TECHNICAL ASSISTANCE WORKSHOP
FOR THE WORLD HERITAGE SITES OF
THE CRAC DES CHEVALIERS, PALMYRA
AND THE ANCIENT CITY OF DAMASCUS
Beirut 13, 14, 15 December 2016

REPORT I:
CRAC DES CHEVALIERS

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Discussions concerning the Crac des Chevaliers site were held in Beirut (Lebanon) on 13 December 2016 as part of the Technical Assistance Workshop on the World Heritage sites of the Crac des Chevaliers, Palmyra, and the Ancient City Of Damascus, in response to the Decision 40 COM 7A.20 of the World Heritage Committee recalling “that the State Party should continue to safeguard the Crac des Chevaliers through minimal first aid interventions, to prevent theft, further collapse and natural degradation, and refrain from undertaking conservation and reconstruction works until the situation allows, for the development of comprehensive conservation strategies and actions that respond to international standards in full consultation with the World Heritage Centre and the Advisory Bodies”.

Representatives of the Directorate General of Antiquities and Museums of Syria (DGAM) participating in the workshop, and in particular Mr. Hazim Hanna, in charge of the restoration works at the monument, presented:

- The clearing and temporary shoring that were undertaken at the site of several structures damaged by the conflict, prior to May 2014,
- The consolidation and restoration work planned in the coming months.
It is here proposed to discuss the detailed examination of these two categories of work:

**Work already completed (since May 2014)**

The implementation of these early works was characterized by a number of constraints imposed on those responsible for the monument:
- The State Party’s request to intervene swiftly in order to proceed with the -even symbolic- reopening of the monument to the visit with acceptable conditions of security,
- Relatively modest budget available for works and no effective commitment for funds allowing definitive work,
- An implicit or explicit aspiration, both of the government authorities and DGAM, to erase quickly the stigmas of the damage caused by the armed conflict.

These constraints have resulted in:
- The rapid clearing of the collapsed materials, whereas in some places their mass and collapsing position could have contributed provisionally and economically to the temporary stability of the damaged structures,
- Clearing carried out without inventorying and locating the collapsed stones, thus complicating the subsequent reuse of stones and anastylosis for the reconstruction of the destroyed structures,
- Shoring (arches, brace links, etc.) made of wood - hence of low durability – of sub-dimensioned sections that are incapable of fully holding the charge loads. An alternative option of shoring in temporary masonry (cement blocks, hollow tile, or even piles of sand bags) would have responded more effectively to constraints of stability, economy and durability, in particular given the uncertain schedule for the implementation of restoration works.

These actions were driven by extreme urgency, economy and feasibility. Nevertheless, it can be a lesson learned for similar cases, on other parts of the monument and elsewhere.

Also, it must not be forgotten that beyond the visible damages and disorders resulting from the conflict, the shocks and vibrations induced by the explosions create invisible damages, which could deteriorate in the months or years to come.
At this stage, the technical recommendations for the Crac des Chevaliers are also be valid for many other monuments which have been similarly destroyed.

**Recommendations:**

1. Never dismantle the material that has collapsed on the ground without first verifying that it does not temporary stabilizes of the works affected by these disorders. This recommendation is accurate for structures destabilized or partly damaged by explosions, as in the case of "natural" collapses. As The collapsed material has been sorted, inventoried, localized, stored and protected for a potential re-use and anastylosis to restore the collapsed element preferably, or otherwise for the restoration of other masonry thus respecting the principle that "the materials coming from the monument must return to the monument".

2. Favor the use of sustainable and economical shoring materials (concrete blocks, sand bags) for provisional stabilization works, in particular when the planning for future consolidation interventions is not defined, thus ensuring the effectiveness for several years or even decades.

3. Explosions may have generated on the building’s structure or material, disorders that are “a priori” invisible. The secondary effects could only be noticed later. Therefore, the recommendation is made to reinforce surveillance and the monitoring of the parts of the building that are immediately adjacent to the damages, and carry out a diagnostic of the cohesion and strength of the materials that are still as well as of the collapsed materials potentially re-used for restoration works.

Restoration works planned in the coming months

The detailed inventory drawn up by the DGAM, with the corresponding data sheets, allow identifying a list of urgent interventions with different levels of priority. It is important not to focus solely on the damage caused by the last conflict, but to adopt a more comprehensive approach that takes into account all pre-existing pathologies resulting from natural deterioration.

