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Evaluation of the protection status of masonry crowns and proposals for their repairs – the castle in Janowiec on the Vistula

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Abstract: The article deals with issues related to the conservational protection of objects in the historical ruin. The article discusses the technical condition of existing protections, their impact on the historical matter and a method for repairing damaged wall crowns.

Keywords: castle, ruin, Janowiec, crowns of walls, protection of crowns.

Introduction

One of the basic features of objects in the form of a permanent ruin is a very large number of free-standing masonry walls. This number consists of historically free-standing walls (mainly defensive curtain walls) and the walls of the original buildings. Definitely the biggest problem is the second group of walls, which do not have a finial, which protects against the influence of atmospheric factors. In these structures without protective elements: roof, flashing, insulation, destructive processes are much faster and their negative effects are much larger than in other types of walls.

This article is devoted to the issue of the state of protection of masonry crowns developed as a part of works related to conservation and restoration in the castle in Janowiec on the Vistula. Work carried out in the 1976–1994 led to the construction protection and conservation of the walls of the majority of the castle. One of the last steps was to secure historical and secondary wall crowns using different technologies and materials.

Due to the deteriorating condition of the walls' crowns, in 2017, research and evaluation of the technical condition of the higher parts of the walls and elements protecting them was carried out. Due to the significant degradation of the above-mentioned elements, a number of solutions have been proposed to secure free-standing walls at the castle in Janowiec on the Vistula.

Types of protection of masonry crowns with assessment of technical condition

The protection works of masonry crowns are usually connected with partial or complete reconstruction of the wall. Depending on the assumptions of the conservation program, the method of securing the crown is chosen. Individual types of security features are characterized by different durability, readability, and reversibility of their use. Solutions aimed at protecting the crown against the influence of destructive factors depend on: the type of the wall – the form in which it survived to the present times, the type of construction and materials

in which it was erected, condition, architectural concept for the whole building, and the conservation works conception. Methods of securing the wall's crowns can be divided into two groups.

The first involves the creation of a new additional layer on the historical wall. In principle, it is a layer that can be destroyed and when destroyed, it will be periodically rebuild. This group includes: rebuilding of part of the walls, bricklaying, protection of the crown with mortar or concrete, and the technical-green method.

The second group are methods which aim is to cover and protect the historical matter against rainwater. This type of solution may be temporary or permanent. The second group includes: roofs, protection of the crown with steel sheets and chemical coatings.

In all cases, earlier repair of a degraded historical wall is required to a greater or lesser extent. The methods applied on the walls of the castle in Janowiec on the Vistula are described below.

Bricklaying

Bricklaying is the basic and most frequently used conservation treatment aimed at protecting the historic matter of the wall. It consists in completing defective or damaged fragments of the upper part of the wall, with the appropriate shaping of the upper surface. Bricklaying does not stop the processes of a crown destruction but transfers destructive actions to the material of the superstructure intended for periodical replacement. The correct selection of masonry materials and mortars is important to extend the lifetime of the security. The materials used must not adversely affect the historical fragments. The superstructure is made using native or foreign materials. In the case of native materials, over time the problem of distinction of additions may occur. When performing superstructures with foreign materials, the distinctive protection of the crown looks not natural and the artificiality of such a solution can be felt. An important advantage of superstructure is the ability to shape the crown line freely. This allows to obtain a shape, which is compatible with the historical state. Superstructure can be made with the introduction of the insulation layer.

The superstructures of the walls' crowns of the Janowiec castle was made mostly with the use of quartzite stone (foreign material on a strong cement mortar). In the case of all crowns, the insulation layer was not introduced in contact with the historic wall or the wall made of limestone rock.

