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## Conservation renovations of the bridges in the Muskau Park Remonty konserwatorskie mostów w Parku Mużakowskim

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**Słowa kluczowe:** Park Mużakowski, mosty, konserwacja

### 1. HISTORY OF THE PARK

The Muskau Park, as it is known in the history of garden art, is considered to be an outstanding composition modelled on English parks, surprising one with the individuality and originality of its solutions. The park composition is an expression of the unhindered imagination, artistic licence and originality of its creator – the owner of the local estate Prince Hermann von Pückler-Muskau, a person who has gone down not only in the history of gardens, but also in the history of the European culture of the 19th century.

The park laid out by him in the valley of the Lusatian Neisse river (Fig. 1) has been recognized, both by his contemporaries and the posterity, as the purest and most original expression of Romanticism in garden art. In its composition the creator in a unique and ingenious way managed to exploit the scenic values of the land. By transforming the existing residence Pückler created, on the area of over 800 ha, not only a park composition, but also a new, unusual in its scale and expression, landscape designed in the minutest detail – a micro-world understood as a poetic ideal which became part of the surrounding reality. A story, partly true and partly invented or adapted by Pückler, became its content. The layout, referred to as *Haupt-Idee* [1], was to be “nothing else, but only a desire to reflect a tender image of our family or the native aristocracy, who received their education here, so that this idea could develop, so to speak, on its own, in the observer’s soul”. In order to reflect this content, all what potentially was situated within the composition – both people and any evidence of the local history or objects deemed by Pückler to be such evidence – the past and the tradition – combined to form a whole, was to constitute together with the present, a visualization of the hitherto existing order.

Pückler devoted a fortune and the best years of his life to realize his work in the years 1811-1845. The large-scale investment programme ultimately led to a financial collapse

and to the sale of the estate [2]. Although at the time of the sale the park reached the size comparable with the concept, extensive lands, particularly on the east side, have never been developed. Nevertheless, the original concept of the work, which he transferred into the realms of fantasy, was fully realized on the pages of a book [1].

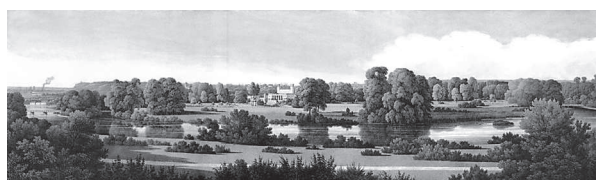


Fig. 1. Panorama of the Park from the east site (19th cent.) [1]

After it had been sold to the Counts von Nostitz and von Hatzfeld, in 1846 the estate became the property of Prince Willem Frederic Karel der Nederlanden (Willem Frederic Karel von Oranien, 1797-1881), the son of the later King of the Netherlands Wilhelm I. In the person of the prince the park gained not only an owner, but a caring patron, full of understanding and respect for his predecessor’s work. After his death, from 1883 the next owner of the Muskau estate was Count Traugott Heinrich von Arnim (1839-1919), a diplomat and for many years Bismarck’s personal secretary. Also the years 1883-1945, when the park remained in the hands of the successive generations of the von Arnim family, were a period of full respect for the achievements of the park creator. However, as a result of the progressing industrialization and the considerable deterioration in the economic situation of the estate, local transformations of the composition did take place in that period.

As the consequence of the new order in Europe after 1945 the park composition was cut in two by the border between two countries. The residential centre with the Castle Park, the Mountain Park and the Spa, a fragment amounting merely to one third of the composition (about 200 ha), found itself on

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the German side. Since the fragment included architectural structures it could function independently. Once the difficulties of the first post-war years had been overcome, already at the beginning of the 1950s the heaviest damage was repaired. In 1953 the park board was established and in 1955 the park was designated as a monument. Thus the formal basis for the protection and conservation of the park was created. The damaged buildings began to be conserved and in 1965 the full restoration of the Old Castle, which was to serve as museum, began. The Bachelor House was extended to serve as a sanatorium. Thus the use of the park on the German side was determined by the spa tradition, rooted in the history and being of great local importance. Owing to this through the whole post-war period the Park was maintained up to high, for those times, conservation standards. The east part of the Park – the former suburbs of a small German town, amounting to as much as two thirds of the Park's historic area (about 700 ha), found itself on the territory of Poland. This fragment, taken out of context, devoid of compositional reference, was administratively incorporated into the newly created town of Łęknica. The "tree-covered" part was incorporated into the State Forests National Forest Holding and the historic fancy farm was taken over by the State-Owned Farm. The Park would get overgrown and some of it was under forestry cultivation, whereby the interconnections between the two parts would become obscured over time.