The challenges are multiple and can be considered from two different angles: on one hand, the evolution of disorders, on the other hand the importance of the risks induced to the building.

The importance, complexity and thus duration of the different key steps to be considered before any restoration is implemented are a third imperative. Those stages are namely: undertaking studies (documentary, graphic, static, materials, etc.), getting appropriate expertise and validation for the works proposed.

Finally, the need to mobilize adequate funds for the implementation of works represents a fourth constraint.
Crac des Chevaliers
Immediate Interventions
(1) Destabilized pillar and collapsed vault
(2) Vault of the cistern in the central courtyard
(3) Vault and terrace of the chapel
(4) Vault and terrace of the Leader’s Tower
(5) Vault leaning against the upper wall in ruins
(6) Parapet of the North curtain of the 2nd enclosure
(7) Small staircase of the Tower Sultan Qualawun

EMERGENCY INTERVENTIONS
Interventions to be studied in parallel
(8) Rear of Tower Al Zahir Bybars
(9) Wall above the Hall of the Knights
(10) Hall of the Knights (Gallery)
(11) Cannon staircase
(12) Upper wall in ruins between the two towers
(13) Bedrock at the NE of the 1st and 2nd enclosures
The recommendation would be to carry out in the months to come, e.g. at the end of the next 6 months, the following works:

- **Restoration works on stabilized elements, more or less at risk**, in particular the main pillar and the collapsed vault at the south of the gallery of the Hall of the Knights (1).

The option of a complete reassembly of the collapsed vault, which has been but well-documented before its destruction, is retained. It is recommended to:

- Keep the maximum number of original stones for the pillar, replacing strictly the ones that cannot play their static role anymore (estimated at 1.14 m. cu.). Reintegrate to the old cladding the new material, carefully cut and sized.
- Reuse as much as possible the original stones of the vault sorted from the collapsed materials, and supplement them with identical new materials extracted from the quarry of origin.

If budget constraints delay the restoration, at least protect the upper masonry of this structure from water ingress in order to avoid further disorders. To this end extend the waterproofing membrane in place, and temporarily seal and grout the joints.
Restoration works on structures (in particular vaults) where water ingress will result in a rapid degradation, but which works present no difficulty in terms of documentation and technicality. This concerns the following structures that have been damaged to the point of perforation:

- (2) the cistern’s vault beneath ground located at the foot of the old cannon staircase in the eastern area of the central courtyard,
- (3) the vault and terrace located at the first span of the chapel
- (4) the vault beneath the upper terrace of the Leader’s Tower located at the southeast corner of the second enclosure. Also undertake restoration works for the levelling and upper part of northern wall of the tower, twice impacted. In parallel, conduct a thorough visual examination completed if possible by simple monitoring (e.g. installation of Saugnac gauges) the overall stability of the tower, which Eastern base has also been damaged and potential risk of foundation settlement.

For the restoration of the vaults, ensure a maximum reuse of the original materials and restore the continuity of the superior seals guaranteeing that the concerned terraces are kept out of water. In anticipation of the restoration, install urgently temporary tarpaulins or sheets of metal on the perforations generated by the projectiles to keep structures out of water and allow the drying of the masonry in place.
Restorations that are less urgent but necessary and relatively simple to undertake:

- (5) Restoration of the section of the vault at the west side of the ruined wall forming a screen between the Tower of Command and the Tower of the Knights, at the South of the second enclosure: vegetation control, jointing, sealing and rock filling;
- (6) Reassembling, with the maximum reuse of original stones, the recently destroyed portion of the parapet in the crenellation of the north curtain of the second enclosure (at the East of the Daughter of the King’s Tower);
- (7) Restoration of the stairs demolished at the back (North side) of the Tower Sultan Qualawun, the central squared tower located on the southern curtain of the first enclosure.

The rapid launching of this series of work would allow, at the end of the months to come, a first experience feedback with the DGAM managers in charge on the difficulties encountered, the confirmation or reorientation of technical approaches, need for additional approvals, etc.
• In addition to these priorities that are relatively simple and rapid to implement if a budget is available, a number of complex restoration works have been identified. Each of the following operations will need further studies and the development of a restoration project, to be submitted to UNESCO before its implementation.

