PROJECT OF INTERVENTION WORKS TO RESTORE A HISTORICAL COMPLEX - PART I

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Abstract. The historical monument called Yellow Ravine (Râpa Galbenă, Rom.) of Iaşi, subject of a consolidation and rehabilitation, has been in a constant state of decay for several years, up to 2005, when started a project of intervention works to save the complex.
The paper details the need of using the method of lowering the level of groundwater for removing and/or monitoring the level of ascending groundwater. The method helps to create conditions to eliminate the source of water through siphon drain systems, in order to dry out the damaged structure of this historic monument.

Key words: gravity drainage, siphon drains, ascending groundwater.

1. The recent historical perspective of the monumental Complex state

The historical monument called Yellow Ravine Complex was built between 1898 and 1900, on the basis of a draft drawn up by architect G. Vignale. The general plan provided the union of Charles Street with Railway Station Street crossing the Yellow Ravine valley to resolve a level difference of 28 m to 320 m in length. Since the maximum slope accessible to carriages at that time was 6% took the route extending to 550 m. Before 2005, the monumental Complex had been in a constant state of decay for several years. A basic visual analysis (Fig. 1, 2, 3, and 5) revealed the damage of the supporting wall, stairs, parapet walls and balusters and a slow landslide of the right slope. The damaged area was of 5200 m^2. Taking into account the historical, architectural and practical utility of the monument, its consolidation and rehabilitation was immediately required. Any delay would have caused the monument's condition to grow worse and further rehabilitation costs would have been incurred.

Fig. 1. – Front view photo of the historical monument Yellow Ravine Complex
Location: Central area of Iasi municipality between G. Muzicescu, Railway Station, Yellow Ravine and Gh. Lazăr Streets, covers nearly 7000 m^2.

Considering the significance of the monument as well as the damage complexity in relation to the permanent or temporary causes which led to the monument's deterioration, the City Hall of Iaşi Municipality decided to save the Complex.

The paper briefly presents an excerpt of the aspects which were dealt with during the technical stages (accompanied by comments) on which was based and executed the intervention project (a complex of hydro geological and structural strengthening works) to consolidate and rehabilitate the complex.

2. Assessment of the initial natural risks

2.1 The exposed historical objective requested in the period 2005 urgent measures for a complex strengthening to prevent the irreversible development of the existent deterioration. As the groundwater penetrated into the covering of the supporting wall, it might detach and fall down. This might have led immediately to the effective break of the wall (which is made of stone and sand bond, that is non - cohesive materials), and to the destruction of the corresponding sewage and of Gheorghe Lazăr Street.

2.2 Removing the cause of slow landslide under the concrete supporting wall and between the columns in the 3 area. This phenomenon will last and it will influence the stability of Gavriil Muzicescu Street and of the nearby houses (Boțu and Carastoian, 2005).

Fig. 2. Detail of the deterioration of the finish layer and of the damaged supporting wall, stairs, parapet walls and balusters

Fig. 3. Detail of the deterioration of the finish layer and of the damaged supporting wall, stairs, parapet walls and balusters

3. Detailed analysis of the monument's damaged areas

Remark: *At the time of the initial study of the damages caused by ascending groundwater, which was conducted directly in the location before starting the strengthening works (April - May 2005), the following aspects were revealed:*

1st Area

In this area no deterioration of the slope, street, sewage system was noticed. The tilted trunks of the trees planted on the slope were determined by a landslide which has been active for several years. At that moment, no deterioration was found which might be triggered by groundwater.

2nd Area

During the last years, the monument underwent *a series of significant deteriorations, primarily caused by the high level of groundwater.* The stone covering of the supporting wall came off on an area of nearly 10 m^2 on its left side. Taking into account the construction type (stone work with cement mortar), it was drawn the conclusion that this phenomenon was going to amplify unless the cause of wall covering detachment is completely removed. We should also point out that the supporting wall was made of non-binding material mix (broken stone and sand) with high rate of permeability (Boțu and Carastoian, 2005).

The main cause of these deteriorations was the water coming from the groundwater layer and from the urban sewage system leaks, as well as from rain. This finding is also supported by the fact that the damaged area was located exactly near a rain water drain which gets easily clogged up by large flows (diagrams P1 and P2).

