Masonry structure in the Crusader’s Castles – Syria

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ABSTRACT: This research is dealing with the fortified complexes, which have been built during the Crusaders’ invasions in Syria. In some cases reusing structures already existing, and later transformed by the Arabs. These complexes are under exam regarding their architecture and building structure, which is entirely in masonry. A special attention has been given to the structural design and typology, structural detailing and their production and assembly, as well as the structural behavior on the whole.

This study gave first of all an important contribution to the History of Construction; either in the Arabic as in the European context, as the building of these complexes marks an important point of intersection of both “worlds”

1 INTRODUCTION

As a matter of fact, it was not yet known and one of the objectives of the study, to what extent European planners and craftsmen worked on the realization of these complexes, or local technicians, or skills from other parts of the Arabic-Islamic word, and to what extent different technical experiences have merged in these works and have perhaps later on the development of architecture and construction techniques in Europe and in Syria.

Besides that, such a study was a necessary prerequisite for the requalification of the restoration works that have been carried out in the past, towards the preparation of those works that urgently have to be done in the next years. Therefore, the study was planned to be carried out in close contact to the ministry of culture, and the Ruins administration (DGAM) in Syria, as well as to the specialists assigned for the realization of the future restoration works.

In the middle ages during the struggles that have taken place in the entire area associated with the Holy Land, these castles and fortifications moved from one side’s domination to other, according to the battles results, especially on the Fort-line between the Moslems and the crusaders. As a rule, every party added his own structure during his domination of castle in order to reinforce and improve it to use it later against the opposite side.

Particular group of castles have belonged alternately to the two sides appeared, and therefore different architectural styles, additionally to the existing Byzantine buildings, and fortifications, can be noticed there. Most of these castles were old Byzantines constructions or sites, after, the Crusaders and the Moslems occupied it; different architectural styles, construction technologies and details, and materials can be associated with these different groups.

For long centuries, these complexes suffered from negligence and damages, while people, through the last centuries, beside the weather, earthquakes, and wars, caused the decay, and damaged these nice buildings.

Nowadays it became in care of the organizations and the administrations, so that, some of preserving studies and works have been done to these complexes, most of them was supported by the (Age Khan Group For Architecture), and some other works was done by the ministry of culture, and the Ruins administration (DGAM), in Syria.
1.1 Research goals

The need of a good documentation and a surveying, arise strongly. Especially that international organisms such as Unesco, offered to take part in the restoration works or to support it through the Syrian government.

While we still miss the basic surveying of these complexes, the restoration works are going faster and faster, without taking care to the speciality of every kind of masonry, and the speciality of its problems, though most of the restoration works are just reshaping, cleaning, or filling cracks without searching deep in the causes and the results of every restoration task.

One can summarize the aspects needed:

- Knowledge about the old construction techniques and the stone cutting methods used to build up these complexes.
- Knowledge about the old materials, which were used (mortar, plaster, and the stone kind).
- Survey of some important complexes, defining recent decays for every kind of masonry and what further damages need to be expected.
- Evaluation of the restorations, which have been completed, as well as evaluation of the materials used.

2 RESEARCH ITEMS

This research has two main bases on which we can built all the research structure we are waiting to achieve, the bases which are Study on material and their properties, and searching the old building technique, afterwards we can start the main analysing tasks.

2.1 Study on material and their properties

In this main item we have deal with the old building materials was used to built up these castles, examine the stones, the mortar, and the plaster.

It was necessary to define the materials used in every masonry type, this could help later not only to distinguish the masonry builders in the undocumented sites, but also to suggest the new restoration materials.

A complete knowledge about the materials, was the right base to define the decay in every material, such as the stone decays, mortar and plaster decays, this made later the structure damages more clear and understandable.

2.1.1 Taking samples

A lot of samples have was picked from these historical sites and brought to the testing in the facilities in Dresden University of Technology.

The aim of this work was not only getting the final tests results for the materials which used in the formal times, but to have also a complete scientific example of taking samples, and the documentation work, the example which can be used as a mythology in documenting the other Syrian historical site.

Samples report was made for every site, in which you can find the exact information for every sample, the weight, size, characters, notices, and the place it was taken.

The first sampling works was done the two important castles Saone, and Crac des Chevaliers, the samples were taken mainly for mortar, plaster and stone, from the main three masonry types, these samples was taken from walls, and vaults. While we still need some more samples from the roofs and the pavement.

For this some investigations using the drilling technique are to be made, in the next few months while the tests will be made also in the TU Dresden laboratories.

2.1.2 Samples tests

Stone samples have been tested in the facilities of the Dresden University of Technology. Chemical and physical analyses of mortar and plaster samples have been be taken out at the Materialprüfungsanstalt Dresden and the Dresden University of Technology. Preliminary test are currently in progress. Such like the pressure tests and the water absorption.

Decay catalogue is to be completed in which we can find an example every type of material decay, this will make the next analysing steps more easy, so in case of need we can find back the necessary information using this guide.

2.2 Study on the building technique

Understanding the building technique in this research is the base, which we have analysed on the structural behaviour in this study we have worked on.

Figure 2. Pressure tests – Characterizing the stone resistance.

Table 1. Damages documentation.

