THE IMPLICATION OF THE FACULTY OF ARCHITECTURE AND CONSTRUCTIONS IN THE REHABILITATION PROCESS OF ORADEA FORTRESS

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ABSTRACT

The fortress from the centre of Oradea spreads over a total surface of ~150.000 m ^{2}, and it is more than nine centuries old.

The fortress of Oradea, although its national and international **historical and architectural value** has been re-cognized, is in an advanced state of degradation.

Both the local administration as well as the citizens wish for the rehabilitation of the fortress and its reinstatement in the tourist, cultural and economic circuits.

The profound study of the classical techniques of building and seismic retrofitting, considering the structural behaviour of historic buildings and the intervention technique using compatible materials to the original ones, have become the new research objectives of the Technical Department of the Faculty of Arhitecture and Construction, Oradea.

Complex research programs have been initialized regarding the monitoring of the behaviour of fissures/cracks and existing damage; methods of consolidating and structure safety; rehabilitation of the foundations and brick masonry structures.

1. PREZENTATION OF THE FORTRESS

The pentagonal fortress is included in the modern coat of arms of the city and of the University of Oradea, (Figure 1) symbolizing its cultural antiquity.

Situated in the center of the city, the fortress spreads over a total surface of ~150.000 m^2, with a builtin area of ~26.000 m^2 and usable area of ~ 38.000 m^2.

The monumental ensemble (Figure 2) is comprised of:

- the defensive wall with five bastions, two gates and the moat with counterscarp (1570–1618);
- the pentagonal construction which includes the former princely palace (marked A, B, C), the baroque church (D) and barracks (E) , (1638-1780);
- thirteen annex buildings (marked F...M): bakery, casemates, customs, stables, the officers' barracks, etc.

The main functions of the fortress during its nine centuries of existence were for a long period military and defensive; Episcopal See of the Roman Catholic Church for 465 years; prison, archives, deposits and other secondary functions in the last 150 years.

The ensemble of the castle, with a renowned national and international historical and architectural value, is in an advanced state of physical degradation.

It is the wish of both the local administration and the citizens that the fortress be rehabilitated and reinstated in the tourist, cultural and economical circuits.

Figure 1.Modern coat of arms of the city and of the University

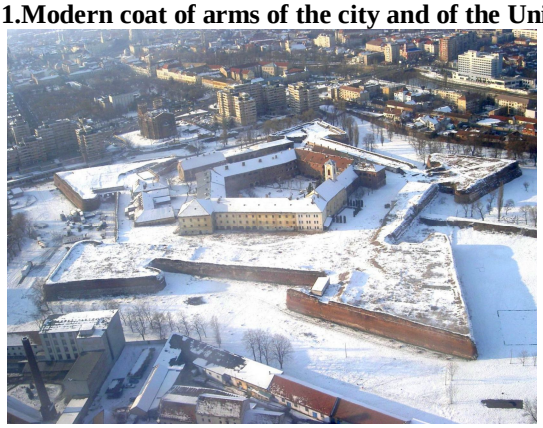

Figure 2. The monumental ansemble

2. THE IMPLICATION OF THE FACULTY OF ARCHITECTURE AND CONSTRUCTIONS IN THE REHABILITATION PROCESS OF THE FORTRESS

The profound study of the classical techniques of building and seismic consolidation, considering the structural behaviour of historic buildings and an intervention technique of using compatible materials to the original ones, have become the new research objectives of the technical department of our university.

Complex research programs have been initialized regarding the monitoring of the behaviour of cracks and other existing damages; methods of consolidating
and structure safety; rehabilitation of the foundations and brick masonry structures.
After observing the most important and frequent types of damage in more or less all the blocks from the fortress complex, and studying their causes, solutions were searched for eliminating the causes of these deficiencies and for structural rehabilitation.

Considering the points of view of experts expressed in the “Venice Charter” (1964) concerning the precautious usage of modern materials in the process of a historic building conservation and the recommendation that the intervening elements be recognizable and limited to a necessary minimal, consolidation with traditional materials and techniques is preferred.

Hereinafter will be presented the general physical state of the castle, and after those two recent interventions with the contribution of the students and teaching staff from the technical department.

