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Orginal Article

Methods of protection and the state of preservation of the wall topping of Gothic brick castles

Maciej Trochonowicz[1], Katarzyna Drobek[2]

[1] Department of Monument Conservation; Faculty of Civil Engineering and Architecture; Lublin University of Technology;40 Nadbystrzycka St., 20-618, Lublin, Poland;
m.trochonowicz@pollub.pl 0000-0001-7742-7916
[2] Department of Monument Conservation; Faculty of Civil Engineering and Architecture; Lublin University of Technology; 40 Nadbystrzycka St., 20-618, Lublin, Poland;
k.drobek@pollub.pl 0000-0003-3599-1169

Abstract: This article is an analysis of methods of securing historic walls in objects in the form of so-called permanent ruins. The research group consists of the brick Gothic castles of Mazovia in Ciechanów, Czersk, Liw and Sochaczew. Based on the analysis of documentation and our research, the effectiveness of the solutions applied in 4 different technological variants was evaluated. The state of preservation of the introduced solutions after several years of work was also assessed. The entire study was summarised in a table and conclusions were drawn.

Keywords: historical ruin, castle, castle ruins, wall topping degradation, protection of wall topping

1. Introduction

One of the most characteristic features of the structures and complexes left as so-called permanent ruins is the relatively large number of free-standing walls. These structures consist, in addition to historically free-standing walls, of walls from volumetric objects. Free-standing walls are most often devoid of weather protective elements. The lack of protection thus exposes them to accelerated degradation. These processes are particularly intense in originally volume masonry, which has a smaller thickness and was often erected with lower-quality materials. This is due to the fact that buildings of this type did not always have a defensive function.

The greatest damage is observed on the crown of the masonry, i.e. the part that is most highly exposed and vulnerable to damage. The main factors responsible for the degradation of masonry crowns, include the following:

– Climatic, caused by environmental factors related to the climate – precipitation, frost, insolation, the intensity of temperature change, wind.

– Chemical, related to the action of chemical compounds existing in the masonry and supplied from outside – leaching of substances from mortars and masonry material, decomposition of plants growing on the masonry, salt crystallization.
– Biotic, caused by the action of microorganisms and living organisms – algae, bryophytes, fungi moulds, lichens, grasses, perennials and succulents and trees and shrubs.
– Mechanical, caused by external and fatigue stresses, abrasion, and mechanical impacts.

The destructive factors listed above and the degradation processes which imply them practically never occur individually. The condition of masonry crowns in ruins is most often responsible for all or almost all of them.

2. Methodology and aim of the work

This article aims to analyse the protection of the wall topping at selected Gothic castles found in the Mazovian region. For this purpose, the following was performed:

– Study visits were carried out,
– Necessary photographic documentation was made,
– 3D scanning was carried out,
– An analysis of the applied safeguards was carried out,
– Assessments of the technical condition of the over-built walls topping and historic wall fragments were carried out.

All work of an inventory and research nature was carried out between 2019 and 2020.

3. Methods of protection and state of preservation of the wall toppings of Mazovian Gothic brick castles

Works to protect the wall topping are usually combined with the partial or complete reconstruction of the wall. The method of protecting the wall topping is chosen depending on the objectives of the conservation program. They differ in terms of durability, legibility and reversibility. The solution applied depends primarily on the type of masonry (its current form and state of preservation, the material from which it was built, the type of construction and the concept of conservation and architectural work proposed for the entire building).

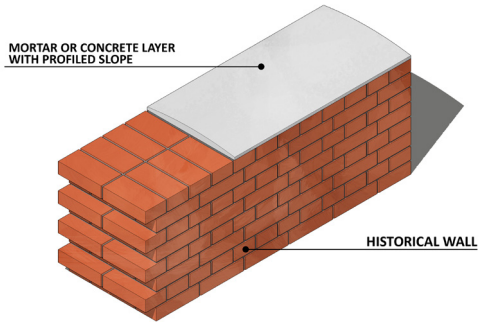
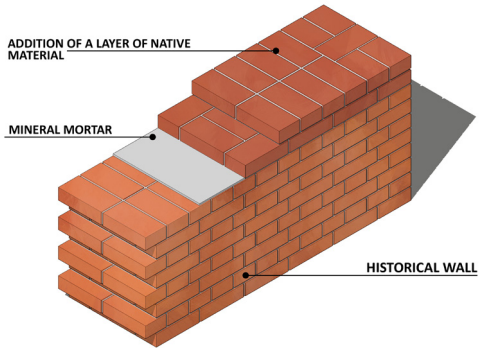
There are two groups of methods for protecting masonry crowns. The first is to make a new layer on the historic wall. This layer is assumed to be a lost layer, i.e. it can deteriorate and should be cyclically restored. This group includes: rebuilding part of the masonry, overbuilding, protecting the crown with mortars or concrete and the technical-green method.