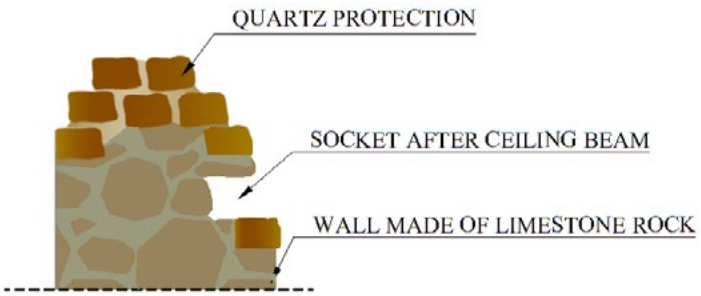

Fig. 1. Cross-section of the protection described

Fig. 2. Photo 1 Bricklaying the crown of the wall with a quartzite stone

Fig. 3. Photo 2 Bricklaying the crown of the wall with a quartzite stone

The technical condition of the quartzite superstructures is in most cases good or sufficient. There are minor damages, loosening of the quartzite material from the joints, and surface paralysis with the biological corrosion.

In insufficient condition there is a wall made of limestone rock directly under the quartzite superstructure. At the interface there was a strong degradation of the limestone wall. It was found that there were numerous large surface losses of masonry facing layers, losses of individual stone blows, defects and corrosion of joints. Degradation of the wall under the quartzite protection is related to the lack of any insulation at the interface of the layers. Over time, the quartzite superstructures lost their tightness and rainwater penetrates at the interface of quartzite and mortar into the interior of the limestone rock wall. In addition, the lack of drips allows penetration of water flowing down the quartzite superstructures.

An important problem is also the poor technical condition of the superstructures with quartzite for wall faults in the places of wooden ceilings (not existing at present). These superstructures, usually made of one layer of quartzite stone, are locally defective and detached from the face of the wall. Intense damage occurred mainly in the sockets on the ceiling beams.

Shaping the crown of the wall

The protection consists in making an additional layer, the purpose of which is to give a slope allowing the rain water to drain away from the wall surface. Various types of solutions are used, using mortars, concretes, and using native or secondary materials. In each case, the protected wall must be prepared in advance for the finishing layer (reinforced, standardized or aligned). The crowns are secured by profiling slopes of various shapes that allow water to be drained in one direction (one-side) or on both sides (gable or spineless). The assumption is that the slope layer should have tightness as high as possible so that rainwater can not penetrate into the protective layer and penetrate into the historical layers in case of absence of the insulation. In the case of low walls this method can be perceived as not very aesthetic.

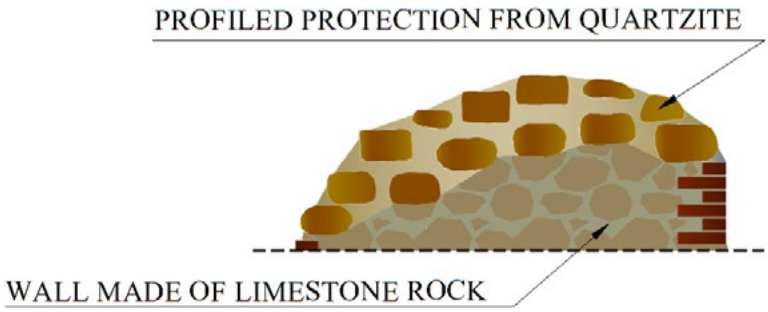

Fig. 4. Figure 2 Cross-section of the protection described

Fig. 5. Photo 3 Shaping the crown of the wall

The crown made of quartzite is in good technical condition. As a part of the inspection, longitudinal fractures of the crown were noticed (several meters long), which were most likely caused by the performance and deformations of the masonry structure. In the poor technical condition, as in the case of the superstructures of the original structures, significant damage was found at the interface between the crown profiled and the limestone rock wall.

Protection with ceramic materials

The protection is usually made of small-size elements, ceramic tiles, or glazed tiles on the mortar layer laid on the crown. This type of protection is of permanent character and is most often made in the case of the wall crowns of relatively small width at high altitudes. Due to the materials used, it is a solution with a very high

durability. This solution was applied on a significant part of the walls of the east wing of the castle in Janowiec and partly on the south wing.