<table>
<thead>
<tr>
<th>No: Yah S3</th>
<th>Decay description</th>
<th>Photo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decay:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In stone</td>
<td>Caving in the lime sandy stone.</td>
<td><img src="image1.png" alt="Image" /></td>
</tr>
<tr>
<td>Climate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decay</td>
<td>Stone is brown to red.</td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yahmur</td>
<td>Can easily crushed by hand.</td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
</tbody>
</table>
2.2.1 Structural items definition.
In this item I have worked to define the structural items were used in every masonry type. Islamic, crusaders, Byzantine, through his work a lot of 3d cad models and photos have been made and collected in tables in which you can fined the full description of every structural item.

We have started with notifying the vaults kinds and we have described these vaults according to the stone ashlar and the building technique as Figure 3 shows.

2.2.2 The Streotomy Art
A knowledge the stone cut in every structural item or in every decayed building can make the damage more understandable in the structure, its also necessary to give during the restoration tasks the good genius suggests.

This research item also has a special importance for the architecture history development, because most of the stone cuts techniques in these castles where not documented yet any of the Streotomy books such like Frézier.

A detailed drawings and 3D models where made to show the stone cut and the way used to do this fine stone cuts.

Figure 3. Special stone cut vaulting works, Saone.

Figure 4. Stone cut in Crac des Chevarlies.

Not only documenting the stone cuts, but only the aim was inventing some simple ways to be used in the workshop during the restoration progress, which can be easy enough to be carried by the normal workers under the supervision of the architect or the responsible engineer.

A stone cut guide was set with all the necessary photos to show the way of inventing the stone units in the workshop and we show an example for one of these units in Figure 4.

2.3 Analyse
After exploring the complete information finding out the last two research bases we can start analysing the result to reach the goals of the research.

2.3.1 Analysing Structural behaviour
The structural behaviour and the possibilities of reinforcement of the historic masonry is under study basing on the vast experience available at the Dresden University of Technology, the work taken out in the IQN Project “Traditional and Innovative Structures in Architecture” and the Centre of Excellence in Masonry Construction. Numerical modelling of the structures and the possible interventions at the TUD is supporting this work.

Interventions will be developed that take in account the documentary value of the existing historical structure.

In this field we have started to model the structural decayed items in order to import in the structural analysing systems.

This way can be more scientific in giving accurate results understanding the real damage causes.

Accurate 3D models where done depending on a very accurate survey for the decayed items, these models are a scaled accurate examples on which we can analyse the cracks, to obtain the causes in a first step to stop damage and to find the suitable restoration solutions.

2.3.2 Evaluating the restoration works
After analysing materials that were used in these structures we can start to evaluate the restoration works, which took place in the past for many years using different materials. In this item we are defining the materials, which hurt these structures, and trying to find more suitable materials for every kind of masonry, which could be used in the next restoration work.

This also will solve the shape problem, which made the three kinds of masonry look the same after restoration, on other hand the new suggested mortars and plasters will take in care using the same old materials, trying to solve the colours problem which arrows in many sites after the restoration.
Many restoration works were done without a complete structural study, then our evaluation must carry the restoration solutions, which were adopted to solve the structural problems depending on the new information we had established, about the structural behaviour.

2.3.3 Survey
In this item we are working to name the existed documentation, as a result we will get a Guide catalogue in which we can find all the information about the survey and the stocktaking.

We are adding to this documentation some necessary survey for some highly decayed structures, and the other stocktaking for the examples we are working on.

This documentation was done in the normal manual way but in a mythology, which enables the restoration. Contractor to use it easily and to find in it all the necessary information for his restoration works.

Another important numerical technique — Photo geometry — will be used to get more accurate survey for the crusaders towers in Saone castle, this technique which we are trying to develop in a way that enable us to use in measuring the highly damaged stones to exchange it with an invented new ones. This technique will enable us to do all the cut drawings in the office or any another site away from the histrionic site.

2.3.4 Restoration and working methods
Some special restoration techniques are still under work. The solution, which fits to the special decays, can be found in these masonry types.

We can give an example for one of the special kind of vaulting used by crusaders in the main donjon and the defending towers in shone castle.

The towers, which were highly decayed by earthquake, are to be recompleted after it was highly damaged like the entrance tower in Sane.

Special tools were developed to invent the new stone unit in a similar technique of the historical ones was used before.

2.3.5 Documenting the historical development of the castles
This study is based mainly on the existing literature. Some verification, however, is necessary either from studies on site, especially regarding wall textures and construction typologies, as comparisons with contemporary structures in the Near East and in Europe.

But the new information we are adding in this topic is about the exchange in the building technique knowledge between the east and the west in that area of the world.

A special building technique were learned by the two sides, not only in the architecture types or designed. But also in the materials use and the Streotomy art.

In this item we concentrate about this exchange depending on the compression between the results we got through this research.

This research is to be completed in April 2006, so the work is still going on in the faculty of architecture in the university of technology in Dresden, many more samples are to be tested and more results are to be documented in the same way which we show during this short report.

Some more restoration solutions already exists and the techniques shown are just examples to show the documentation mythology we are using, while the documentation task will be finished in the final research stages.

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