The other group of protective actions is characterised by covering, shielding the historic fabric from the effects of rainwater. This group can include various types of canopies, protection of the wall toppings with sheet metal and chemical coatings.

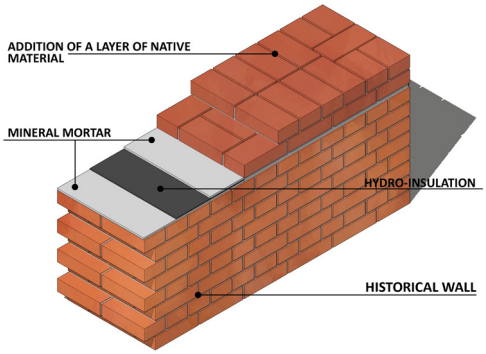
In all cases, more or less prior repair of the degraded historic wall is required.

The Table 1 shows only the solutions applied at selected Mazovian castles:

Table 1. Selected ways of protecting the wall topping of brickwork castles. *Source:* author

Protection of the wall topping with mortar or concrete	
 Fig. 1. Scheme for the protection of the cope of a brick wall with mortar or concrete	Construction of an airtight layer of mortar or concrete on the degraded wall topping. This method consists of making the protection directly on the historic masonry or on a layer of insulating material as a separating layer and allowing the reversibility of the solution applied. The historic wall to be protected must first be properly prepared for the application of the finishing layer. Protection with a layer of mortar or concrete allows any slope to be shaped to allow rainwater to drain into or out of the building. The plasticity of the material makes it possible to form the crown according to the line formed by natural factors. The plasters used for protection should be as tight as possible to prevent them from penetrating the protection layer and, in the absence of insulation, from penetrating the historical layers of the masonry. This method of protection for lower walls may be considered not entirely aesthetically pleasing.
Insertion of an insulation layer with addition of a new layer of native material	
 Fig. 2. Scheme for the protection of the cope of a brick wall by over-bricking with native (historicising) material.	Overbricking of the existing masonry with additional layers of material, either native or foreign, depending on the preservation program. In the case of the Mazovian castles discussed here, this was a lining with native material. As the basic and simplest way of securing the wall topping, this method is most frequently used. The upper part of the wall is filled in and appropriately shaped. Overbricking transfers the destructive action to the new material, but does not stop the wall topping deterioration process itself. Periodic inspection and replacement of the material is necessary. For this solution, it is extremely important to select the strength of the masonry material and the strength of the joint. When there is too strong a mortar, the brick or stone will quickly crumble and deteriorate. On the other hand, a mortar which is too weak will lead to sections of the brickwork falling off and the wall topping deteriorating again.

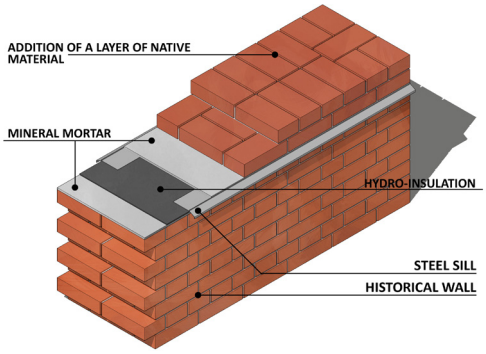
Insertion of an insulation layer with addition of a new layer of native material



The insertion of an insulation layer in the form of roofing felt or metal sheeting is a cheap and quite effective way of protecting the wall topping. It is also a much better solution than to merely over-brick the wall topping. Insulation gives additional protection to the old masonry, provides a separating layer and makes the solution reversible. In contrast, brickwork provides a pressure layer for the insulation and is considered a lost layer that needs to be restored periodically.

Fig. 3. Scheme to protect the wall topping of a brick wall by applying a layer of insulation and over-bricking with native (historicising) material

Addition of a new layer to the wall topping with insulation and capping



A major problem in the case of masonry crowns protected by lintels in the form of so-called permanent ruins is the seepage of rainwater onto the faces of the masonry. The core of the masonry remains protected by the insulation layer, but the seeping water starts a series of processes which degrade the near-surface layers. The solution is to fix slightly visible drips, so that the water is drained away and does not cause the masonry to become damp. Steel or non-ferrous metal drip caps are used. Due to the separation of the lintel by a layer of insulation, the solution is reversible. The lintel should be treated as a lost layer.

