Windmills in Fortifications

(Вітряки в фортифікаціях)

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1. Introduction.

One of the problems of ancient fortifications, which is not often talked about these days, was nutrition and food storage during siege. Fortifications were designed to protect the defenders and provide a possibility of efficient counterstrikes, though long-lasting sieges raised the issue of supplying the defenders with weapons, ammunition, food, etc.. Therefore, if circumstances and location allowed, the grounds of ancient strongholds were developed so as to ensure that the defenders be self-sufficient for as long as possible. Hence, the premises were equipped with facilities allowing to store and process raw materials and food.

During siege, warehouses were stocked with the necessary tools, materials, and preserved food. Animals providing the defenders with indispensible products (e.g. meat, milk, hides, etc.) were herded inside the stronghold. Problems arose with grain storage. Flour, if stored at all, was kept in far lesser amounts than grain, which could be stored much longer. Grain could be milled into groats or flour, as well as fodder. In order to do so, the defenders required mills. Based on drive type, they were either watermills, windmills, or treadmills.

Water mills would be situated at the banks of adjacent rivers, where they were inaccessible for the besieging forces. Of all the aforementioned mill types, these were characterized by the highest milling efficiency. Many fortifications were equipped with additional, internal reservoirs or canals which could also be used as watermill drive.

Windmills were used when land form and wind conditions enabled effective utilization of wind energy. Watermills, though more efficient, were often less profitable or unfeasible. Windmills were a challenge for their designers. With windmill efficiency increasing when working undisturbed, any environmental interference was inadvisable, though hard to avoid due to the cramped space within the fortress. Windmills were often built into protruding bastions or incorporated into the walls.

Treadmill is a type of mill propelled by muscles of animals or people. It was used when other constructions were impossible to erect or too complicated and costly. Moreover, treadmills would often support the functioning of other mills in grain milling, remaining a warranty for the situations when using other constructions was impossible (e.g. mechanical damage or unfavorable weather conditions).

My paper focuses on the subject of windmills in fortifications. I shall address the problem of commemorating their existence, preservation and architectural diversity, as well as the cultural significance they gained operating throughout centuries to become part of cultural heritage worthy of being preserved.

2. Windmills. An overview of basic solutions.

As regards the architectural factor, there is a wide variety of windmills which can be differentiated from one another based on the period, region, etc., a typology which cannot be outlined within the scope of a short paper. Covering this topic, though, warrants a brief typology

of windmill constructions. One of the most common divisions is the one based on the mechanism of setting the blades towards the wind. The typology includes three distinct windmill types:

- pillar windmill,
- tower mill (the so-called Dutch windmill),
- roller windmill (paltrak).

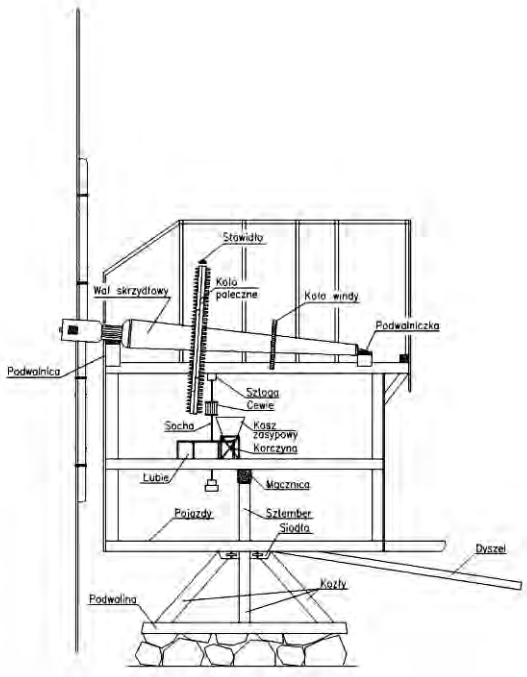
Pillar windmill

The pillar windmill (picture 1) swivels around the main axis – the pillar, a vertical pole set in the center of the building, secured in a stationary foundation. The lightness of its construction, which is entirely wooden, allows to rotate the entire building according to the direction in which the wind blows.