Although the remaining wall covering did not come off from its initial position (there are still 2 parts which were about to come off and other areas with major cracks), it was noticed that on large areas, *it was affected by mineral salts from groundwater. In time, these mineral salts attack both the stone and the mortar used for the brickwork, and it is likely to trigger the collapse of the wall covering.* However, only part of these mineral salts is coming from groundwater (laboratory tests showed that the water collected from drilling F1 at a depth of 9.80 m is very poorly aggressive with magnesium Mg^{2+} and poorly aggressive with carbon dioxide), most of them coming from the salt thrown during winter on the footways, streets and on the stairs of the monument against sliding. This can be easily seen as the most damaged areas are under the two flights of stairs. *During the rainy periods, water has infiltrated in large part of the supporting wall at various depths.*

Significant structural damages were also found at the level of the two platforms making the connection Carol I Street and The Railway Street. Several types of deterioration (displacements, breaks, cracks) of stairs, parapets and balusters were noticed. Many of the elements were even partly or completely destroyed by the salts coming from groundwater.

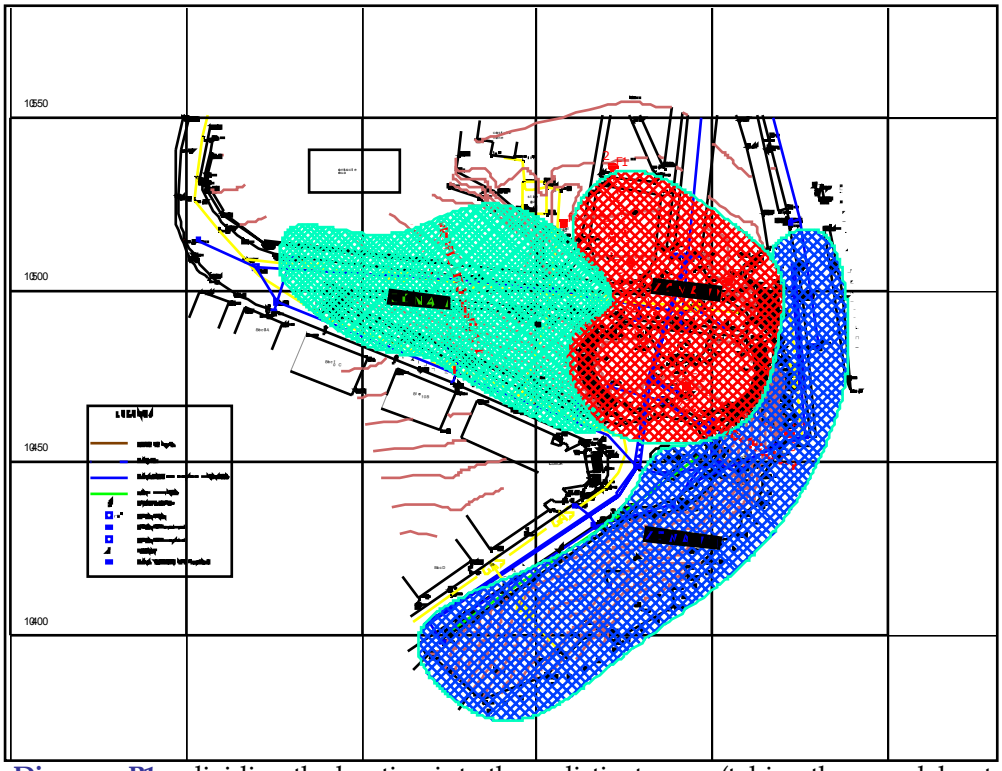

Diagram P1 – dividing the location into three distinct areas (taking the roundabout as reference point) where drillings F1…F6 were performed in 1st,2nd,3rd Areas.