3. THE GENERAL STATE OF THE CASTLE

The predominant construction material in the fortress is brick- and stone-masonry used ingeniously both in the case of walls as vaults (Figure 3.), arcades, slabs, plinths and foundations (Figure 4).

The number of floors of the edifices is B+ GF +1(2) F.

Most of the buildings have timber roof structures with tiles, and those that are attached to the fortification walls are covered with backfilling and vegetation (with the role of protection against cannonballs).

Excluding the wilful human ravage**, the major causes of degradation** of the ensemble are:

- the aging of the materials (the stone and the binder from the mortar);
- the lack of building maintenance;
- the degradation of the foundation due to rainwater infiltration;
- the appearance of vapour;
- lack of horizontal waterproofing, facilitating the capillary ascension of humidity in the masonry, destroying the quality of the construction materials;
- change in the environment (level of underground water, vegetation, climate, pollution, surroundings, etc.);
- the change in the original designation caused complex functional and structural modifications: interior space partition and extensions were made without the assurance that the different structures work together efficiently;
- exceeding the load-bearing capacity of the masonry structure due to exploitation and / or of incorrect consolidation;

The postponement of the most necessary intervention works lead to further deterioration and even to collapse.

Figure 3.Brick masonry vault.

Figure 4.Arcades in building L.

The characteristic degradations of masonry structures from the fortress of Oradea are:

— cracks and fissures of the masonry structures – walls and vaults above the basement, ground floor and upper floor, as a result of the foundation's degradation – example block I;

— fissures and cracks in walls, vault dislocations due to the lack of spatial co-work between the corridor and the rooms – example block A;

— the partial collapse of walls, due to over solicitation and the postponing of the consolidation works – example block E and J;

— the disintegration of masonry materials due to the humidity of the structure through capillarity raise – example block J;

The concept of the consolidation pursues the following objectives: eliminating the causes of damage, assuring that the different vertical and horizontal loadbearing elements work properly together and assuring the building's stability.

The recommended **procedures of the structural rehabilitation** are:
— grouting and caulking of the fissures and cracks;
— mending of fissures with clasps and reinforcements;
— rebuilding the dislocated walls;
— partial construction with concrete;
— the rebuilding of wall next to the doorways
— tying the corners' areas;
— introducing tie-rods;
— coating with composite materials;

4. INTERVENTION NR. 1

Eliminating the moisture content from the masonry, taking into consideration the retaining of the structural quality of the construction material.

To reduce the discomfort and the permanent disintegration of the masonry materials due to high humidity, a structural treatment with silicone micro-emulsion was done for the horizontal waterproofing in the conference centre from block J. The walls have a medium thickness of ~160 cm and consist of brick-masonry with a porous stone nucleus, with lime mortar joints.

The masonry construction materials (brick, stone, mortar) have hygroscopic qualities that determine the absorption of the humidity from the soil. Thus it is recommended that a protective layer be effected that will impede the ascension of the humidity through capillarity, and that will regulate the acidity and alkalinity of the injected elements.

Preliminary research:

A survey of the problems that impose interventions:
- The identification of the level of humidity and of the salts, from the surface of the walls;
- Complex and precise diagnosis by tests performed in a laboratory:
(average humidity of 15,4%; composition of the salts);
- Establishing the necessity of interventions through obtaining a horizontal, compact and waterproofing layer, which will prevent the capillary ascension of humidity through the walls;
- In some cases the preliminary removing the plaster on the damp areas.

Figure 5.Drilling holes

Figure 6. Put and stuffing the tubes

The intervention process:

— Securing efficiency by treating the wall simultaneously on both sides;
— Determining the grouting level – as close to the ground as possible;
— Positioning and marking the place of the orifices, which will be drilled – at a distance of ~20 cm from each other (Figure 5.);
— Drilling the wholes with a 18 mm bit, with a length of 70 cm in an oblique direction from up towards down;
— Removing the fine dust (powder from destroyed construction material) from the orifices, cleaning with compressed air or a vacuum cleaner;
— Introducing the special plastic tubes, with the help of which the grouting will be executed (Figure 6.);
— Preparing the grouting instrument and the system of tubes belonging to it (Figure 7.);
— Carrying out the grouting at 4,5 atm and disassembling the instrument (Figure 8.).