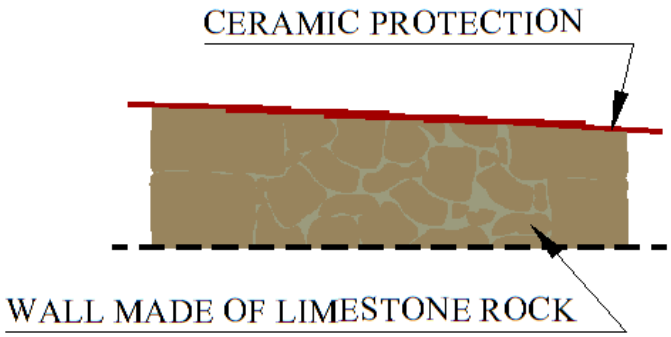

Fig. 6. Figure 3 Cross-section of the protection described

Fig. 7. Photo 4 Shaping the crown of the wall

The walls protected with ceramic tiles remain in a much better condition compared to other types of protections. The roof tiles beyond the face of the wall lead rainwater to the outside of the castle. No significant damage to the face was found directly under the roof. The condition of ceramic tiles is good. Only point damage to the security material was found.

Roofing

They are a little aesthetic, but permanent and reversible solution protecting the wall crowns from atmospheric precipitation. The most often canopies are made as temporary covering especially damaged or degraded fragments of walls and as permanent structures over pedestrian routes enabling visiting the crowns of the walls. In the case of temporary solutions, freedom is noticeable in the use of materials and constructional solutions. Permanent roofs in their form and material can be historicizing or completely contemporary. They are made directly on the crown or on supporting structures without permanently binding the material to the historical matter. As the covering material in roofs, metal sheets, laminates, wooden shingles, ceramic roof tiles, roofing paper are used.

In the case of the castle in Janowiec, a very large variety of applied technological and material solutions was found. The roofs of a wooden structure with roofing paper, corrugated board, and galvanized steel sheet are visble.

Fig. 8. Photo 5 Cross-section of the protection described

Fig. 9. Photo 6 Shaping the crown of the wall

The technical condition of the protection system is varied. Elements protected by steel sheets are in good condition in most cases. The extended metal sheets protects the face of the elements being shielded. No significant damage was found to the coating itself. The problem is not the great aesthetics of this type of protection and the color diversity of plates used in the Janowiec castle. Wooden canopies occurring primarily in the southern part and they are in a bad technical condition. Both wooden constructions and cover are damaged. The occurrence of newly erected protection structures has also been found.

Proposal to repair masonry crowns

Due to the technological and economic aspect of all methods used to secure the crowns of the walls, the methods of protection were chosen: by superstructure and roofing (by a lead sheet or ceramic molders). An advantage of the methods proposed is the possibility of re-using some of the materials that will come from the demolition works of existing protections. The proposed solutions together with the technology of their implementation are described below.

In all cases, due to the poor technical condition of the historic and secondary walls under protections, there is a need to carry out repair works consisting of bricklaying, injections, and other structural reinforcements.

Protection of the quartzite superstructure with an insulation layer

The technology of performing the protection of the quartzite superstructure with the insulation layer:

1. Removal of the existing protection layer of the wall's crown – in the case of demolition of the quartz stone protection, works should be carried out carefully so as not to damage the stone. The stone coming from demolition works can be used as a material for re-securing the crowns. The demolition stone must be protected from weathering during storage.
2. Visual assessment of the technical condition of the wall below the protection – a detailed inspection of the technical condition of the masonry structure is possible only after removing its surface layer. At the design stage, the designers were not able to make such an assessment. The inspection should be carried out by an experienced person with appropriate qualifications: designer or work supervisor. If the technical condition of the wall during the visual assessment is doubtful, it is necessary to perform a detailed expert assessment of the technical condition of the wall in a given place.
3. Preparation of the wall for the protection planned – after a visual assessment, a decision should be made regarding the works related to the construction of the wall under the superstructure.
4. Leveling the substrate for the insulation – due to the necessity of laying the insulation on flat surfaces and sharp edges of wall elements that can damage the insulation, it is recommended to create a leveling layer. The thickness of the leveling layer will depend on the shape and structure of the wall and the assumed slope. To level the surface for the insulation, it is recommended to use the trass mortar.
5. Laying the insulation layer – due to the need to create a waterproof membrane, it is recommended to perform the membrane from the roll materials. The flexibility of these materials allows to adapt to the shapes of the wall's crown. Joining the insulation layers must be carried out in accordance with the technical card and the manufacturer's instructions.
6. Making drips made of the lead sheet – in order to drain water from the face of the wall it is necessary to make drips. The lead sheet will allow to fit into the irregular shape of the wall structure. The drips should be attached to the previously made insulation.
7. Isolation of drips in the masonry structure – after attaching the drips, on their surface, another layer of insulation should be made. The insulation should be on the whole surface of the sheet, which will be in the wall's surface. Connecting with existing insulation should be performed in accordance with the product technical card or manufacturer's recommendations.
8. Implementation of the supporting structure for the superstructure – it is necessary to use a support structure due to the need to veneer the superstructure with the structure of the existing wall. It is recommended to construct a supporting structure made of U-shaped ribbed steel bars anchored in the

existing wall structure with resin adhesives. Detailed solution of the supporting structure should be performed in accordance with the drawing below.

9. Sealing of the transitions of steel rods through the insulation layer – it is recommended to use bentonite-polymer masses.
10. Superstructure with quartzite stone – on the insulation layer, the superstructure with quartz stone should be performed. The shape of the superstructure should be in accordance with the shape before replacing the structure protection. It is not acceptable to increase the height of the wall. Quartz stone should be mason on the trass mortar. Additionally, it should be tied with the support structure.

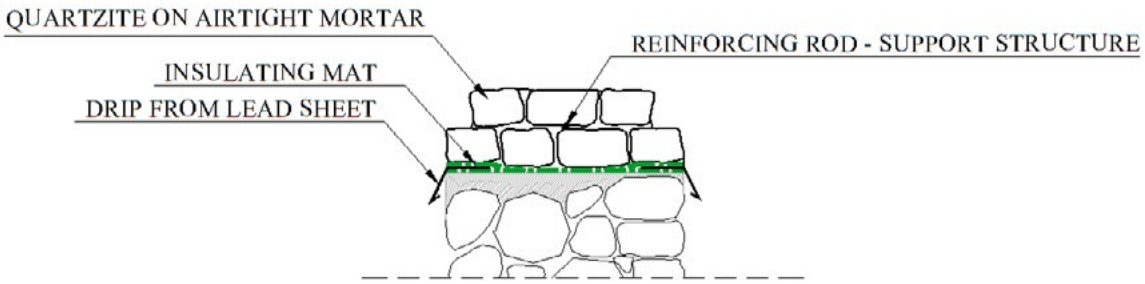

Fig. 10. Figure 4 Cross-section through the quartzite protection with a layer of insulation

Protection with the ceramic molders of a wall step

Repair technology for the quartz protection:

1. Visual assessment of the technical condition of the wall fragment under the protection planned. The substrate should be consistent and free of biological corrosion. If the fragments of the wall raise doubts as to their technical condition, they should be partially disassembled or reinforced and repaired.
2. Aligning the masonry surface and making a slope – in the case of significant surface irregularities, the fragments of a wall should be leveled with the trass mortar. Additionally, the appropriate slope can be made by the trass mortar (at least 2% towards the fall of water).
3. Laying the mineral insulation layer – lay a layer of the mineral insulation on the leveled substrate. The thickness of the insulation and the method of applying should be according to the recommendations and the manufacturer's technical card.
4. Laying the insulation layer in the corner of the walls – in the place of connection with vertical walls, the insulation should be pulled out on these walls at a minimum of 5 cm and pulled with horizontal insulation. If the substrate is not suitable, local repairs and restorations should be performed as in the case of the horizontal insulation.
5. Arrangement of the ceramic molders – the frost-resistant ceramic molders should be laid on a frost-resistant adhesive. Ceramic molders should be extended behind the face of the wall at about 3 cm. It is recommended to use molders with profiled drips.