Fortunately, from this condition the Park was brought back to life thanks to the Polish-German agreement on undertaking its restoration, and reconstructed jointly in 1991 as the first monument commemorating its creator, it became the foundation stone not only for the restoration of the Polish part of the park, but also for the whole process of reintegration of the historic composition.

## 2. PARK COMPOSITION

Pückler meant the park he designed to be a synthesis of different fields of art – "a holistic work" – *Gesamtkunstwerk*, in which the fields of art, jointly with nature, coexist on equal rights [1]. He pursued this aim in an exceptionally consistent and multiplanar way through all the elements of the programme.

The shape of the future composition was mainly determined by the location of the main buildings of the family residence, situated on the left bank of the Lusatian Neisse river, widening in this place of the valley, and by the unique lie of the land, created by the Lusatian Neisse when it broke through the geological formations of the frontal moraine formed during the Mid-Polish glaciation, today called Muskau Arch (Muskauer Faltenbogen). The formations were designated as a Scenic Park in 2001 and as a National Geopark in 2009.

The project planned on a grand scale involved a wide range of work connected with the necessary remodelling of the residence's main buildings, changing the routes of the surrounding streets, building new structures, also artificial lakes and streams, drainage work, changes in the topography and planting thousands of trees.

The centre of the park composition was the complex of three main buildings: the Old Castle, the New Castle and the theatre, deriving from the earlier layout. The buildings (except for the Old Castle) were designated by Pückler for general remodelling, which was the basis for the original

concept of modernization of the whole layout, began by him after 1815 [3]. The idea consisted in not only changing the form of the buildings, but also in their full integration with the surroundings. Therefore it was essential to remove the old fortifications and the moat, including the retaining walls erected by his grandfather [2]. The artificial Lucie Lake (also called the Castle Pond) was created in their place. The lake waters surrounding the palace on its three sides provided a proper background for the building. The bridge in the east side entrance was replaced with a ramp.

The idea of the ramp was suggested to Pückler by John Adey Repton (1787-1849), a son of the famous English pianist Humphry Repton (1752-1818). Pückler invited the eminent Prussian architect Karl Friedrich Schinkel (1781-1841) to create the architectural designs. The ramp built according to his design was to be one of the few building plans ever put into practice by Pückler. The ideas of the general remodelling of all the three buildings and integrating them into a single architectural complex have never been implemented. According to the designs supplied by Schinkel the buildings were to be given Gothicizing forms and connected into one complex reflecting the many centuries of the history of the place. The former official residence was to be explicitly identified with the oldest element of this complex. Hence the name Old Castle to emphasizing this intention. The buildings were connected by two bridges supported by arcade arches, constructed on different levels, with a tower in the central part.

Main residence buildings were surrounded with richly equipped flower gardens constituting an extension of the dwelling interiors. Among the abundance of architectural and plant detail, parterres, original and fanciful in form, found application here. The central part of the residence was then surrounded by a pleasure ground – a park zone used for strolling, cut through by the scenically shaped Hermann Neisse – an artificial branch of the river, dug through in order to enrich the park sceneries. Owing to this, artificial lakes – the above mentioned Lucie Lake and the Oaks Lake in the north part of the Castle Park – were created. The Hermann Neisse river was accompanied by numerous little bridges and picturesquely shaped cascades and appropriately planned out park roads. As a transitional zone the pleasure ground, on one hand, included very decorative elements, making it resemble the gardens, and on the other hand, by the extensiveness of the park interiors and the freedom of its form it alluded to the composition of the park proper. It was characterized by quite extensive, exquisitely manicured lawns, rare plants and original in form shrubbery arrangements scattered on the lawns [5].

