorate of Antiquities in Chanià, Hellenic Ministry of Culture and the Municipality of Sfakià. The principle of relevance to the uses and significations of such a structure during the six centuries of its presence, and the principle of compatibility between original materials, entire structure and technical solutions for the restoration, form the subject of this paper. The finite element method was used for the study of static integrity of the structure and the decision of the strengthening techniques which must be applied. The finite element model was based on the existing condition of the geometry, the material, the cracks and failures of the structure.

2 ARCHITECTURAL STUDY AND STRUCTURAL CONDITION

2.1 Architecture and history

The fortress consists of four corner towers linked by curtain walls. At a height of 3 and 6 m from the average ground level of the courtyard, the walls narrow, in order to reduce the building mass on the higher levels and provide support for the beams of the barrack rooms. Only the south wall shows the same thickness throughout, except at the very top, just below the battlements. All the walls are topped with typical medieval battlements, which continue around the four corner towers. Three of the towers, at the NW, NE and SE corners, reach an average height of 9 m; the SW tower is taller with a wider base, reaching 15 m. The main entrance to the fort, on the side facing the sea, is crowned with Venetian coats-of-arms and the lion of St Mark. The smaller gate in the east wall is a later intervention dating from the Turkish period. There are two walkways along the curtain walls, indicating the existence of a wooden structure supported on corbels, at least for the first two centuries of operation of the fortress.

In planning the consolidation interventions and the introduction of new uses, the history and structure of the monument was taken into account. Into this framework the following can be stated:

- The construction of the late medieval fortress of San Nikita is based on a type of defensive engineering widespread in southern Europe.

- The basic structure of four walls with corner towers was added at different times with barrack rooms, although their size, as depicted in historical images, is uncertain.
- The mortises on the inner sides of the walls, intended to support roofing beams and wooden walkways along the battlements, would only occasionally have been used in full.
- The history of the castle is marked by a successive periods of few repairs followed by abandonment and theft of building materials.
- Frangokastello was not modified for guns during the Renaissance. Interventions for defence with rifles and external embrasures were only carried out much later, when it was transformed into a *koulés*, with little regard for its existing structure.

We also prioritised the existing advantages of the monument and their importance to its future:

- Frangokastello is a historic monument, which can demonstrate to future generations how warfare was carried out in the late medieval period and the 19th century, together with contemporary building methods and know-how, and the presence of a foreign power, that of the Venetians, the Western power best disposed in early modern times to the Greek, Orthodox nation.
- This is one of the most important and complete castles of this type in the Mediterranean, worth recording as an example of a type of wider significance.
- The relief coats-of-arms on the south facade, with their repetitive motifs and old-fashioned execution for the time, are of historical rather than artistic value.
- The historical events that unfolded around Frangokastello and for which it was a point of reference make the wider area a place of memory and national self-knowledge.
- The tales of the *Drosoulites*, the "dew men" supposedly seen at certain times of year, together with the morning dew and various other changes in atmospheric moisture, make the surrounding area a theatre stage of cultural and environmental value.
- Time, assisted by natural factors, has coated the material of the monument with a crust of rust that makes unsuspecting visitors aware of the value of age.
- The history of the wider area of the Sfakià communities today can be symbolised and represented by Frangokastello. This gives it a modern value, meaning that the building must remain a living cell for local society, continuing to transmit messages regarding the struggle for dignity.
- The social dimension of the castle, together with its use as a landmark for the wider area and a recognisable symbol for local tourism, increases its significance.