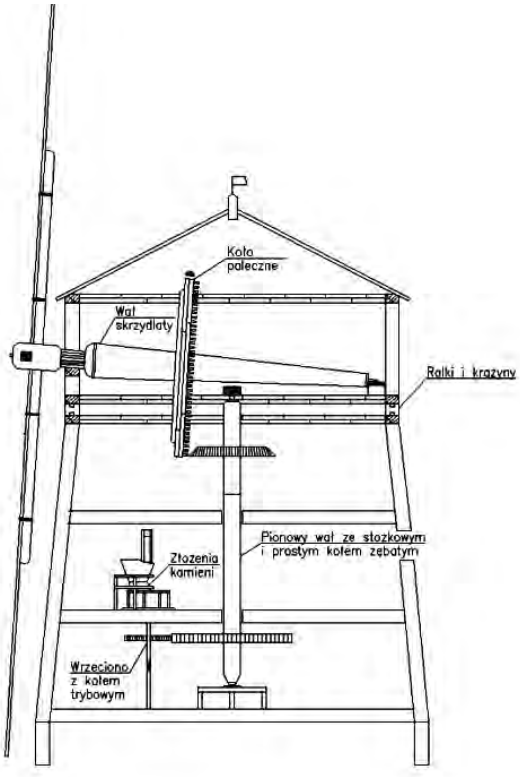
The wind energy is transferred from the blades on the drive shaft on which the pillar wheel is positioned, which transmit the rotating motion onto the winder connected to the wooden plow. The plow in turn propels the millwheel, installed in the upper, movable millstone, propped on the spindle

Tower mill

Tower mill (picture 2) has a stationary base. Therefore, it was often made of bricks and stone, so that it would be more durable and able to perform defensive functions, which can be seen in the following quotation: "In the 13th century, there were mentions of large and fortified windmills. Jan Długosz, for instance, accounts that in 1279, the finest inhabitants of Elbląg took shelter at the mill when attacked by Prussian pagans, with whom they would eventually negotiate and to whom they would turn in 25 hostages, yet the heathens slaughtered both the hostages and the sheltered."[1].



Picture 1. *Pillar windmill. Source: private*



Picture 2. *Tower mill.Source: private*

[1] Zygmunt Gloger „Encyklopedia Staropolska" tom II, Warszawa 1958 r. (przedruk fotooffsetowy wydania czterotomowego z lat 1900-1903 w dwóch woluminach), s.221.

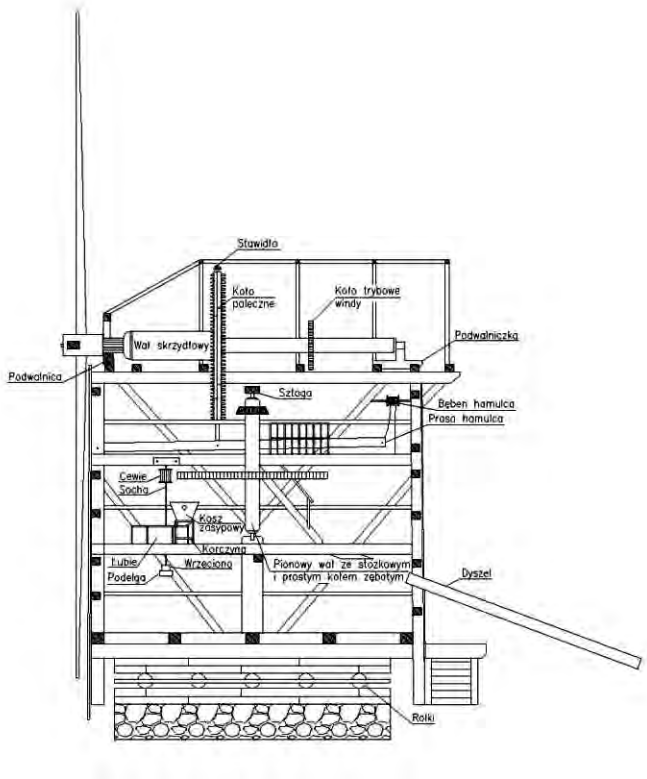
Accordingly with the assumption, the body of the building remained stationary, thus adapting the upper part of the windmill to setting the blades to the wind. The upper part consists of the roof and the rotary "hat" (its the swivel mechanism based on a system of rolls and centrings) .