The rest of the park, the park proper, laid out above the town adjacent to the residence, and also, in major part, stretching on the east side of the Neisse, was clearly distinct from the central park composition. The river terraces rising above the valley, as high as 50 m, and selected places on their edges on both sides of the river were used to situate there structures viewed from the centre of the park and vice versa. Special structures, e.g. the gazebo in the Castle Park, and park benches situated in the places selected by the creator, were used to admire the views. Thus the valley's two sides were interconnected by a network of vantage points, however, still focusing attention on its interior in whose centre the "lordly residence" dominated [5]. The park filling the valley on both sides of the Neisse river was to create the impres-

sion of a gallery of pictures viewed according to a scenario constructed by Pückler, showing the main buildings of the residence, the pavilions, the structures and the park scenes in ever different frames and perspectives. In the pictures the structures, having not only a decorative character, but also performing useful functions, e.g. the bridges linking the edges of the gorges together, would blend in with the natural, or rather almost natural, sceneries. The desired effects would be produced through the skilful composition of plant elements, the sometimes slight modelling of the terrain, or simply the “retouching” of some parts. Often these were solely compositions of trees, arranged in groups of different size, clumps, or standing solitary against the background of a vast interior, laid out with dramatic tension characteristic of Pückler. A substantial role in those compositions would be played by venerable trees, especially oaks several hundred years old, attracting attention because of their great size and noble form.

The skilfully designed roads would lead the visitor from point to point, along the edges of the terraces, offering various impressions, depending on the time of the day and the lighting. The sunlit sequences of vast glades and the long open vistas contrasted with the shady parts, especially with the muted natural sceneries of the gorges, into which this time narrow paths would lead.

Among those vast spaces there was no lack of attractive destinations for expeditions. On the right bank of the river there was the Spa with curative waters and mud baths, in the northern regions of the east part of the park a charming hamlet – a complex of pavilions and equipment for games and play in the English cottage style, called “England” or the “English House” (Englisches House) was located.

On the pattern of the 18th century English gardens also farmlands were included in the composition. Adding variety to the extensive field areas, groups of trees and solitary trees formed a landscape composition in which, at least in the conception, the practical aspects were combined with the decorative ones.

The particular parts of the park were connected by green promenades, enclosing the town of Muskau and its agricultural suburbs within the composition [5].

### 3. BRIDGES, SMALL BRIDGES, VIADUCTS

#### 3.1 Cross-border bridges

The architectural programme for the park was consistently defined by Pückler in a way which made it possible to implement the main idea. It comprised of a few tens of buildings and structures, representing a great variety of cubatures and architectural forms, but forming a clear and cogent complex correlated in terms of content. This programme described in [1], however, only to a small degree coincided with the programme actually carried out by Pückler.

Besides the architecture of the main buildings situated in the central part of the park, the diversity of the styles of the park structures was fully consistent with the principles of the picturesque style. Despite the partly commemorative character of their forms (e.g. the English House as a souvenir of a journey), through their location in specific spatial contexts the contents associated with them acquire new meanings, supporting the implementation of the historical programme

assumptions. Most of the planned buildings and structures had also a practical character, which was an important postulate of the creator. Also the bridges represented a variety of forms. However, most of them in a later period were replaced with new structures or disappeared.

From among the bridgestone should single out two bridges over the Neisse river, situated in the central part of the composition, conditioning the functioning of the Park as a whole. The Double Bridge (Doppelbrücke), consisting of two segments separated by an island, connects the centre of the residence with the nearest park interiors on the east side. The other bridge – the English Bridge, situated north of it, constituted the shortest connection between the palace and the cottage (the English House) on the east side. Erected in 1822, as a wooden structure, it was destroyed by the waters of the Neisse several times, each time acquiring a slightly different form.

In 1867 the Double Bridge was replaced by a masonry structure with granite and clinker piers. Blown up during war operations, it was rebuilt as part of an agreement between the Polish and German Park Boards in 2003. The English Bridge, also erected as a wooden structure in 1822, gained in 1858, in the times of Frederic der Nederlanden, new masonry piers. The balustrade was changed several times, to be finally replaced, after the bridge was damaged by flood in 1897, with a wrought-iron one. The bridge was rebuilt in 2011, in its last known form dating back from before 1945.

Using the two bridges one could travel in the park along a ring road whereby one could get to know the extensiveness and uniqueness of the composition. Besides their communication importance the two bridges were also objects viewed from different perspectives.