- (8) Stairs, vault and back side wall of the damaged Tower Al Zahir Bybars, at the south-western corner of the first curtain: The area was quickly cleared from debris; the shoring of the staircase vault is insufficient. This is a temporary situation that should not last. The perforated vault no longer keeps the tower out-of-water holding and the relatively thin wall of the rear façade is alarmingly instable. It is urgent to consolidate the weakened structure by:
  • Installing urgently a temporary umbrella over the opening of the destroyed vault and shoring of the two doors located at the ground floor of the rear façade,
  • Establishing simultaneously a detailed survey of the damaged structures and develop a restoration project, to be submitted to UNESCO, which should aim at:
    - preserving as far as possible the original stones in place defined sound and stable by the diagnostic conducted, even if they show traces of impacts,
    - replacing only the stones that are too weakened or degraded to ensure an effective static role,
    - recovering and reusing as much as possible the original material found in the pile of debris, reintegrating it while reassembling the masonry (estimate of 30% of reusable stone).
- **(9)** Wall on the terrace above the Hall of the Knights, at the west of the central courtyard:
  The isolated wall is a vestige of a former upper room, which seems to present a major risk of collapse due to the lack of bracing and the poor cohesion of the masonry, in particularly on the rear (western) face. Without analyzing the situation on the field, it is difficult to confirm the effective seriousness of the risk.
  However, in anticipation it is recommended that the DGAM undertakes a detailed survey of the structure (front and rear facades + two to three sections) and makes a proposal for a feasible the temporary shoring and/or definitive consolidation, which would be examined and approved in the framework of an expert mission to the site.

![Inner face of the wall](image1.png)

![Gallery of the Hall of the Knights topped by the wall (exterior face)](image2.png)

- **(10)** The gallery of the Hall of the Knights (west side of the central courtyard):
  This is one of the major architectural masterpieces of the Crac des Chevaliers, whose façade with Gothic arcades as well as some of its molding have been badly damaged by the bursts of a projectile fallen in the courtyard.
  The comparison between old and recent pictures of the arcatures show the restoration carried out on the elements in the 1930s by the French teams, putting into question today the authenticity of the elements still in place after the recent destructions.
  The range of restoration options could go from one extreme to the other, from the preservation of the elements as they are today "martyred" by the conflict, to the entire restoration of the elements as they were before destruction, including various intermediate options.

To move forward with complex choice, it is recommended that the DGAM undertakes the following actions in order to anticipate the experts’ mission to the site:

1. Gather as much as possible all documentation available for this major architectural element: archive photos, old and recent surveys, plans, archaeological studies and existing publications, documents relating to previous restoration campaigns, etc.
2. Conduct, based on the documentation, a critical analysis of the authenticity of the element, to be translated by a cartography that is dating and identifying masonry works, in plan, sections and elevations,
3. Conduct a structural diagnostic and draw up a similar cartography showing the state of conservation of the element (stones in good condition, degraded, very degraded, collapsed, missing, etc.)

This methodical approach should allow specifying and provide guidance on the scope of restoration options, by crossing the criteria of authenticity and state of conservation. It is recommended to submit the results of the study to UNESCO before undertaking any restoration works.
Arcatures on the front façade of the Hall of the Knights after the destruction

Interior of the Hall after destruction

The Hall after its cleaning
- **(11) Cannon staircase:**
  Also located in the central courtyard opposite the Hall of the Knights, this structure illustrates a major historical change brought to the original defensive system of the Crac des Chevaliers, showing the evolution of the history of fortifications and military armament in the Middle Ages, with the first use of artillery at the upper terraces (complementing the firearms positioned in priority inside the towers).

  The low slope and the large width of this staircase were allowing handling up the heavy artillery material. The later creation of the staircase results in an independent structure abutting the preexisting façade without any junction.

  The collapsed stones of the destroyed staircase have been hastily cleared without carrying out a careful inventory the stones were moved and provisionally stored.

  The complete restoration of this major element testifying to the history of fortification of the Crac appears absolutely imperative. It has been well documented before its recent destruction, with a highly precise survey available to guide restoration works.

  The staircase is also essential to guaranty the fluidity of the visitor flow, which reached up to 9500 visitors a day before the conflict. The restoration should be undertaken by reusing as much as possible the original material back to its original location or similar location, most probably complementing them with new stones.