Subsequent measures and monitoring of behaviour during the use

- Ensuring the necessary conditions for the evaporation from the masonry situated above the waterproof area of the accumulated damp in time – in some cases pulling down the plaster and permanent ventilation of the rooms;
- Monitoring the physical behaviour of the masonry through observation and laboratory testing – results after a month from the treatment (decrease of the humidity level with ~5 cm; discoloration of the wall surface with ~2 shade or hues; average humidity of 8,9%).
- After a period of drying, depending on the wall thickness (~5 cm a month), the cleaning of the whole surface is recommended with metallic brush or using the more modern method of sand blowing;
- Cleaning out the wall's joints until the depth of ~2-3 cm;
- The last two operations concern the removal of the salts that appeared during drying;
- If the lab results indicate the complete dryness of the wall, one may proceed with its rendering;
- If the wall is not completely dried out, it is recommended that the rendering be made with a porous mortar.

Figure 7.Preparing the pipe network

Figure 8.The used grouting equipment

5. INTERVENTION NR. 2

Consolidation of the masonry, for the assurance of the structural stability of some walls/diaphragms in a state close to collapse.

This intervention was necessary in the case of block K, the former officers' barracks, due to the raised degree of structural aging (mostly brick, but also stone), the appearance of some cracks due to the lack of horizontal rigidity and lack of roof. In order to prevent the collapse of this building, it needs the raising of a new roof, but the state of the masonry – currently with a low capacity of load bearing – permit this only after a preceding consolidation.

The more than 230 year old walls have been consolidated before, two metal rods with anchor are visible, disposed at two meters from one other and framing the window opening at the southern facade of the K block.

Preliminary research:

– A survey of the problems that impose consolidation: the identification of the fissures, the disposal and monitoring of the crack markers to see if these are active;
– The exact survey of the affected areas – wall with brick arches, in some cases determining the necessity of previous propping up and/or rebuilding of dislocated parts;
– Adapting the solution of mending the existing vertical wall fissures, and the consolidation of the brick arches with elastic, austenitic steel reinforcement, provided with diameters of 6, 8, 10 mm. Next to the high resistance of these reinforcement, they have the advantage of being manipulated/modelled and cut easily, of being anticorrosive and of having a good adherence to the elicoidal traces, with which they are equipped;
– Performing some calculations and designing the optimal reinforcement.

The intervention process:

— Defining the deepness at which the reinforcement will be fixed ~3 cm;
— Positioning and marking the line of the reinforcement according to the drawings;
— Repointing the horizontal joints of a ~3 cm depth on the determined line;
— Drilling the arch for four radial anchors;
— Cut of the Φ8 austenitic steel reinforcement at the lengths indicated in the drawings;
— Cleaning of the joints with compressed air or vacuum cleaner and wetting the neighbouring masonry;
— Inserting the reinforcement and preparing the fixing mortar;
— Grouting the special mortar with a pistol;
— Maintaining the moisture content of the wall around the consolidated area for two days.

Subsequent measures and monitoring of behaviour throughout a period of time:

For the monitoring of behaviour during a period of time – of the work between the reinforcement and the brick masonry– of the consolidated system, the setting of crack marks next to the vertical fissures is recommended, and their observation;

In the case of the K block intervention, even if for the moment it was saved from collapse – the continuing of these urgent interventions is necessary, firstly pooting the roof over the building.

6. EPILOGUE

During the practical classes of civil engineering, third year, a great number of hours are dedicated to the study of the behavior of the simple masonry to different actions, which may be used at the rehabilitation of the castle.

An initiative of the technical department was to arouse the labour and creative potential of our students from the cadastre, architecture and constructions department, in view of a collaboration at the rehabilitation of the castle.

This way the students accompanied by a specialist teaching staff, have effected topographical survey of the ensemble and of its area; architectural surveys at blocks A, D, L, K; photographic documentation of the damages and of the most important interventions. They have also participated at the archaeological campaigns and at different unqualified labour (clearing away the vegetation, pulling down rendering, etc.)

As a result of its contribution to the rehabilitation of the castle, the young Faculty of Architecture and Constructions from Oradea will receive inside the castle a space to arrange a laboratory for testing building materials.