In this type of windmill, the rotary motion of the blades is transmitted from the pillar wheel onto the conical cogwheel placed on a vertical shaft. A horizontal cogwheel is placed on the lower part of the shaft, linked to the cogwheel attached to the spindle. The spindle is set in the millwheel of the upper millstone within an arrangement of millstones, transmitting the rotary motion onto the millstone.

Roller mill

The third basic type of windmill is the roller mill (picture 3). Its base rotates thanks to a system of guides and rolls, installed in the windmill's foundation.

The mechanism of this windmill used to vary. Some of them utilized a similar mechanism to the pillar windmill, others operated based on the Dutch windmill's system. Another mechanism, characteristic solely of roller mills and represented in picture 3, was also in use. The upper part of the mechanism was identical to the Dutch windmill, while the horizontal cogwheel placed on the vertical pillar propelled the winder instead of the spindle, while later continuing in accordance with the pillar windmill's mechanism.



Picture 3. *Roller mill. Source: private*

3. The problem of locating the windmill in a fortified area.

Sometimes, natural conditions and the development of fortifications would disable the use of wind energy in grain milling. For proper operation, windmills required appropriate setting in relation to the wind's direction, so that they could maximize its energy. Apart from this, the wind itself had to be adequately strong. Too strong a gust could damage the windmill and,

consequently, cease its operation. Too weak winds in turn would not set the blades in motion. According to Jan Święch, "the windmill could work if the wind blew at the minimum speed of 4 m/sec."[2]. Elżbieta Dąmbska also touches upon the subject: "It is evident that the fundamental factor shaping the operation of a windmill was its energy consumption, i.e. the occurrence of such conditions, in which the speed of wind would set the blades in motion (no less than 2 to 4 m/sec., most favorably 12 to 18 m/sec.,[3] the speed at the same time not exceeding these values and becoming hazardous for the windmill, whose blades would at the given moment be in motion."[4]

Also crucial was the influence of the surroundings on the wind's flow. Various barriers, such as buildings or woods, disturb the wind's flow, thus causing it to lose some of its energy and become more difficult to utilize. Hence, windmills would most often be erected on tops of natural bulges situated in open spaces (the higher the altitude, the faster the wind, transferred in turn onto its force). Such a solution is represented in Matthaeus Merian's print depicting the fortified town of Lipiany (picture 4). The windmill is situated outside of the town on a hill.

Picture 4. *Forified town Lipiany. The windmill, highlighted in red circle is situated outside of the town on a natural hill. Source: Matthaeus Merian, Martin Zeiller et all, „Topographia Electoratus Brandenburgiae et Ducatus Pomeraniae […]" Frankfurt am. M. 1652 r., s.165*

In the cases of deficiency of natural elevation, mounds would be raised or, alternatively, windmills would be erected on foundations laid of brick or stone. Such a solution was applied in Szczecin (picture 5).

[2] J. Święch „Tajemniczy świat wiatraków", Polskie Towarzystwo Ludoznawcze, Łódź 2005, s. 105.