The fortress could house the following: The Open University of Sfakià Municipality, The Eftychios Tzirtzilakis Knife and Rifle Collection, Infrastructure for plays and music events, Raised walkways around the enclosure walls, and of course a guard's residence and public toilets

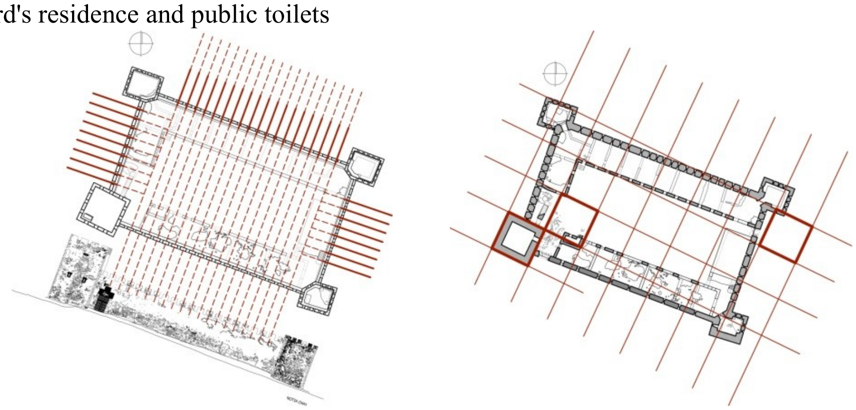

Figure 1. Photo diagrams of roof and diagrams of ground floor

In the architectural interventions, the main working criteria were the value that time has added to the towers and the walls, in correlation with the monument's value as a symbol of freedom and independence to the local communities. The principle of compatibility emerged in the proposed works applies not only to the building materials but also to further additions to spaces and structures, as a set of forms and actions compatible with the history of the monument.

The geometrical grid for the positioning of the wooden frameworks is provided by the interstice of the spires of the south wall, while the grid for the external pavements is provided by the differentiation of the large southwest tower, as it is shown in figure 1.

2.2 Existing structural situation

The presence of small cracks in the foundation soil contributed to the strengthening of the seismic charge of the structure. As a result, cracks in weak parts of the structure appeared, such as the walls of the small towers and the southern and eastern wall.

- The reduction of the wall thickness of the towers to the low level in the period from 1883 to 1886, aided by the opening of the rifle boxes, resulted in a decrease of the strength of these structures in seismic stress, as a result, (as mentioned above) the through and through cracks.
- The destruction of the intermediate buildings of the barracks and the floors in the towers (horizontal diaphragms), led to the increase of the free height of the outer walls and thus, to the development of bigger oscillations.
- The walls and their depended horizontal surfaces, that have not been modified, have kept their original structure.
- The walls and the surfaces, despite the reduction of their size, were sealed with new mortar during the construction period from 1883 to 1886, thus preserving their good condition.
- Restoration works periods from 1972 to 1974, 1992 and in 2006, although not in line with modern principles of intervention in historical sites, were able to avoid further damage.

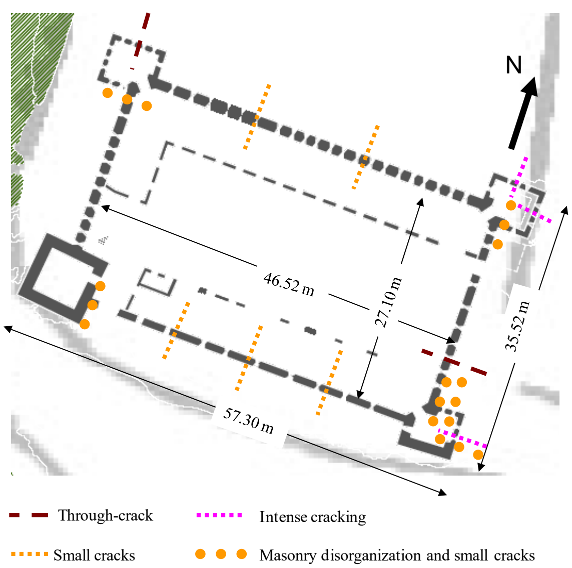

Figure 2. Plan view of the carrier and major structural damages.

A plan view of the castle follows, which indicates the main dimensions and the position of the damages, is shown in figure 2. The major damage is located on the northwestern tower, and is visible with a vertical crack which runs the north side and creates an opening of a few centimeters. The crack appears along the entire height of the tower, Figure 3a. It is a bending tensile crack, out of plane bending of the wall, in combination with the tower turning as shown at the results of the analysis.