#### 3.2. Bridges on German side

In the Castle Park, on the park roads and paths accompanying the Hermann Neisse river, which in several places intersect its course, there were located several small bridges. Each of them was given an individual form, matched to the character of the composition of the particular area, and its own name. And so there is Carp’s Bridge, formerly wooden, replaced by a small bridge with cast-iron balustrade in the 1860s, the Castle Bridge between the New Castle and the Bachelor House, with an original cast-iron balustrade, the wooden Rheder Bridge (Rhederbrücke), dedicated to the first gardener of the Park, the Shepherd Bridge (Schäferbrücke) and the brick-and-fieldstone Bridge by Oaks’ Lake (Eichseebrückewasserfall).

The Red Bridge in the Mountain Park was built together with the Upper Road in about 1830. Situated above a small street leading from a small town (Bergsche Kirchgasse) to the Mountain Park, it is a red brickwork structure with a wide arch. Its openwork brick balustrade topped with a sandstone parapet was modified as a result of restoration work carried out in the 1960s. The original form of the bridge alluded to the wall near the gardener house by the Turkish Baths in the Sanssouci garden [2].

#### 3.3. Bridges on Polish side

Three masonry bridges are the only historic structures on the east side of the Park, which survived World War II. All the three were erected after the middle of the 19th century, in

the times when the Park was owned by Frederic der Nederlanden. The bridges, by design, have double importance. On one hand, connecting the edges of the gorges they ensure the continuity of the park roads and on the other hand, as local dominant features they are part of the park scenes observed in the views from the Park.

Prince's Bridge, also called the Royal Bridge in honour of prince and later king Frederic Wilhelm IV (1795-1861), is situated within the first above-flood-level terrace north of Pückler's Stone. Designed and erected by Pückler as a wooden structure, in the form of a trellis covered with grapevine, made from "young oaken rods in the form of arches", it is shown in plate XXV in [1].

The bridge was rebuilt in 1854. Since then it has been a brick structure supported by three arcades, with an openwork sandstone balustrade. Its current good condition is the result of restoration work carried out a few years ago.

The Arcade Bridge is situated within the second above-flood-level terrace, near the Mausoleum Terrace. It is a monumental structure supported by five arcades, connecting the edges of a deep gorge on the bottom of which Sara's path runs. Erected in 1853, it replaced the wooden bridge – the Viaduct over Sara's path – previously existing in this place. In the construction of this bridge, being at the same time a viaduct, besides brick, also glass slag, a byproduct of the smelting of iron in the 19th century ironworks, was used. The original form of the bridge is not known.

The Viaduct is a masonry bridge connecting the edges of a deep gorge cutting through the second above-flood-level terrace. The structure planned by Pückler was finally erected as late as after 1862/63. It was built from brick and glass slag, with an ogival gate opening. The original form brings to mind a gate inviting one to the interior of the park and it is regarded as such since the beginning of the 20th century. Overhead runs a road from Lord's Mountain (Herrenberg) towards the north end of the park. A source included in [1] shows a bridge supported by five arcades.

Moreover, in Pückler's times there also existed an Oak Footbridge – a small wooden bridge over the gorge on the Nightingale Path route. The bridge was built from tree trunks and brushwood. Mentioned in [1], shown in lithograph no. XXV in the collection appended to [1], it existed until 1865, as confirmed by cartographic materials and later accounts.

Neither the form of the Chain Bridge [1], probably suspended over the gorge with the Hermann Road leading directly to the dairy, is known.

#### 4. PARK TODAY

The restoration of the park as a whole made up of two integrally interwoven parts is not merely a restoration problem. It is a process which required and still requires the solution of a whole range of administrative, legal and conservation problems.

Each of the park's parts has its own peculiarity stemming from the historical and compositional determinants and its condition.

In the German (west) part of the Park, since 1993 managed by the Saxony Prince Pückler Foundation in Bad Muskau (Stiftung Fürst-Pückler-Park Bad Muskau), the main focus has always been on projects aimed at restoring the architectural structures [2, 7].