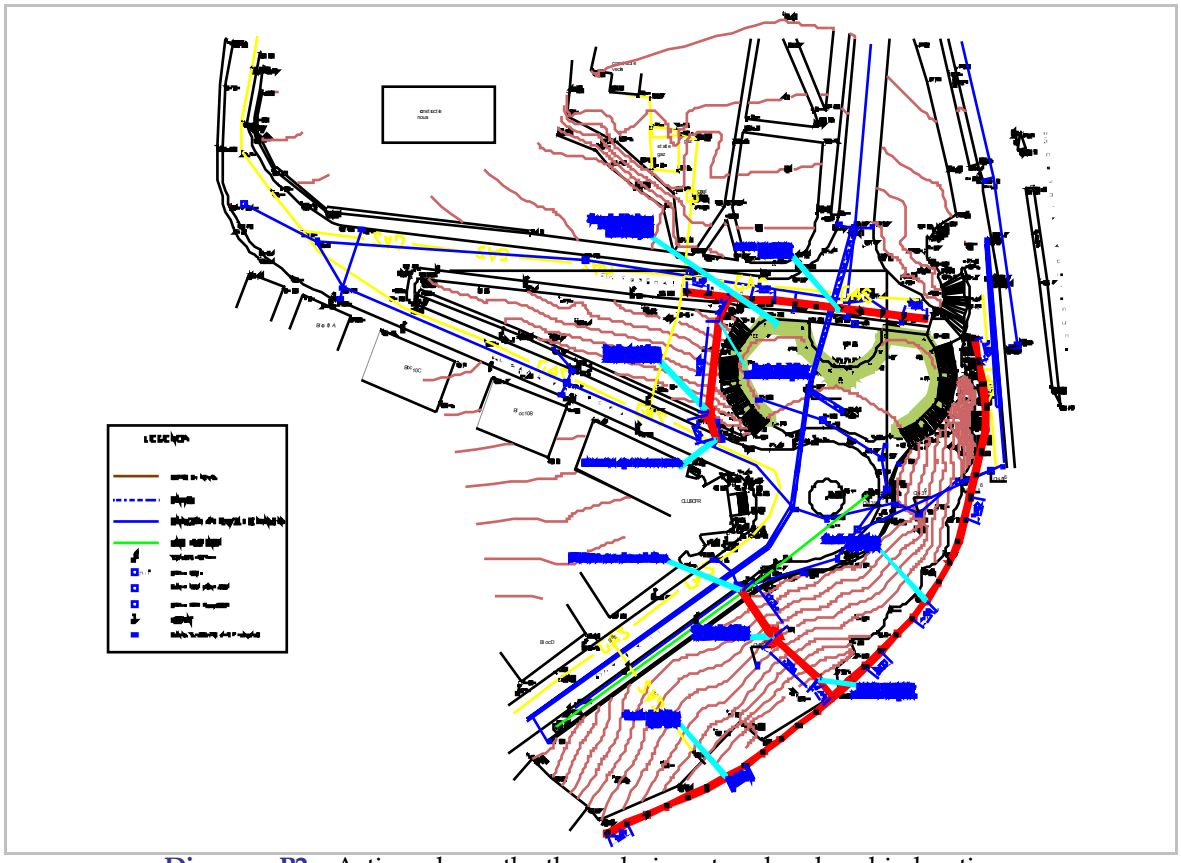

Diagram P2 – Action plan – the three drain networks placed in locations to increase their efficiency

During the examination of this part of the monument, an underground shaft was found (displayed in Diagram P2) through which sewage water and the water drained from the upstream are flowing towards The Railway Street. The construction is well preserved except for the wall of an internal refuge, whose brickwork is displaced.

All of the above described damages indicate the fact that in the 2nd Area there are no active or potential land slides. The actions which were performed as quickly as possible, aimed at the removal of groundwater from the supporting wall area and its waterproofing in the area of the wall coverage.

3rd Area

Although in the mid '80s large monument strengthening works were performed, it is still evident the phenomenon of slow land slide forming the slope. Its subsidence under the foundation of the supporting wall which reinforces the columns varies within a range of 30-50 cm. On the slope periodically spring out several streams with variable flows. It was seen that during rainy periods the underground water infiltrates in large areas of the supporting wall and in its foundation.

The phenomenon of slow flow also brought about the oval form and even break of two shafts located on the margin and at the basis of the slope.

The aforementioned damages occurred on account of the fact that during the strengthening works of the '80s, they did not build a drain in the upstream of the supporting wall which would enable the lowering of the groundwater to the to the level of the Railway Station Street and would remove the cause of potential landslides.

We point out that those works were not completely finished (balusters and parapets were missing, lighting poles were left unfinished), even though this did not influence in any way the damages presented.