Fig. 4. Scheme for the protection of the wall topping of a brick wall by over-bricking with native material (historicising) with insulation and capping

4. Protection of wall toppings of Mazovian castles – analysis of selected objects

4.1. The castle of the Dukes of Mazovia in Ciechanów

The Castle of the Dukes of Mazovia in Ciechanów dates back to late 14th century. Built on a rectangular plan, the walls were made of ceramic brick on a stone foundation. The fortress was located on a flat area, which was a floodplain of the Łydynia river and surrounded by a wide and shallow moat. The defensive layout consisted of two round towers and curtain walls with blanketing. The castle was rebuilt several times and expanded with buildings inside its perimeter. Never conquered by enemies, the structure began to deteriorate as early as the end of the 15th century due to its loss of importance. The first restoration work took place in the second half of the 16th century. At the beginning of the 19th century, the demolition of the building was started by the Prussians. Since the 20th century, restoration and conservation work has been carried out on the ruins [1].

Today it is one of the best-preserved Polish Gothic brick castles. It is maintained as a so-called permanent ruin. In 2013, work to revitalise the castle was completed. Inside the castle perimeter, a new museum pavilion was erected in place of the so-called Little House, and a complex of sanitary facilities and utility rooms was located under the courtyard.

Ciechanów Castle is in overall good to very good technical condition. There are two types of protection of the wall toppings on the site. One curtain wall and two towers have wall toppings over-built with native material with a crenelation, without an insulating layer and a capinos. The other wall toppings of the perimeter walls are over-bricked with a slope towards the courtyard and a metal capstone installed under the top layer of bricks.

The wall toppings of the external walls protected by over-bricking with a crenelation without an insulating layer are in good technical condition. Damage to the crenelation, i.e. spalling of contemporary bricks, carbonate efflorescence on the surface, cavities in the joints and biological corrosion are present in places. At the Gothic basements, the crenelations are in varied technical condition. The wall toppings are in good condition where the walls have been restored. There is point damage to the bricks and loss of pointing. However, the wall toppings of the Gothic cellar walls are in a poor condition. There is complete degradation of the surface layers, numerous defects in whole sections of the topping, cracks and separations. This causes rainwater to penetrate deep into the masonry. There is algal, lichen and vegetation growth at the preserved surfaces.

Where the masonry has been protected by over-bricking with native material and the addition of a metal capping, the technical condition of the protection is good to very good. There is some sparse damage to the vertical and horizontal surfaces of the lintel with minor damage to the brickwork and joints.

Fig. 5. The wall topping of tower is in good technical condition. Locally visible damage to the top layer of bricks. Defects in pointing, damage to bricks. *Source:* author, 2019

Fig. 6. Tower wall topping. Severe salt corrosion of the brick face of the tower terrace exit. Salt corrosion damaged brick faces. Carbonate streaks on the surface of the masonry. *Source*: author*, 2019*

Fig. 7. The wall topping. Localised damage to the surface of the upper layer of bricks. The wall topping contaminated with bird droppings, spotty lichen growth. *Source*: author, 2019

Fig. 8. The wall topping. The wall topping of the wall on the courtyard side. The junction of the historic wall and the over-brickwork. Brick used and pointing to ensure the layers are distinguishable. Sheet metal dripline draining rainwater. *Source*: author, 2019

4.2. The castle of the Mazovian Dukes in Czersk

The Castle of the Mazovian Dukes in Czersk was built at the turn of the 14th and 15th centuries [2], on a Vistula escarpment, on an irregular polygonal plan. The fortress consisted of a square gate tower (eastern), two round towers (southern and western) and a defensive wall surrounding a large courtyard. The building material of the castle is brick on fieldstone foundations. The building was rebuilt several times. During the Swedish Deluge, the castle was conquered and ruined. In the second half of the 18th century, attempts were made to restore it, but at the turn of the 18th and 19th centuries, the Prussian government ordered the demolition of the walls.

The castle in Czersk was preserved in the form of a so-called permanent ruin. Its present form is the result of conservation work carried out on the site since the end of the 19th century. The castle walls were rebuilt with contemporary bricks similar to the Gothic ones, differing in colour and texture from the historical material.

There are two types of protection for the wall topping on the site. All towers have been protected by a layer of cement mortar with a profiled slope, while the brick perimeter walls have been protected with solid ceramic brick over the entire surface. The wall topping of the south and west towers are additionally reinforced with steel bars.