Since the mid-1990s most of the work has concentrated on the reconstruction of the main building in the complex, i.e. the New Castle, which now houses a modernly arranged exhibition on the history of the park and its creator, an information centre, a café as well as seminar and office rooms. From smaller buildings, the orangery (1993) and the utility buildings on the castle grange, where tourist service functions and garden utility buildings are located (2012), have been restored. In some of them the historic function has been restored, whereas the other buildings now house exhibition rooms and catering establishments. The renovation of the Bachelor House has begun. Also projects aimed at restoring the smaller architectural structures are steadily being carried out. Moreover, the road surfaces are being restored, the current maintenance of the tree stand and the water system is being conducted, the spatial arrangement is being corrected and the plant system is being shaped. Steadily the decorative elements – flower stands, flower beds and fittings, are being restored.

The Polish part of the park taken over, on behalf of the Ministry of Culture and Art, from the State Forests National Forest Holding, by the Board for the Protection and Conservation of Palace-Garden Complexes, later the Centre for the Protection of Historic Landscape, is currently administered by the National Heritage Board of Poland. The specificity of the initial situation determines a completely different set of problems to be dealt with [8].

The main area on which the conservation efforts concentrate is the reconstruction of the spatial structure obscured in the post-war period as a result of the discontinuation of maintenance and forest husbandry. The recovery of the park interiors and their characteristic elements, the reconstruction of the viewing interconnections with the west side, necessitate practically continuous sequential work.

The unveiling of Pückler's Stone in 1991, which restored the historic panorama from the east side onto the west side, was from today's perspective a relatively simple action, whereas it took a few years to recover the view from the Mausoleum Terrace in the direction of the New Castle because of the kind and range of the work involved. The next unveilings revealed the next stages, including the clearing of 50 hectares of the 50-year old alder stand obscuring the view, and the drainage of the Reeds Meadow.

The sequential work entails the maintenance of the ancient forest and the further shaping of the plant structure – the regeneration of the system, making up the losses in order to bring back the composition as close as possible to the original design, which is also a condition for preserving its value for the next generations.

An enormous range of work is involved in the reconstruction of the park roads. They have generally survived in the form of road base and accompanying elements, such as stone gutters, limiters, or stones which indicate crossroads. But the missing parts need to be replaced and the surface reconstructed. Owing to the use of the same materials and work methods in the two parts of the Park the reconstructed roads have become an element which strongly integrates the composition on both sides of the Lusatian Neisse river.

A major question is what procedure should be adopted in the case of the structures which have not survived, such as the mausoleum commemorated with a granite cross. The reconstruction of the unpreserved grave – called Stranger's grave is considered. In 2011 reconstruction work in the park



retreat called the English House was begun. The road network there has been restored, the foundations of the unpreserved main building have been exposed and one of its pavilions has been restored.

## 5. CONSERVATION RENOVATIONS OF BRIDGES

So far the conservation of the bridge structures on the park grounds has covered: small bridges in the German part of the park, Prince's Bridge, also called the Royal Bridge (subjected to conservation as the first in 1999) and the Arcade Bridge (its conservation renovation was carried out in 2011) in the Polish part and the reconstruction of the two bridges across the Lusatian Neisse river – the Double Bridge (2003/2004) and the English Bridge (2011) was carried out jointly by the Polish and German administrators. Currently, the third bridge on the Polish side is to be renovated.

### 5.1. Royal Bridge



Fig. 2. Royal bridge (before 1999)



Fig. 3. Royal bridge (2011)

Originally the Royal (Prince's) Bridge was a wooden structure lined with Virginia creeper. In 1854 in its place the current masonry bridge was erected (Fig. 2). The bridge was renovated in 1999 (Fig. 3). As part of this renovation the whole surface of the bridge was cleaned, the cracked structural masonry elements were rebuilt, necessary damp-proofing work was carried out, a new bridge deck surface was made and the balustrades were reconstructed.

### 5.2. English Bridge

After many years of efforts the second, after the Double Bridge, bridge on the Lusatian Neisse river was finally built. Preserved historical pillars, the iconography and relics of the balustrade, providing the basis for the restoration of the English Bridge in the form from before the World War II (Fig. 4).