[3] Cytując za autorką: „Wg informacji p. Ignacego Piaseckiego, młynarza ze wsi Modła pow. Mława. (Zawód młynarza przechodził w jego rodzinie od kilku pokoleń z ojca na syna)", Lubuskie Towarzystwo Naukowe w Zielonej Górze.cBiblioteka Lubuska Zeszyt 10. Rudolf Śmiałowski, Elżbieta Dąmbska. „Budownictwo drewniane i młyny wietrzne Ziemi Lubuskiej" Poznań-Zielona Góra, wyd. Poznańskie, Poznań 1968. Część: E. Dąmbska „Młyny wietrzne na Ziemi Lubuskiej ", rozdział „Charakterystyka wiatraka i jego funkcja" s.132

[4] Lubuskie Towarzystwo Naukowe w Zielonej Górze.Biblioteka Lubuska Zeszyt 10. Rudolf Śmiałowski, Elżbieta Dąmbska. „Budownictwo drewniane i młyny wietrzne Ziemi Lubuskiej" Poznań-Zielona Góra, wyd. Poznańskie, Poznań 1968. Czesc: E. Dąmbska „Młyny wietrzne na Ziemii Lubuskiej " rozdział „Charakterystyka wiatraka i jego funkcja" s. 135.

Picture 5. *Szczecin. Highlighted in red circle windmills are seated on man-made earth mounds. Source: Matthaeus Merian, Martin Zeiller et all, „Topographia Electoratus Brandenburgiae et Ducatus Pomeraniae […]“ Frankfurt am. M. 1652 r., s.235.*

As seen at the above illustration, windmills are seated on man-made earth mounds, so that thanks to their elevation they would be exposed to the energy of the blowing wind. I think that in this case the fortifying wall was a wind-blocking factor, thus causing constructors to resort to the above solution. Also worth pointing out is the arrangement of windmills in one complex, which leads us to conclude that this terrain could have had the most beneficial wind conditions in the entire town.

Yet another solution was placing windmills directly on the curtain walls, thus gaining both elevation and unobstructed exposure to wind. Such a solution was implemented, among other places, in Cologne (picture 6).

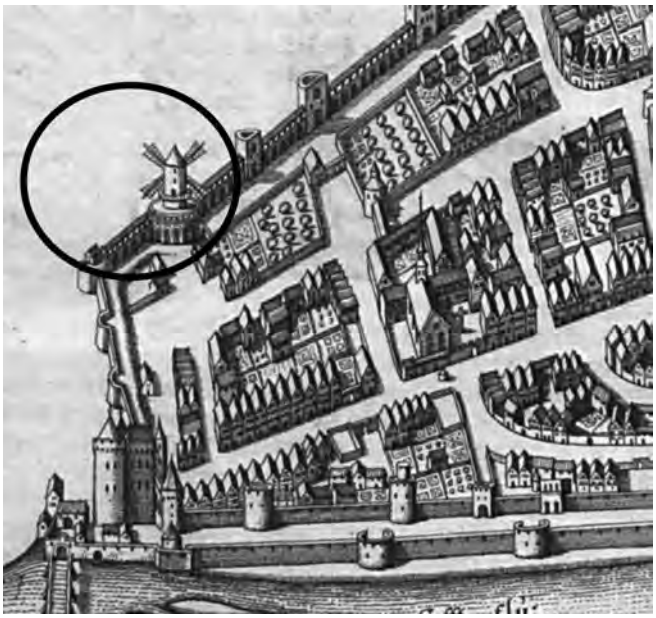
Picture 6: *Cologne. Highlighted in red circle windmills are on the curtain walls. Source: Matthaeus Merian, Martin Zeiller „Topographia archiepiscopatuum Moguntinensis, Trevirensis et Coloniensis[…]", Frankfurt am M. 1646 r., tablica 35.*

A similar approach was assumed in Bonn (pictures 7 and 8).