Technical condition of the cement mortar protection on the outer wall topping of the main tower and the west tower is without significant damage to them. Only in the areas of direct contact between the cement layer and the brick masonry is there biological corrosion (lichen). The toppings of the south tower masonry are in good technical condition. There are localised defects in the joint. In poorer technical condition, there are the walls topping of the south and west tower shelves, where numerous spalling and damage to the concrete surface and the presence of vegetation were found.

The protection of wall topping of the perimeter walls created by re-bricking with contemporary bricks is in sufficient condition. There is a lack of horizontal insulation at the

junction between the historic masonry and the over-brickwork. There is substantial damage at the junction between the face and the wall topping. In parts, the wall topping is detached from the masonry proper. In places, the cope brickwork is not connected to each other due to defects in the mortar. As a result of inadequate protection (no bond between the last layer of the face and the crown lintel), the surface of the bricks has become detached and a deep crack has formed, allowing precipitation to penetrate into the masonry. Perennial vegetation has sprung up in these leaks, with its root system causing further damage at the interface of the layers. There is also a localised infestation of algae (mainly on the final of the face), which is evidence of the markedly higher and persistent moisture content of the bricks.

Fig. 9. East wall, view from the tower. Detaching of the face layers of the wall. In areas of damage, water enters the wall. *Source*: author, 2019

Fig. 10. North wall on the courtyard side. Damage to contemporary brick topping. Damage to pointing, salt deposits. *Source*: author, 2019

Fig. 11. The north wall from the exterior. Degradation of the surface layers of the modern superstructure. Intense carbonate efflorescence on the face of masonry. *Source*: author, 2019

Fig. 12. South wall. Localised damage to wall topping repointed with fieldstone. *Source*: author, 2019

4.3. The castle of the Mazovian Dukes in Liw

The castle of the Mazovian Dukes in Liw was built at the turn of the 14th and 15th centuries. It was built on a square plan with a gate tower located outside the outline of the walls. The foundations were made of pebbles, the walls were built of Gothic brick. The castle precinct also included a Large House and a Minor House (on the site of the present manor house). The fortress was first rebuilt in the 16th century and had to be reinforced due to the many dangers. The castle was destroyed twice. The first time was during the Swedish Deluge; the building was rebuilt quickly enough. The castle was destroyed a second time after the Northern War and no more attempts were made to rebuild it. At the end of the 18th century, the Minor House was replaced by the starost's office. From the beginning of the 20th century, work was carried out to secure the castle. [3] The last comprehensive preservation works took place in 2017-2019. The overall technical condition of the fortress is good to very good. The only damage is mainly to the surface layers of the elements.

There are two types of protection for the wall toppings at Liw Castle. The first type is re-bricking of the wall topping with contemporary bricks with the top layer of bricks laid flat. The second is the construction of a mortar coating. The repointing occurs on brick walls, which are in good to very good condition. In places there are carbonate deposits associated with carbonates leaching from the mortar. However, mortar protection is found on the lower parts (at the stone wall) of the gate tower buttresses. The technical condition of this type of protection is poor. The mortar layer is cracked and delaminated, and rainwater penetrating into the wall has damaged the joints directly under the protective coating.

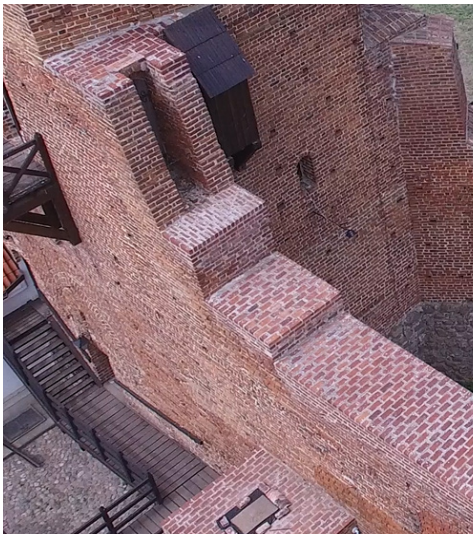


Fig. 13. The wall topping of north-west wall. Localised mortar staining of face, careless pointing of bricks. *Source*: author, 2019

Fig. 14. Tower, view of south-west elevation. The repointed wall topping of the tower buttresses. The brick-work and pointing used ensures that the layers are distinguishable. *Source*: author, 2019

Fig. 15. The wall topping of north-east wall. Unaesthetic pointing, localised carbonate deposits on surface of bricks. *Source*: author, 2019

Fig. 16. South-east wall. Damage to joints, detachment of individual tones of face and top layers. *Source*: author, 2019