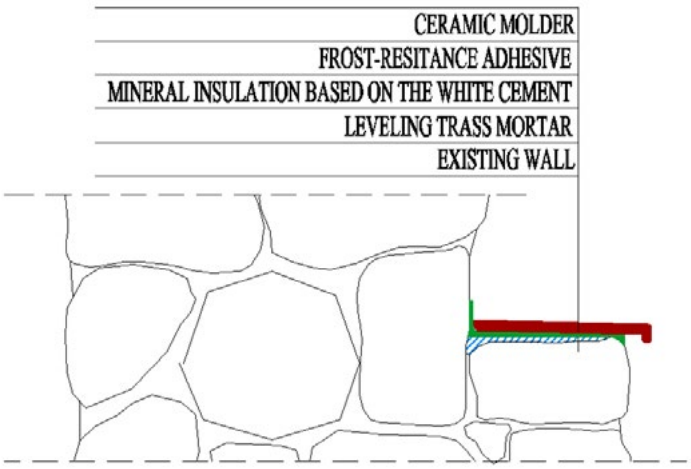

Fig. 11. Figure 5 Cross-section through the step of the wall secured with the ceramic molders

Protection of a step of the wall with a lead sheet

The protection is an alternative to the ceramic molders.
Technology of making the protection with a lead sheet:

1. Visual evaluation of the technical condition of an existing protection or a wall fragment – if signs of irregularity are not found after the fragments have been cleaned beforehand, it is possible to provide them with the lead sheet insulation. If the fragments of the wall raise doubts as to their technical condition, they should be partially disassembled or reinforced and repaired.
2. Alignment of the masonry surface – in the case of significant unevenness of the surface, the fragments should be leveled with the trass mortar. Additionally, the appropriate slope with the trass mortar should be made (at least 5% towards the fall of water).
3. The incision of the wall over the insulated part – in the first place it is necessary to furrow or cut the wall to a depth of approximately 3 cm at a height of about 5–6 cm above the insulated surface so that it can be insulated.
4. Cutting the wall under the protected step – under the row of the wall of the protected part, the joint should be cut in order to anchor the lead sheet.
5. Execution of the facet made of the trass mortar in the corners of the step with the wall – the shape of the facet should correspond to the future shape of the forged lead sheet in the corner.
6. Laying the lead sheet layer – place the lead sheet layer anchoring the bent section in the wall. The fragment of contact with the wall should be secured with a roofing sealant. Then, using a rubber hammer, the lead sheet should be "hammered" to the existing shape. The sheet should be turned from the bottom to one row of a limestone rock and taped to anchor the sheet in the previously prepared joint using a roofing sealant.

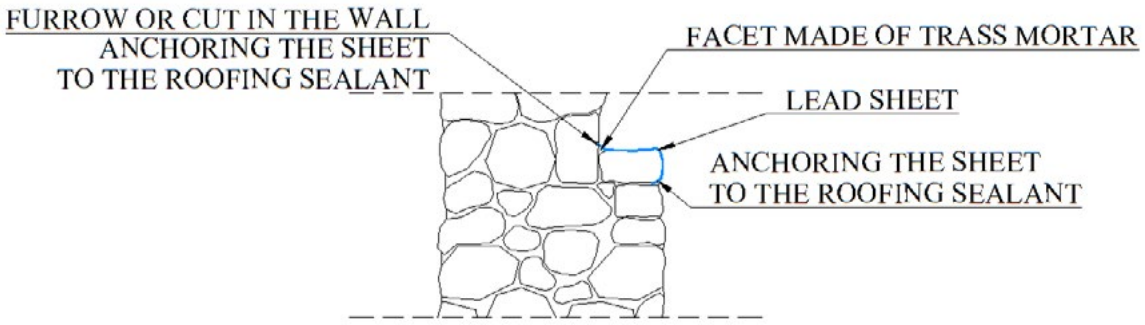

Fig. 12. Figure 6 Cross-section of the step secured with the lead sheet

Securing the crown of the wall with the ceramic molders

A repair technology for the quartz protection:

1. Visual assessment of the technical condition of the wall fragment under the protection planned. The substrate should be consistent and free of biological corrosion. If the fragments of the wall raise doubts as to their technical condition, they should be partially disassembled or reinforced and repaired.
2. Aligning the masonry surface and making a slope – in the case of significant surface irregularities, the fragments of a wall should be leveled with the trass mortar. Additionally, the appropriate slope can be made by the trass mortar (at least 2% towards the fall of water).
3. Laying the mineral insulation layer – a layer of the mineral insulation on the leveled substrate should be laid.
4. Laying the insulation layer in the corner of the walls – in the place of connection with vertical walls, the insulation should be pulled out on these walls at a minimum of 5 cm and pulled with horizontal insulation.
5. Arrangement of the ceramic molders – the frost-resistant ceramic molders should be placed on a frost-resistant adhesive and should be extended at about 3 cm. It is recommended to use molders with profiled drip.

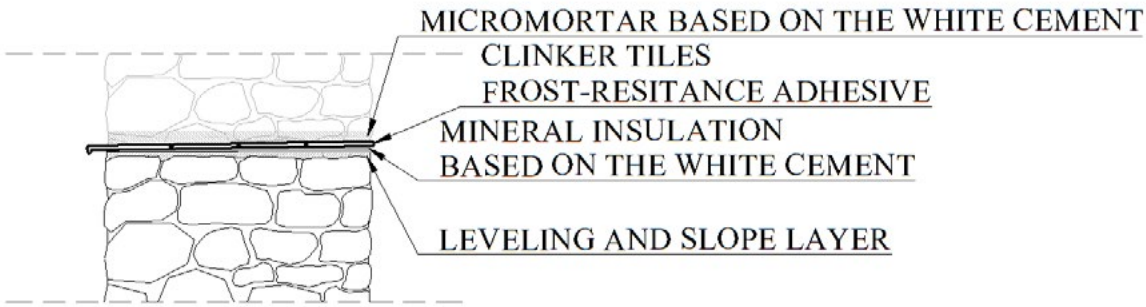

Fig. 13. Figure 7 Cross-section through the protection with the ceramic molders

Repair of existing quartzite protections

Repair of existing quartzite protection applies to the places where only the mortar bonding of the quartzite stone has been damaged, and the complete removal and re-provisioning of the crown protection would not be justified. Cracking of mortars of the quartz superstructures is recommended to be completed with a low-viscosity injection resin. The crack can be sealed by repeatedly soaking with a brush or pour the material directly into the crack by gravity.

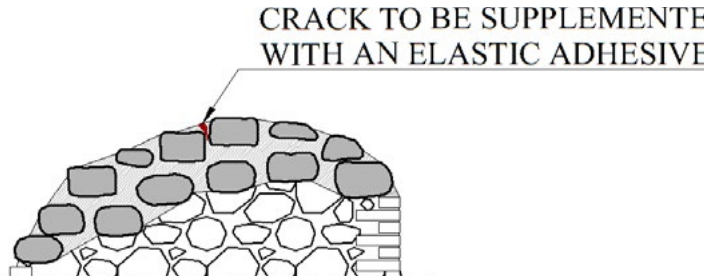

Fig. 14. Figure 8 A cracked fragment of the profiled stone superstructure

Summary

The diversity of the protection of the walls' crowns at the castle in Janowiec on the Vistula is associated with a very large material, geometric and functional diversity of the protected fragments of the object.

In the best technical condition are the protections made of ceramic materials permanently connected with the crown of the walls. The greatest damage was observed in the case of dominant protections, i.e., the quartzite superstructure on a cement mortar without horizontal insulation. The row of limestone rock walls (mostly secondary) lying directly under the superstructure has been damaged.

Damaged crown protections negatively affect the historical matter of the walls. Limiting the degradation process requires taking conservation and repair actions. The publication proposes solutions to protect the historical part of the walls from rainwater.

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