Another, shorter range, through and through crack appears along the entire height of the east wall of the structural core (fig. 3b). To the southeast tower, cracks on the east side and disruption of the masonry at lower levels exist. The cracks in this specific region are due to the out of plane bending of the masonry and shear failure, which begins from the opening and appears at the region, where we have reduction of the cross-section. Smaller cracks appear on the south wall, due to out of plane bending (according to the analysis). At the same time, lower on the south wall and at the area which is connected to the tower, we can detect strong disruption of the masonry. The north wall, and the southwest tower are in good condition, without any significant damage, in terms of cracks or the disruption of the material are concerned. Local problems can be solved by the restoration of the continuity of the material.

Figure 3. a) North facade, of the NW tower (internal view), b) East wall.

3 CHARACTERIZATION OF THE ORIGINAL CONSTRUCTION MATERIALS AND DESIGN OF COMPATIBLE RESTORATION MORTARS AND PLASTERS

A reverse engineering approach has been adopted in order to design compatible restoration mortars and plasters. Primarily, characterization of mortar and plaster specimens originating from representative areas of the monument was carried out. More specifically, the macroscopical characterization and the microstructural analysis were carried out using optical microscopy on entire samples, their cross-sections and fractions derived after the grain size distribution analysis. Chemical and mineralogical anaylses such as, Fourier Transformation Infrared Spectroscopy (FT-IR), Energy Dispersive X-Ray Fluorescence (EDXRF) and X-Ray Diffraction analysis (XRD) were employed to identify the components and the minerals included in the original mortars and plasters. Moreover, thermogravimetric and differential thermal analysis (DTA-TG) provided information on the hydraulic components of the mortars. Elaborating all these results it becomes evident that the state of conservation of the construction materials can be identified along with the raw materials and the technology employed during the manufacture process [4].

Despite minor diversification, the overall evaluation of the results provided by the employed analytical techniques demonstrated that hydraulic lime had been used for the production of the historic mortars. The use of pozzolanic binders and crushed brick was insignificant and limited in random cases. The origin of the hydraulic lime could be explained by firing marly limestones, rich in the area, to produce lime. Into this context gypsum, abundantly found in the local area was also added to facilitate the workability of mortars and plasters. In support of using local materials, marine sand and crushed stones were deliberately chosen as the main aggregates. The hydraulic character of the mortars was principally responsible for the adequate preservation condition of mortars and plasters. The major coating removal was observed in the southern wall, where the weathering conditions are very aggressive. Therefore, the masonry and the mortars are still functional and any significant corruption or cracks are mostly attributed to mechanical faults or violent historic devastations of the castle rather than the mortar manufacturing condition.

To proceed with conservation interventions, compatible raw materials have been chosen including either hydraulic lime or other binders, such as lime with pozzolanic additions, namely metakaolin. The designed mortars when subjected to durability tests, showed a better mechanical and salt decay resistance than the original ones. Taking into serious consideration the aesthetical requirements of any conservation, the addition of specific ochres provided plasters similar to the originals, but with clear diversification in the hue following and respecting the well-established restoration guidelines.

The designed mortars and plasters based on the reverse engineering approach adopted, constituted a specific directive to be followed when conservation works were performed. Highlighted issue is the raw materials, which should be carefully chosen and evaluated for implementing restoration mortars with sustainability.

4 STRUCTURAL FINITE ELEMENT ANALYSIS

4.1 Mechanical properties of the masonry

In order to create the computational model and the assessment of the structural ability of the static core, there has been a selection of key properties of the materials. The selection was based on laboratory measurements (compression test and appropriate processing) on different stone samples, of non-structural elements, taken from the area of manufacture. The value of Young's modulus, which was finally used in the analysis, according to the requirements of Eurocode 6 (EN1996), is equal to 21,15 GPa. For the compressive strength of the stone, the average of the experimentally measured values was found equal to 78.46 Mpa. For the mortar, the value was estimated based on its composition, with an average compressive strength equal to 10 Mpa.