Picture 7: *Bonn. Pillar windmill is situated on the city walls. Source: Matthaeus Merian, Martin Zeiller „Topographia archiepiscopatuum Moguntinensis, Trevirensis et Coloniensis […]", Frankfurt am M. 1646 r., tablica 37*

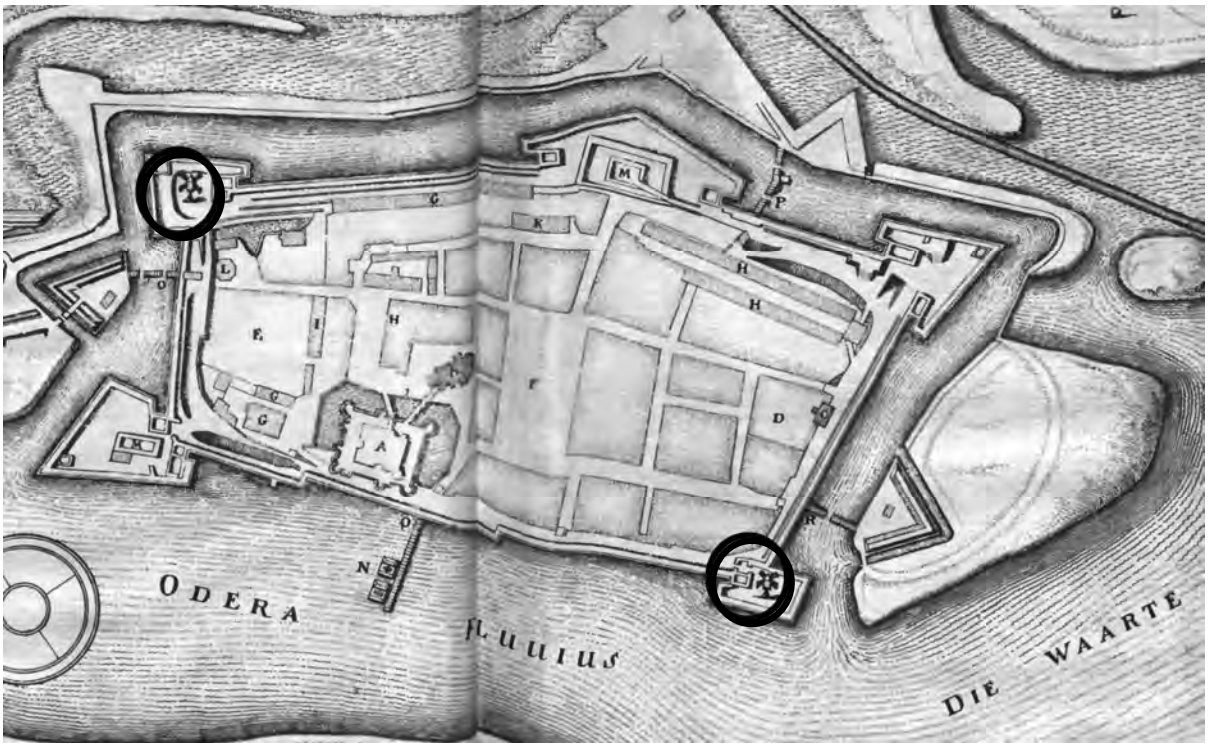
Picture 8: Fragment ryciny przedstawiający Bonn. Bonn. Highlighted in red circle pillar windmill is situated on the city walls. Source: Matthaeus Merian, Martin Zeiller „Topographia archiepiscopatuum Moguntinensis, Trevirensis et Coloniensis[…]", Frankfurt am M. 1646 r., tablica 37

Another example of such an approach can be found in Neuss (picture 9). The print's fragment clearly indicates the use of a tower mill.



Picture 9: *Neuss. Highlighted in red circle tower mill. Source: Matthaeus Merian, Martin Zeiller „Topographia archiepiscopatuum Moguntinensis, Trevirensis et Coloniensis[…]", Frankfurt am M. 1646 r., tablica 40.*

An interesting example of how windmills were set within the fortified area can be seen in the case of Kostrzyn nad Odrą (picture 10). The windmills are situated at the rampart terraces at the fortress's opposite ends.