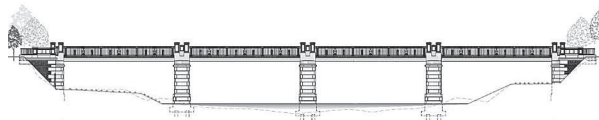


Fig. 4. English Bridge – fragment of reconstruction design (Architekturbüro Bonk + Herrmann, Dresden)

The range of work included dismantling the historic piers, strengthening the foundations and the abutments, sealing the abutments, rebuilding the piers (in the form of a concrete core with granite and brick masonry cladding) using the historic material, repairing the external surfaces of the abutments, making an abutment crown for the bridge steel frame structure, assembling the steel frame structure, the sandstone parts, the pedestrian parapets and the wooden bridge deck.



Fig. 5. English Bridge (ca. 1940) Fig. 6. English Bridge (ca. 2005)



Fig. 7. English Bridge (2011)



Fig. 8. English Bridge (2011)



The English Bridge (Figs. 5-8) together with the Double Bridge enable one to drive along the roundabout, patterned on the English “drive” layout, road through the park, whereby one can delight in this great composition and its unique elements. The bridge constituted Pückler’s favourite direct connection to the English Cottage – a nonexistent today cottage-style layout with a licensed establishment and an entertainment complex, with a place for dancing, games and a shooting range. This exceptionally lively part of the Park gave name to the English Bridge, and through the association with England and the models from England, was given the name England. Besides the practical function the English Bridge has also a great artistic value and forms a unique architectural point seen from different sides of the Park.

The reconstruction of the two bridges on the Lusatian Neisse beyond the functional aspects of conservation and also has value for the perception of the park on both sides of the border as an integral whole.

### 5.3. Arcade Bridge

The Arcade Bridge (Figs 9-12) located in the park’s east part is one of the three architectural structures which have survived on the Polish side. It is a monumental structure supported by arcades, connecting the edges of a deep tree-covered gorge with Sara’s path running on its bottom. The structure was erected in 1853. For the building of the bridge, being at the same a viaduct, besides brick, also glass slag, a byproduct produced in the nearby ironworks, was used. Formed into blocks it adds interesting variety to the structure. The maximum height of this five-span bridge amounts to about 9 m, the width to about 4.5 m and the length to about 28.5 m.

After 1945 wooden beams were introduced into the bridge flooring, to which a temporary wooden balustrade, replacing

the destroyed steel balustrade, was secured. The space between the vault, the head walls and the bridge flooring was filled with soil, additionally loading the vaults. The masonry structure was protected by about 25 cm thick layer of cohesive soil and the remaining space was filled with permeable soil in which a system of drains was installed, carrying off rain water seeping through the bridge flooring made up of breakstone with varied fractions ensuring both good compaction and permeability to rain water. For bridges built before the 20th century clay soil would provide insulation. Water is carried out by protruding ceramic pipes.

Prince Pückler did not give this bridge a name. In the plans from 1856 and 1865 the name Viaduct is used. In the plan from 1888 it is referred to as the Viaduct over Sara’s Path. In the plan from 1926 the name the Gorge Bridge is mentioned. The currently used vernacular name is the Arcade Bridge. Despite the considerable damage to the balustrade and the weakening of the structure, the bridge was used until 2007, and subsequently was put out of service until 2011 when the renovation work started.



Fig. 9. Arcade Bridge (beginning of 20th c.)



Fig. 10. Arcade Bridge (1990s)

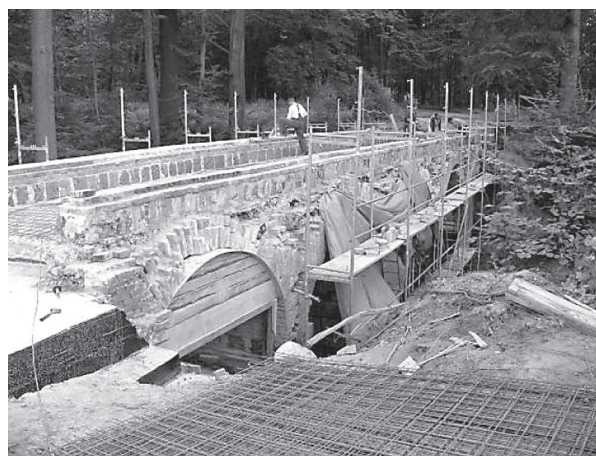


Fig. 11. Arcade Bridge during renovation work (2011)



Fig. 12. Arcade Bridge (2011)

According to the renovation plan, the historic function of the bridge was to be preserved. The bridge was to remain a park structure to be used only by pedestrians and by cars with a weight below 10 t, directly connected with the current operation and maintenance of the park.