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*Section on the inner courtyard, with the cannon staircase, before recent destructions (survey by John Zimmer)*

*Recent damages to the cannon staircases*

*The inner courtyard after the cleaning of the rubbles of the staircase*
- *(12)* High wall between the Tower of Command and the Tower of the Knights:

This masonry in ruins that forms a screen between the two towers is the vestige of the rear facade of a building, vaulted at this ground level and lately added to the crenellation of the south face of the 2nd enclosure, which has now disappeared.

Its northern rear cladding is well preserved, but its southern façade appears to have widely lost its cladding and therefore degrades rapidly.

DGAM made proposals for the consolidation of the wall, in order to ensure the stability and reinforcement of the structure, which is very exposed to wind forces (partial reassembly of the missing vault and stiffening cables between the two towers). However in the absence of drawings, it is difficult to decide the relevance and effectiveness of such a device.

Without contesting this option that could be further developed, it appears essential to precisely survey and draw the two elevations as well as several sections of the masonry.

The consolidation project is a particularly delicate project to design and implement, as the structure is extremely fragile. Furthermore, it should not alter the ruined silhouette of the wall, which is archaeologically significant (added building) and aesthetically interesting because of its picturesque character in the general silhouette of the fortress.
Stability of the bedrock on the Northeast sides of the two enclosures:
On this side, the basaltic base of the fortress presents natural cracks that are more or less deep and often degraded by the growing of vegetation.

It superficially results in rock falls that are a threat to visitors but it is also likely to put the stability of the walls the bedrock supports at risk.

The following interventions are recommended:
- Vegetation control
- Grouting shallow cracks
- Injection of mortar into deep cracks
- Filling deepest crevices with rubble sized stones.

As the site is not open to visitors yet, these works are not a priority. However, it would be useful to proceed with fist tests in order to develop and validate the protocol for implementation, during the next expert mission to the site.
Aside to damages resulting from the conflict the "normal" erosion of the monument should be taken into account: in order to avoid the natural degradation of the monument, it is recommended to budget and reactivate the regular maintenance, which has been interrupted for six years. In particular, it should focus on vegetation control on the façades of the fortress (walls, glacis, crenellation) and jointing with traditional mortar (lime, brick powder and pozzolana) the degraded areas exposed to water ingress.

DGAM is encouraged to pursue the works started to this end.
Conclusions and summary of recommendations:

A. Approve that the DGAM undertakes the below listed emergency works of average complexity, to be carried out within the next 6 months if possible, given that if the situation allows a UNESCO technical assistance mission to the site would then take place to examine and reoriented works if necessary.

1. Destabilized pillar and collapsed vault at the south of the gallery of Hall of the Knights,
2. The vault of the cistern in the central courtyard,
3. Vault and terrace of the chapel,
4. Vault and terrace of the Leader’s Tower,
5. Vault leaning against the upper wall in ruins between the Tower of Command and the Tower of the Knights,
6. Parapet of the north curtain of the 2nd enclosure,
7. Small staircase at the rear of the Tower Sultan Qualawun (central South Tower of the 1st enclosure).

B. Request the DGAM to develop accurate drawings in plans, sections and elevations, and undertake a technical diagnostic of complex pathologies and risks of instability affecting the citadel, within the next 6 months if possible, given that if the situation allows a UNESCO technical assistance mission to the site would then take place to examine results and give recommendations on the restoration projects to be implemented for the following structures:

8. Rear of Tower Al Zahir Bybers (Southwestern corner of the 1st enclosure),
9. Wall above the Hall of the Knights,
10. Gallery of the Hall of the Knights,
11. Cannon staircase (inner courtyard),
12. Upper wall in ruins between the Tower of Command and the Tower of the Knights,
13. Bedrock at the Northeastern of 1st and 2nd enclosures (testing operations).

During works and before a UNESCO technical mission could take place to the site if the situation allows, documents showing the progress of works at the site and the studies undertaken could be submitted to UNESCO for examination.
In the medium term, an overall **Conservation Plan** including a risk management plan, should be developed addressing the priorities listed above in paragraph A, the more complex projects identified in paragraph B, as well as regular maintenance works and future restoration projects for the monument. This would clarify planning and setting priorities, technical issues, budget and time phasing.

Although this report has been developed through a desk study, as a mission to the site could not take place, it can be considered a first draft to the development of a Conservation Plan.