For the wooden beams of the floors, of the south-western tower, the following mechanical properties were selected: Young' s modulus E = 9,807 Gpa, Poisson ratio ν=0.25 and Mass Density: ρ=600 kg/m^3.

Considering the major structural damages (like cracks, masonry disorganization) different finite element models were used in order to model these damages. The mechanical properties which were used are given in Table 1.

Material	Young's modulus E (GPa)	Yield stress (MPa)	Compressive strength f_{cd} (MPa)	Tensile strength f_{td} (MPa)	Shear strength f_{sh} (MPa)
M1	21.15	3.53	11.75	1.06	4.8
M2	20.36	2.81	11.31	0.7	4.63
M3	14.63	2.70	8.13	0.5	5.95

Table 1. Mechanical properties of masonry

4.2 Finite element models

For the evaluation of the mechanical behavior of the structure the finite element method (FEM) was used, which is appropriate for the simulation of monumental constructions, with special geometry, stiffness and mechanical behavior, which can hardly be simulated with simplified models [5-7]. For the modelling the existing geometry, the history of the monument, the quality of building materials and subsoil conditions were considered. The model consists of 16743 three-dimensional finite elements (fig. 4a). In order to investigate the way that structural failures affect the structural behaviour of the masonry castle, the existing cracks and faults like disorganization of the material considered were considered in our analysis. Cracks were simulated by the technique of unilateral contact interfaces between contact bodies [8-9]. A number of potential interfaces are defined and along these interface separation and frictional effects are considered. The actual state at each point of the interface will be found after the solution of the problem. In case of unilateral contact and friction, algorithms have been proposed and modern general-purpose finite element software (like the MARC which is used for this study) can be used for the solution real-life problems, like the study of the existing cracks to a masonry structure. So the whole structure is separated to contact bodies which describe the boundaries of interfaces (Fig. 4b), between the different parts of the structure and the cracks. So two different finite element models were analyzed:

Model 1: The state of the body, before the failures, assuming an average quality of material (M1), (fig. 4a).

Models 2: The present condition of the structure considering the extensive cracks of the structure (fig. 4b). Average quality of material around the structure, (M1) was assumed and for the regions of the large fracture (north side) of the north-western tower, the south wall, the east and north wall of the South-East tower and the north wall of the north eastern tower, material with much lower modulus of elasticity and strength (M2) was considered. Additional lower quality of material was used (M3) for a specific area around the large fracture (north side) of the north-western tower with intense disorganization of the masonry (Figure 5). For unilateral contact and friction model, two values of friction coefficient (μ) were assumed: 0.6 for small cracks and 0.4 for large cracks. The friction stress limit (σ_t^{limit}) which is used to bound the maximum friction stress was considered equal to 1 MPa. For the separation procedure which is based on maximum normal, the limit equal to 0.5 MPa was assumed.

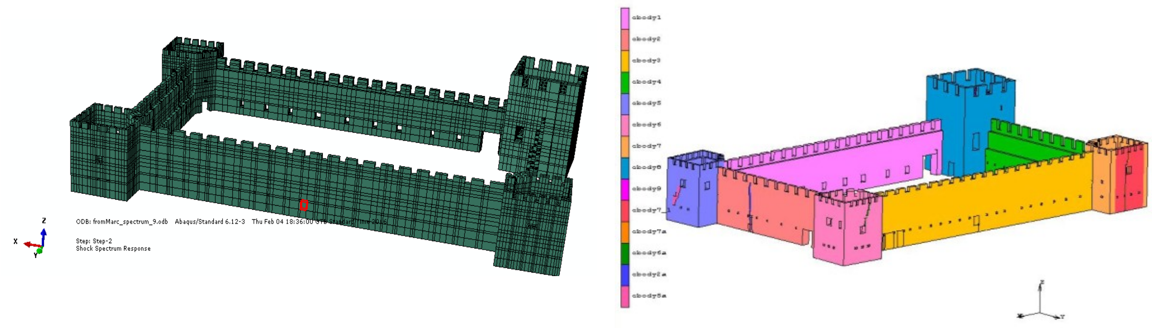

Figure 4. a) The finite elements mesh (Model 1), b) Contact bodies from which the finite element model consist.