4. Technical data of the work

In order to strengthen the monumental ensemble and restore its original appearance, *the design and execution of intervention works* were performed by the company SC PROEXROM SRL Iaşi, specialized in design, execution and prospecting in geological engineering and foundations, the City Hall of Iaşi Municipality being the beneficiary (Proexrom, 2005). The work started in 2005, it was carried out during 2006 and 2007 and the results of the intervention (Fig. 9, 10) have also been monitored since 2009 up today by the company's specialists and INCD URBAN INCERC, who supervised the operation of drainage network and equipment, assessed the intervention works' results and the provision of technical assistance for the beneficiary of the works (Cobzaru *et al.*, 2008). INCD URBAN INCERC (2009, 2012) also worked to issue the Technical Approval for the method stated as "*gravity drainage procedure based on siphons drains*" for groundwater control level, developed in France by the geotechnical specialist company GROUPE RESS, as scientific and technical results of over 10-year long studies. The French company completed this work, holding the European patent **EP 0678 632 B1** since 1999, Bulletin 1999/39 (INCERC Iasi, 2009).

Taking into account the causes of the damages in the three studied areas (as shown in cap. 3), the land bedding, the position of groundwater and the results

of the stability to landslide calculation, in order to strengthen the historical complex Yellow Ravine and to restore its initial appearance, the project solution after the feasibility study, considered to *lower the groundwater level to 9.00 ÷ 9.50 m compared to CTA, to create proper conditions for the monument's brickwork drying*. Thus, it was removed the main cause of deterioration of the supporting wall coverage and of the left slope (Fig. 1 and diagrams P1, P2) As there was a difference of level between G. Lazăr and Railway Station Streets of nearly 10 m (86, respectively 76 m height above sea level) it was necessary to lower the groundwater level with practically the same value. The water will flow into the shaft with automatic lock chambers, built at the height of +78.85 m above sea level and from here it will be discharged in the urban sewage system located along the Yellow Ravine Street.

We should also mention that the following works were also performed, in addition to the intervention already described:

- restore the damaged elements: stairs, parapet walls, balusters, balconies…made of stone resembling the material initially used; cleaning the salt deposits from the front's coverage;
- redesigning the sewage of the monument in order to remove the possibility of water leakage and infiltration in the supporting wall, or the landslide from the 1st and 3rd areas;
- remodeling ditches and gutters to take in surface waters;
- growing grass on the entire area or laying a garden lawn, especially on the slopes of the 1st and 3rd areas.
- restore street lighting and emphasizing the historical monument with light fittings.
- strengthening the walls of the shaft from 2nd area where it was necessary.

Fig. 4. – Overview of shafts

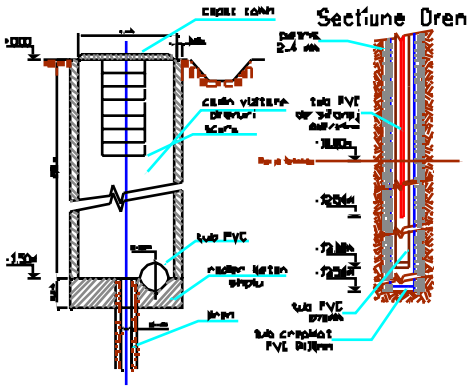

Fig. 5. – Detail of a drain section

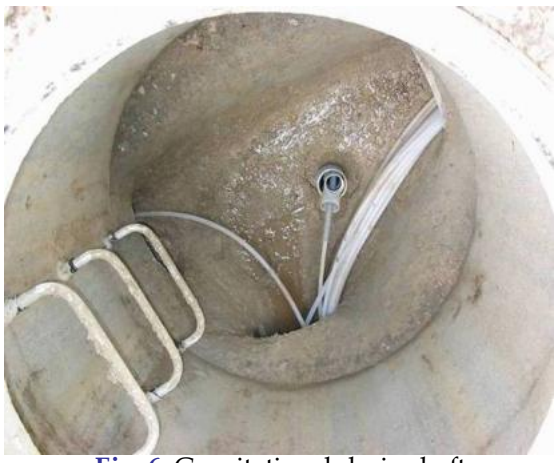

Fig. 6. Gravitational drain shaft

Fig. 7. – Automated lock shaft

Fig. 8. – View after end of works

Fig. 9. – The dry wall after drainage works

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