In Annex I and in complement to this report, the engineer Salvatore Russo has proposed technical recommendations for consolidations and a methodological approach a technical diagnostic to be conducted at the Crac des Chevaliers.
ANNEX 1

3. Crac des Chevaliers (13/12/16)

3.1 Technical issues raised

- The emergency static safeguards are few and undersized; they, however, appear only on the outside;
- We need to understand the type of joint between stones in load-bearing walls;
- It is necessary to assess the extent and nature of cross-sections of masonry walls;
- We must reduce the spontaneous loss of material in the most damaged areas;
- We require stabilization of the most damaged masonry walls still under collapse’s risk;
- In some cases the existing shoring systems should be improved (even if already done)
- It is necessary to verify the extent of the internal damage in the monument in a complete and comprehensive way with specific reference also to the arch and vault systems.

3.2 Proposals for technical solutions

- Need for a targeted structural monitoring;
- Implement and integrate the existing wooden shoring and add new principal shoring (see: Annex 2 to 9). This action could be extended after the suggested internal and external structural damage's survey;
- Using wooden shoring lattice structures in all the openings - doors and windows - in the most damaged areas (see detail in Annex 2 to 4);
- Use resin for the restoration of damaged and cracked stones at the base of the monumental complex - to stand foundational level - if confirmed that there are not a cause related to structural aspects. In any case the type of resin to be used must be previously studied in order to be compatible with the type of stone and the environment aggression characteristics;
- Optimize the presence of emergency structural shoring which will also serve for the restoration and not only for an interim basis;
- Shore up all the floors affected by the bombing;
- Cover with geotextile all holes that affect the covering in order to reduce the potential degradation caused by the bad weather.

3.3 Technical recommendations for the future

As for the technical recommendations, they are given below in summary form and chronologically sorted:

1. Complete relief of the structural damage that affects the entire historic complex by means of accurate visual inspection, internal and external, not limited to the areas that denounce the major and visible damage but, above all, in areas which seem not to have been damaged. That recommendation is deemed to have strategic importance for the future restoration of the monument;
a. Transfer the results into drawings (plans, cross sections, details and prospects) which will form the basis for the strategic choices of structural emergency shoring and of the restoration project;
b. Also add to drawings the different levels of structural damage (Damage Categories - DC) as follows as the reference framework for the survey team:

- DC1 – cracks in the walls across the joints
- DC2 – cracks in the walls across the stones/bricks
- DC3 – detachments
- DC4 – discontinuities
- DC5 – fractures
- DC6 – material losses
- DC7 – local failure
- DC8 – global fail
- DC9 – out of plane displacements (walls)
- DC10 – phenomena of rocking facades
- DC11 – crack’s survey in vaults and arches
- DC12 – crack’s survey in the floors
- DC13 – crack’s survey in columns and pillars
- DC14 – crack’s survey in bases and/or foundational systems

Using the same acronyms proposed above - from DC1 to DC14 – the individual damage detected should be shown in the relevant drawings in point 1.a);

2. Analysis of the incipient and expected collapse mechanisms according to the results of point 1;
3. Design, implement and calculate the emergency shoring on the basis of results of points 1 and 2 intended as a first step useful for restoration project (see: Annex 2 to 9);
4. In the more complex cases of recovery and reinforcement of structural elements or macrostructures it is recommended where possible, to proceed with the combination of sonic and endoscopy tests before choosing the adequate reinforcing system, in order to assess the real extent of damage; When stones with a load-bearing function need to be completely replaced - as damaged ones are no longer usable - make a preliminary test campaign by means of a Rebound Hammer – also supported by the analysis of the available historic documentation - and choose new stones as compatible as possible compared to the existing ones. The compatibility check will be done using the Rebound Hammer for comparison between the new stones and to the ones in situ that are still intact and taken as a reference;
5. For complex cases, the use of a 3D numerical finite element analysis – FEA, (Finite Element Analysis) approach to simulate the expected behavior of the reinforced structures is suggested;
6. Based on the points 4, 5 and 6, take the most appropriate technical actions for the structural reinforcement in respect of the historical identity of the monument;
7. In the most damaged areas, the rubble should not be moved before having checked their possible contribution to the temporary stability of the structure or portion of the structure, which have collapsed. In the most sensitive cases, a preliminary analysis with endoscopy and sonic tests could be useful. The shoring could even be completed before the moving of the rubble, raising the level of security and safeguard of the damaged parts of the historic building.