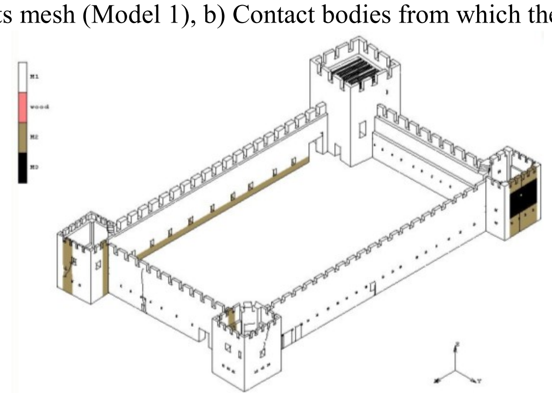

Figure 5. Finite element model with different materials to specific areas (Model 2).

4.3 Dynamic analysis.

From modal analysis the main frequencies of the structure were calculated in order to estimate the frequencies which activate mainly the structural vibration. The nonlinear analysis was done for different earthquakes (like Northridge, California, 1994 with magnitude 6.69 and peak ground acceleration 0.25g, Irpinia, Italy, 1980 with magnitude 6.69 and peak ground acceleration 0.29g, Kobe, Japan, 1995 with magnitude 6.9 and peak ground acceleration 0.8g), which were selected to match to the data of the castle area, to the extent feasible. More critical results were extracted for the Kobe earthquake, (the maximum peak ground acceleration) and special when the base excitation was applied main in y direction (north-south) and in the other direction (x) the same earthquake with an intensity of 60% of the initial.

In order to display any failure of the vector, the nonlinear law of fracture (damage) was used. In terms of this law, the nonlinear law of stress-strain for both tensile and compressive behavior was adopted, according to previously mentioned information. Damage index is an indication of regions where the developed stresses are higher than the permission limits. These areas are critical for possible cracks and materials faults.

In Figures 6-7 the contour plots of damage index are given for earthquake Kobe as base excitation. The activation of cracks acts as mechanism of energy dissipation leading to reduction of the vibration to the structure (fig. 6). When cracks open and no friction mechanism exists the mechanism of energy leads to appearance of more cracks and faults of the structure (fig. 7).

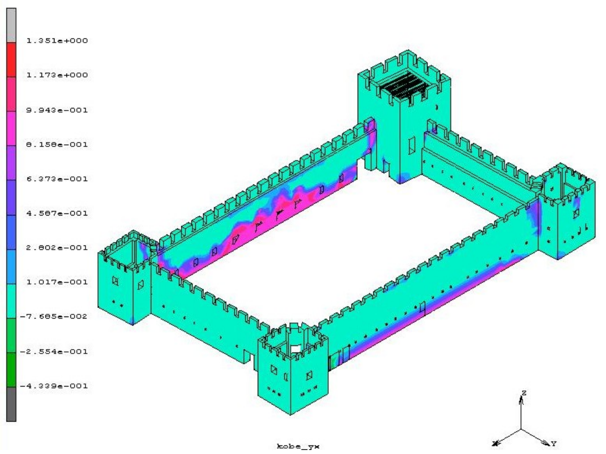

Figure 6. Contour plot of damage index (maximum 1.351) of Model 1 and earthquake Kobe_yx.

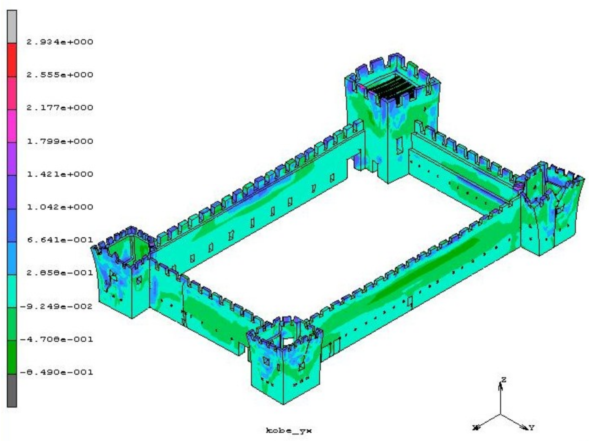

Figure 7. Contour plot of damage index (maximum 2.9337) of Model 2 and earthquake Kobe_yx.