Picture 10. *Kostrzyn nad Odrą. Highlighted in red circle windmills are situated at the rampart terraces (from left) „Queen" and „Philip". Source: Matthaeus Merian, Martin Zeiller et all, „Topographia Electoratus Brandenburgiae et Ducatus Pomeraniae […]" Frankfurt am. M. 1652 r., s. 97.*

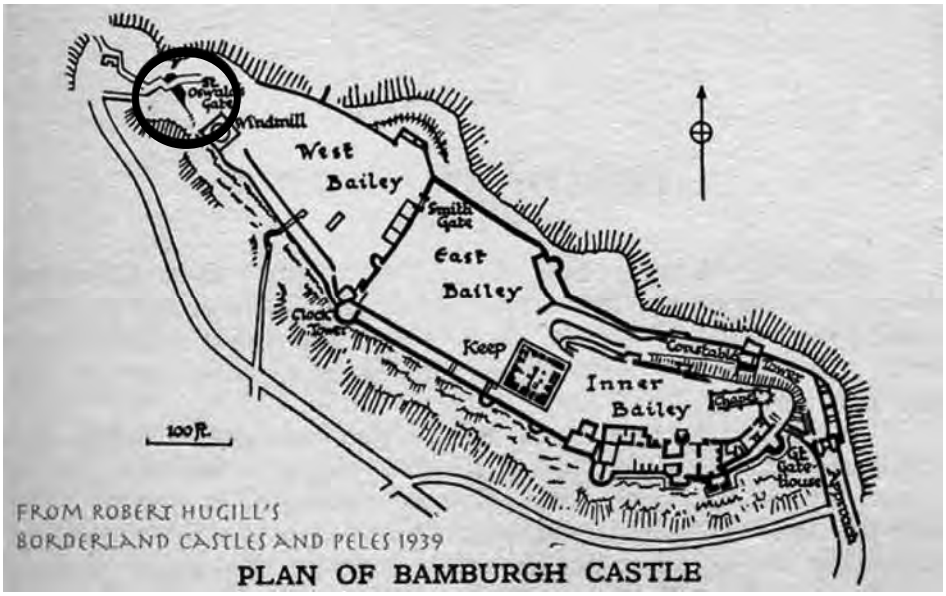
I think such a solution ensured a better adaptation to the local wind conditions. In this arrangement, at any time, one of the windmills would be driven by the wind blowing from the outside of the stronghold, i.e. unobstructed by the buildings inside the fortress. According to documentalist Marcin Wichrowski of the Kostrzyn Fortress Museum, the construction date of the windmills represented in picture 10 remains unknown. It can be linked, however, with the period of reconstruction and development of the warehouse facilities that took place at the end of the 16th century, during elector John George. The image of a windmill at the terrace of rampart "Filip" occurs in the town's and fortress's panorama, the print date of which remains unknown, but which was attached to the plan dating back to ca. 1600. The images of both windmills can be found in the bird's eye view of the fortress issued during the Thirty Years' War. According to Mr Wichrowski, the origin of the aforementioned image is linked to the inspection of the electoral army concentrated in Kostrzyn in 1637. The document served as a model for one of Matthaeus Merian's prints. Carl Friedrich's work, titled "Die Stadt Küstrin," in turn, mentions the 1704 windmill liquidation at the terrace of rampart „Filip."[5] The early 18th century images of the

[5] C. Fredrich „Die Stadt Küstrin", wydana w drukarni Carla Adlera, Kostrzyn 1913 r., s. 128.

fortress do not show any trace of any of the two windmills, yet the exact date of the liquidation of the second windmill remains unknown.

Another instance of a windmill situated within a fortified structure is the 18th century windmill of the castle of Bamburgh in Great Britain (pictures 11 and 12).