For about 150 years the bridge had been subjected to changing weather conditions, i.e. repeated changes in temperature, humidity, etc. Moreover, considering the considerable neglect in the maintenance of the bridge, it can be concluded that the main factor reducing the durability of the Arcade



Bridge was the corrosion of its structural components: the bricks and the glass slag blocks, the washing out of the mortar joining them together and the growing of tree roots into the structural components. Cracks and fractures in the vaults and in the west head wall, the weakening of the piers and damage to structural components due to material loss were found. As a result of the damage the load capacity of the bridge significantly decreased and the structure was found to be locally overloaded. Since the further use of the bridge could result in a structural failure, the bridge had to be put out of service and immediately subjected to renovation.

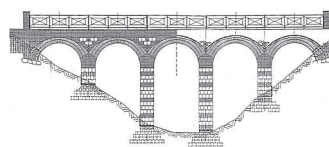


Fig. 13. Arcade Bridge – renovation design [4]

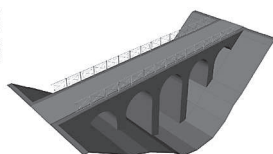


Fig. 14. Arcade Bridge – final spatial model subjected to numerical analysis

As part of renovation work (Figs. 11, 13, 14), the west head wall, pier no. 3 on the east side, the central parts of the vaults, etc., were subjected to crack and fracture injection. Injections increase the strength of the component materials and their load capacity, seal walls and prevent harmful elements, especially moisture and aggressive gases, from penetrating into the walls. Regeneration of the vault and pier systems of a masonry bridge through injections is a very delicate treatment. Currently one can use three methods of strengthening curved masonry structures: gravity injection, pressure injection and vacuum injection.

During the renovation the selected parts of the bridge structure were rebuilt and the missing parts were replaced. This method was applied to both the piers and the brick vaults in order to restore the original geometry of the bridge components. Prior to this it is essential to eliminate the causes of the cracking or fracturing. There are differing views on what binding material should be used. Tests clearly showed that mortars based on cementitious binders, characterized by a much higher strength than the mortars existing on the original elements, had been used for the repairs. The use of mortars with a higher strength than that of the original ceramic material is for many reasons improper and may result in damage. Mortars should be carefully matched to the particular service conditions and trass lime mortars should not be replaced with burned lime or hydrated lime mortars.

An important way of strengthening the brick arches of bridges is through the use of steel tie-back anchors and additional elements bracing the masonry system, which help to reduce wall displacements and coat and rib cracking and may take part in carrying additional tensile forces appearing in the case of damage.

The proper functioning of a steel tieback anchor in historic structures depends on the application and maintenance of a proper force in it. The introduction of a proper tensioning force should produce such a state of stress in the masonry, which will effectively counter the action of the external forces and increase the overall stiffness of the structure. Improper transfer of the force from the tieback to the wall may cause further cracking. In the case of traditional stays, the anchoring of a bearing element (e.g. a metal plate, rosette, flat bar or rod) is usually visible on the façade. Sometimes it is hidden under

a masking layer: plaster, rebuilding or a façade ornamental element. This kind of masking was used also in the case of the Arcade Bridge.

The renovation of the brickwork part of the bridge consisted in removing damaged and rotten bricks in the existing parts, and brickwork joints to a depth of at least 20 mm on the whole brickwork surface. The existing brick was cleaned using CP methods (Fig. 15). Then the joints were blown with compressed air and a water jet. The so-called water lance not only cleans, but also wets the elements, which is recommended prior to pointing and filling cavities. The bricks used for the rebuilding were fabricated to order, in imitation of the historic bricks, in the nearby brickyards. The mortars used for masonry work and the ones used for pointing were based on trass binders. The appearance of the masonry after cleaning, luting, replacing the missing bricks and glass blocks and repointing (Fig. 16) recalls the former splendour of this bridge structure. The whole of the brickwork structure and the recovered and renovated stone cornices were protected with hydrophobic preparations. The bridge deck surface layer was made from granitebreakstone, similarly as all the roads.