5 RESTORATION PROPOSAL

The restoration of the physical structures is based on the following interventions:

- Areas with healthy well sealed surfaces with original plasters or those with repair ones of 1883-86 restoration, remain intact and will be used as a template for the style, application and colour of further interventions.
- The masonry cracks will be filled with new mortar reinforced and secured with stainless steel staples.
- The areas where original material was removed in depth, along with parts of the original masonry at the bottom of the small towers will be restored. The vault of the SE tower will be completed to roof the ground floor.
- The barrack rooms and towers will be roofed and the intervening floors will be constructed of frames of Greek chestnut, connected to the walls. The south wall, which is of uniform thickness and diverges from the vertical, will be supported by a row of wooden piers on a two-metre grid. The piers will bear the weight of the roof that

would have been taken by the wall, while connecting the wall by a lengthwise beam and anchor-points to the main mass of the building, restraining any future deformation (figure 8).

- All areas with total or partial loss of masonry or weathered cement mortar will be replaced by new repair material.
- New repair material will be used to make a rainwater drainage channel along the base of the walls, and also to modify the tops of the battlements for the same purpose.
- Mould in areas affected by visible falling damp will be treated with specific biocides following pilot tests.
- The Ottoman embrasures will be restored using pierced poros-stone blocks, copies of the existing embrasures.

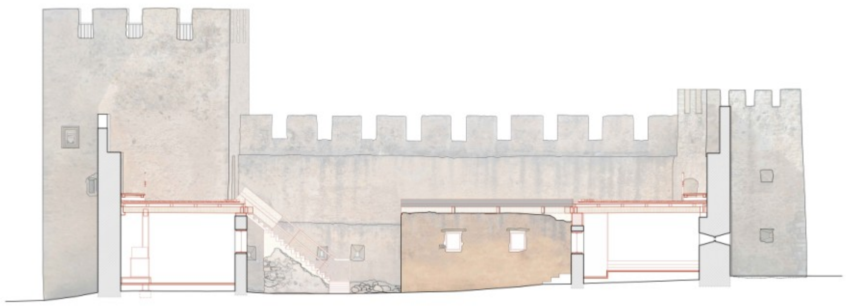

Fig. 8. Section of the north and south wing of the castle, with the proposal for covering the ruined barracks shown in red.

6 CONCLUSIONS

The finite element method was used for the structural analysis of Frangokastello fortress which is in the area of southern Crete. The modelling was based on surveys of existing geometry, history of the monument and interventions have been made, the quality of building materials and subsoil conditions. Especially existing cracks and faults like disorganization of the material considered and cracks were simulated by the technique of unilateral contact interfaces between contact bodies. Smaller faults was not considered to our analysis since they doesn't affect significant to the mechanical behaviour of this stiff structure with large enough wide of the walls.

The choices on the restoration materials and architectural interventions regarding the structure of our fortress were mainly determined by the principles of relevance and compatibility with the totality of meanings of the historical process.

Since the quality control of the structure and the finite element analysis, the following conclusions occur:

1.The large, bright, vertical crack in the entire height of the north face of the northwest tower is a risk factor for the tower. In likely seismic phenomenon could lead to collapse to part of the tower.

2.The disorganization of the wall in the centre of the south wall appears to be due to out of plane bending after seismic phenomenon. This failure mode is confirmed by the non-linear analysis, under actual earthquakes. In parallel the south wall is vibrated at the first frequency as shown by the modal analysis.