Picture 11. *Windmill at the Bamburgh castle. Source: http://www.bamburghcastle.com/phpmedia/poi/lrg/8ed3372c677c501fbf1e2192658f1561.jpg*



Picture 12. *Map of the Bamburgh Castel with windmill highlited in red circle. Source: http://www.northofthetyne.co.uk/BamburghCastle.html*

Based on the information gathered from the castle's employees, I can quote its history. In 1766, Dr John Sharp applied to the governor of Lord Crewe's estate for a thirty-pound sterling subsidy. The said subsidy allowed him to purchase grain which he then could sell to the poor at lower rates – this took place when the price of wheat exceeded 5 s. a bushel. The following year,

Dr Sharp's charity initiative was introduced permanently. The leaseholders provided the grain, and the castle permitted the use of its granary – eventually, two granaries were situated within the fortifications, and two additional ones were located in the village. Dr Sharp himself equipped them with machinery. The windmill was erected in the 18th century,. A flour shop was opened, too, for those who wanted to purchase ready-milled products. Wheat, peas, beans, and barley were sold twice a week to any impoverished person within 40 miles of Bamburgh. The mill's quern have been preserved at the castle of Bamburgh.

Picture 13. Windmills of the el Jonquet in Palma de Mallorca. Source: http://upload.wikimedia.org/wikipedia/commons/a/a4/Molins_des_Jonquet.JPG

The windmill, as the castle itself, enchants with its beauty and condition. Well maintained and situated directly at the sea, it constitutes a fortification worthy of attention.

Another interesting case, in which windmills were placed atop the walls are the El Jonquet windmills in Palma de Mallorca displayed in picture 13. These mills, built into the city walls, have become one of the city's symbols. They are one of the first buildings seen by those arriving aboard into the port.

Picture 14. *Windmill AT the Chateau de Koenigsberg (Francja). Source: http://static.panoramio.com/photos/original/24153701.jpg*

The castle of Chateau de Koenigsberg, with the windmill constituting an integral part of the defensive structure, is another very interesting facility (picture 14).

4. The problem of reconstruction and research deficiency.

Concerned for preserving the remembrance of windmills, and windmills themselves, museums' workers list several main problems. The most acute worry is the lack of documentation, or its inaccessibility, particularly with source materials. Another issue is the lack of

adequate research financing, perhaps accounting for some researchers' unwillingness to voluntarily delve into studies.

Budgetary problems are also an issue when working with the objects themselves, e.g. with reconstruction and renovation works. These usually favor the most characteristic objects, rarely recognizing windmills as significant components.

It is understandable that in reconstructing fortifications efforts are made no to mix the stages of the original construction. Being in possession of a well preserved object does not warrant a reconstruction of another, inexistent building dating back to a different period. This, however, does not justify its oblivion. It is all the more fundamental to make every effort to assemble the most extensive documentation available on the inexistent object, and to disseminate it. Such actions could stimulate researchers and hobbyists to explore the subject and, consequently, extend the range of knowledge of the now-run down buildings, such as, among others, windmills within fortifications.

Yet another drawback is linked to legal issues and often complicated administrative procedures of maintenance of historic buildings and their protection. Fortifications are very demanding in maintenance, requiring significant funds, therefore any regulations which leave the financing and maintenance of such objects to private entities and local authorities, in fact doom them to slow but steady deterioration.

5. Windmill as a carrier of cultural heritage.

Windmills are carriers of a great deal of values. Above all, they are testimonies of the history of milling industry – one of the once significant branches of industry – and at the same time they constitute examples of ancient engineering solutions.

The availability of building materials, the lay of the land, the wisdom and skills of constructors, or the individual pieces of ornamentation made every windmill a unique masterpiece, a sample of which we could witness in the described pictures. Windmill builders – usually carpenters – played a very important role. They would pick suitably durable wood, manufacture the mechanism's components, weigh them, so that the force of the mechanism or the power of winds would not tip over the windmill. The manufacture of components was no easy task. The mechanism, filled with cogwheels, may be compared to the machinery of a watch, whose precision translates into the miller's safety at work and the mill's quality.

Windmills are interesting objects not only because of their architecture and carpentry. They were once meeting places for communities. Thanks to the miller's high social status, his windmill would often be the center of the village's life. The miller would be held in high regard, ordained with significant duties in local organizations, asked for advice or judgment in complex matters, and appointed as witness at religious celebrations.