4.4. The castle of the Mazovian Dukes in Sochaczew

The castle of the Mazovian Dukes in Sochaczew dates back to the 14th century. It was situated on a hill, separated from the town by a natural ravine and a river flowing through it. The walls of the fortress were made of finger-brick on fieldstone foundations. The structure was built on a trapezoidal plan. Originally, the defensive system consisted of two towers and a defensive wall. During the Swedish invasion, the castle was burnt down and functioned in a state of disrepair for more than a century. Subsequently, due to the unstable hill, it was decided to demolish the Gothic castle and a new 18th century foundation was built on its previous shape. [4] Only the north tower remained of the former fortress, and the form of the modern castle consisted of three wings, an octagonal tower and a defensive wall.

Currently, the castle in Sochaczew is kept as a permanent ruin. The overall technical condition of the castle ruin in Sochaczew is very good. In the years 2011-2013, conservation work was carried out to comprehensively protect the remains of the walls, make new floors in the courtyard as well as in the former rooms of the fortress and drainage of rainwater. These protections were carried out according to the standards accepted for so-called permanent ruins.

The toppings of the walls were over-bricked with contemporary material and made as lost layers, clearly recognisable from the historic substance. Above the brickwork a mortar layer with a slope. Protection on the toppings was carried out piecemeal. They are currently in varying degrees of repair. Some of the mortar caps have cracks, which cause rainwater to penetrate deep into the historic masonry. In places there is carbonate crystallisation on the face of the modern bricks, mortar contamination, and vegetation growth has been found at the interface of the layers. In places above the historic wall there is no contemporary re-bricking, sections of the wall have only been secured with contemporary mortar. The lack of regularity of the protections and their inadequate execution results in rainwater ingress and destruction of the masonry.

Fig. 17. The wall topping of tower in good technical condition. Locally visible damage to the top layer of bricks. Defects in pointing, damage to bricks. Source: author, *2019*

Fig. 18. Tower wall topping. Strong salt corrosion of the face of the brickwork of the tower terrace exit. Salt corrosion damaged brick faces. Carbonate streaks on the surface of the masonry. Source: author, *2019*

Fig. 19. The wall topping. Localised damage to the surface of the upper layer of bricks. The wall topping contaminated with bird droppings, spotty lichen growth. *Source*: author, 2019

Fig. 20. The wall topping. Topping of the wall on the courtyard side. The junction of the historic wall and the over-brickwork. Brick used and pointing to ensure the layers are distinguishable. Sheet metal dripline draining rainwater. *Source*: author, 2019

4.4. Summary

On the basis of the analyses and studies carried out, Table 2 has been developed taking into account the character of the work carried out. The following columns refer to: target or temporary character of the protections, material compatibility, reversibility, scope of work (overall, piecemeal, local) and distinguishability of the materials and applied solutions.

Table 2. Selected ways of protecting wall topping of brickwork castles. *Source:* author

	Ciechanów	Czersk	Liw	Sochaczew
Protection of the wall topping YES/NO – character	YES Addition of a new masonry layer Addition of a new masonry layer with execution of a capping	YES Addition of a new masonry layer	YES Addition of a new masonry layer	YES Addition of a new masonry layer Addition of a new masonry layer with mineral mortar sloping layer
Target/Temporary	Target	Target	Target	Target
Materials compatibility	YES	YES	YES	YES
Reversibility of the solution YES/NO	NO	NO	NO	NO
Scope of work Overall/Partial	Overall	Overall	Overall	Partial Fragments of wall faults unprotected
Distinguishability of the solution YES/NO	YES	YES	YES	YES
Slope profiling YES/NO	YES	YES	NO	YES

5. Conclusions

On the basis of the above analysis of the protections made on the toppings of the Gothic brick walls of the Mazovian castles and the summary in Table 2, the following was concluded:

- The least durable solutions are those in which the masonry has been protected by lintels without the introduction of an insulating layer.
- Significantly better durability and effectiveness were achieved when using lintels materially compatible with the insulation layer at the interface between the historic and modern layers.
- The use of additional capping between the historic layers and the brickwork or within the layers of the brickwork (usually 1-3 brick layers from the top of the brickwork) protects the face of the wall.
- The protections should be applied comprehensively without leaving sections of masonry unprotected.
- The protections are targeted and, in most sites, their reversibility is linked to interference with the historic structure.
- Due to the use of materials with similar colours and measurements, there may be a problem with the distinguishability of the protection after several decades.
- The protections made were designed as lost elements that should be continuously monitored and restored.

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