In the architectural solutions, one more guiding principle has been applied: Reversibility. It concerns:

1. The differentiation between the original walls and the new restore sections, creating gradated surfaces, in order to continually highlight the present state of degradation.
2. The use of wooden structures to create the horizontal frameworks, which are connected to the walls by metal sheets (fig. 9).
3. The use of ironwork for stairs and protection panels of all the openings, whenever they can be bolted or unscrewed.

4. All technical details have been designed as free joints, in a kind of elastic combination between different materials, composing the new totality.

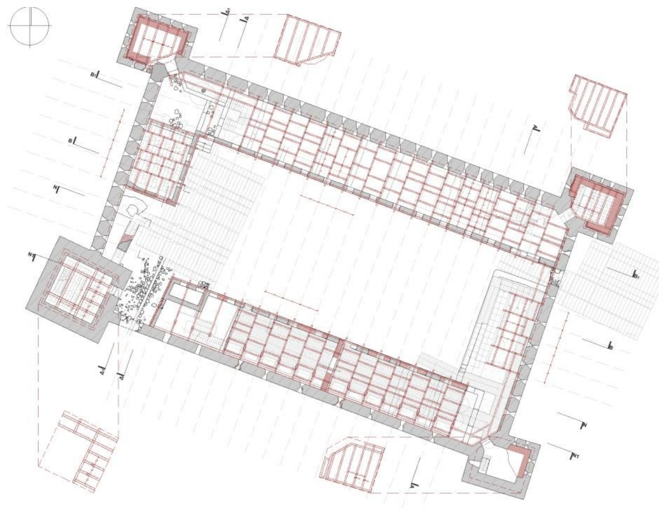

Fig. 9. Plan of the fortress showing the position of the wooden frames.

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REFERENCES

[1] Charalambos Gasparis, (2008,) *Catastici Feudorum Crete. Catasticum Chanee, 1314-1396*, National Research Foundation / Institute for Byzantine Research.

[2] Curuni, Spriridione – Donati, Lucilla, (1988) *Creta veneziana. L’Istituto Veneto e la Missione Cretese di Giuseppe Gerola. Collezione fotografica 1900-1902,* Venezia 1988.

[3] Gerola, Giuseppe,(1905-1940) *Monumenti veneti dell’isola di Creta*, Istituto Veneto di Scienze Lettere ed Arti, Venezia, Vol.I-1 (1905), Vol.I-2 (1906), Vol. II (1908), Vol.III (1917), Vol.IV(1932-40).

[4] P. Maravelaki-Kalaitzaki, A. Galanos, I. Doganis, N. Kallithrakas-Kontos, (2011), "*Physico-chemical characterization of mortars as a tool in studying specific hydraulic components: application to the study of ancient Naxos aqueduct*", *Applied Physics A: Materials Science & Processing*, Vol. 104, Issue 1, pp. 335-348.

[5] Lourenço P.B., (2002), ‘Computations on historic masonry structures’, *Prog. Struct. Engng Mater.*, Vol. 4, pp. 301-319.

[6] Spyrakos, C.C. (1995) **‘***Finite Element Modeling in Engineering Practice’*, Algor Publishing Division, Pittsburgh, P.A.

[7] Leftheris B.P., Stavroulaki M.E., Sapounaki A.C. and Stavroulakis G.E., (2006), *Computational Mechanics for Heritage Structures,* WITpress, Boston.

[8] Stavroulaki M.E., Stavroulakis G.E., (2002), ‘Unilateral contact applications using FEM software’, in *Intern*. Journal *of Applied Mathematics and Computer Sciences, Special Issue on ‘Mathematical Modeling and Numerical Analysis in Solid Mechanics’*, Guest Editors M. Sofonea, J.M. Viano, Vol. 12, No. 1, pp. 101-111.

[9] Stavroulaki M.E., Sapounaki A.K., Leftheris B.P., Stavroulakis G.E., (2002), ‘Nonlinear finite element for damage analysis of the Plaka stone bridge in Epirus’, *GRACM 2002 4th Hellenic Conference of Computational Mechanics*, D. Tsahalis (Ed.), University of Patras, Greece, 27-29 June, CD-ROM.