Windmills and millers were celebrated in poems, folk songs, proverbs and sayings. They also inspired many painters.

Windmills and millers were often surrounded by an air of mystery. As they were able to tame nature's power manifested in winds, millers were more than once imputed to mix with unclean spirits.

After the invention of the electric engine, the number and significance of windmills started to gradually decrease. Windmill mechanisms were often adopted in using electric energy, and

many of them were forgotten and destroyed. Still, some of them survived until today, therefore it is essential to protect them from deterioration and oblivion.

6. Remembering the windmills within fortifications.

While researching for the present paper, I came across difficulties compiling information. Matthaeus Merian's prints of the 17th century proved to be an invaluable reference in my search for windmills in ancient fortifications. They provided me with many examples of windmills situated both inside and directly outside of the walls. Finding more specific information in this respect, though, was difficult and often limited to finding reproductions of paintings with a given windmill incorporated into the town's panorama, or reaching snatches of information at various websites acknowledging the existence of that given windmill. It often occurred that even museums' workers found themselves troubled to answer basic questions regarding the preserved object, justifying this difficulty by the lack of proper research funding and the lack of preserved documentation. In certain cases, I was even unable to find out whether a given object still exists. A natural conclusion comes to mind, that hardly anyone these days pays attention to windmills in fortifications.

7. Conclusion.

Windmills were one of the solutions applied in fortifications to mill grain which was characterized by its durability, thanks to which the defenders were able to benefit from freshly milled products, such as flour or groats. Due to the specificity of cramped strongholds, the use of windmills was a challenge, yet it resulted in many interesting and innovative solutions, adjusted to the conditions of a given fortress, thus proving the craftsmanship of their creators and the historical engineering solutions.

Because of the lack of documentation and research funding, the topic of windmills is often overlooked or recedes into the distance. Legal regulations do not facilitate the remembrance of these objects either, shifting the responsibility for fortification maintenance onto natural persons or private entities who are ill-equipped to address the problem, chiefly because of their financial shortcomings. Administrative obstacles are hurled as to the management procedures of historic object. Therefore, windmills in fortifications, which are characterized by a tremendous range of architectural, cultural and historical values, are slowly being forgotten, although they could potentially make for valuable tourist attractions which would extend people's knowledge of life in ancient strongholds and their functions, both at the time of war and peace.

Concluding the present paper, I wish to express my sincere hopes that the future carry actions aimed at advancing the knowledge of windmills in fortifications: their construction and documentation, as well as the cultural charge they carry.

References:

1. C. Fredrich „Die Stadt Küstrin", wydana w drukarni Carla Adlera, Kostrzyn 1913.
2. Matthaeus Merian, Martin Zeiller et all, „Topographia Electoratus Brandenburgiae et Ducatus Pomeraniae […]" Frankfurt am. M. 1652.
3. Matthaeus Merian Martin Zeiller et all, „Topographia archiepiscopatuum Moguntinensis, Trevirensis et Coloniensis[…]", Frankfurt am M. 1646.

4. Lubuskie Towarzystwo Naukowe w Zielonej Górze.Biblioteka Lubuska Zeszyt 10. Rudolf Śmiałowski, Elżbieta Dąmbska. „Budownictwo drewniane i młyny wietrzne Ziemi Lubuskiej" Poznań-Zielona Góra, wyd. Poznańskie, Poznań 1968. Czesc: E. Dąmbska „Młyny wietrzne na Ziemii Lubuskiej " rozdział „Charakterystyka wiatraka i jego funkcja".

5. J. Święch „Tajemniczy świat wiatraków", Polskie Towarzystwo Ludoznawcze, Łódź 2005.

6. Zygmunt Gloger „Encyklopedia Staropolska" tom II, Warszawa 1958. (przedruk fotooffsetowy wydania czterotomowego z lat 1900-1903 w dwóch woluminach).

7. Web sites:

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