Fig. 15. Surface of bridge before cleaning



Fig. 16. Surface of bridge after cleaning

The so-called glass slag (Figs. 17, 18) which could be used to replace the damaged blocks is now unavailable since it was a byproduct from the nearby ironworks. Some of this material was obtained through the project German partner – the Fürst-Pückler-Park Bad Muskau Foundation. The other missing elements were made from glazed ceramic blocks coloured in imitation of the glass blocks.



Fig. 17. Arcade Bridge – built-in original structural elements



Fig. 18. Arcade Bridge – original and new elements made of glass slag

The renovation also included damp-proofing the vaults on the extrados side, and the head walls from the inside as well as vertical and horizontal damp-proofing of the piers. Drains carrying rain water off the bridge and a road surface were laid and the cornices and the parapets were reconstructed.

The Arcade Bridge after the conservation renovation was opened on 9 December 2011. The renovation was co-funded

from the European Regional Development Fund within the framework of Poland-Saxony Cross-border Cooperation Operational Programme. The main aim of this Operational Programme is to support the sustainable development of the Polish-Saxony support area in order to strengthen its economic and social cohesion.

## 6. CONCLUSIONS

The Muskau Park (Muskauer Park) is the largest landscaped-style park and one of the finest examples of the 19th century European garden art. Since the end of the 1980s it has been the subject of the Polish-German

restoration project. Since 1991 being restored values of the historic composition.

The structural conservation of the bridges is a vital element of this restoration process. Especially that it is probably the only example in Europe of close cooperation of two countries in the protection and conservation of historic objects and the cultural landscape.

*The materials (expert opinions, photographs, designs and inventories) relating to the Muskau Park objects, used in this paper come from the resources of National Heritage Board of Poland, the Prince Pückler Park Foundation in Bad Muskau (Stiftung Fürst-Pückler-Park Bad Muskau) and the authors.*

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## Abstract

The Muskau Park is one of the most extensive 19th century landscape-style park layouts in Europe. From among the numerous landscape-style park compositions created in that period the Muskau Park stands out not only owing to its artistic values, but also because of the fact that the Park, as the consequence of World War II divided by the state border on the Lusatian Neisse river, since the 1980s has been undergoing restoration carried out by two countries: Poland and Germany, within the framework of a joint project. It is owing to the efforts of the Polish side and the German side that this park in 2004 was inscribed on the UNESCO World Heritage List and at the same time became a symbol of the reconciliation between the nations of Poland and Germany and of the conservation collaboration in the field of cultural landscape protection. Thanks to cross-border cooperation measures were taken to restore the Park's historic compositions, including bridges to their former glory. The English Bridge and the Double Bridge, connecting the two banks of the Lusatian Neisse, and the Arcade Bridge situated on the Polish side of the Park have been subjected to conservation renovations whereby the bridges have been restored to their former glory.

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## Streszczenie

Park Mużakowski jest jednym z najrozleglejszych w Europie XIX wiecznych założeń parkowych w stylu krajobrazowym. Spośród licznych kompozycji w tym stylu powstałych w epoce obiekt ten wyróżniają nie tylko wartości artystyczne, ale i fakt, że park, podzielony w konsekwencji II wojny światowej granicą państwową na Nysie Łużyckiej, jest od końca lat 80 XX wieku rewaloryzowany przez dwa państwa – Polskę i Niemcy w ramach wspólnego projektu. To dzięki staraniom strony polskiej i niemieckiej, obiekt ten został wpisany w 2004 roku na Listę Światowego Dziedzictwa UNESCO, stając się jednocześnie symbolem pojednania między narodami Polski i Niemiec i współpracy konserwatorskiej w dziedzinie ochrony krajobrazu kulturowego. Dzięki współpracy transgranicznej podjęto działania mające na celu przywrócenie świetności parkowym obiektom mostowym. Mosty angielski i podwójny łączące oba brzegi Nysy Łużyckiej jak i most arkadowy znajdujący się po polskiej stronie parku poddano remontom konserwatorskim przywracając im dawną świetność.