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Small Hydropower Plants in Pomerania: The Example of Evolution of Modern Industrial Brick Architecture

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Abstract. Modernism is usually recognized and associated with the aesthetics of the International Style, represented by white-plastered, horizontally articulated architecture with skimpy decoration, where function was the main imperative of the architects' ambitions. In Northern Europe though, Modernism also revealed its brick face, representing different manners, styles, and appearances. The brick face of Modernism reflected, in fact, the complexity of the modern change, breaking ties with the historic styles of the 19th century and being still present in the beginning of the 20th century. Regardless of the cosmopolitan character of the International Style and its unified aesthetics, architects tried to find and keep shades of individuality. This was especially visible in the references to either regional or even local traditions. This diversity of modernistic architecture is intensified by its different functions.

The language of industrial architecture derives its forms directly from its nature of pure functional idiom, devoted to economic and functional optimization. The industrial form usually seems subordinate to the technical nature of objects. But regardless of that, in the 19th century and the first half of the 20th century we can observe an interesting evolution of styles and tendencies in industrial architecture, even in such a narrow and specific field like the architecture of small hydropower plants. The purpose of the research was to recognize the evolution of the architectural form of hydropower plants as a developing branch of industry in the first half of the 20th century. In Pomerania, during this period, a dynamic growth of investments took place, which concerned the use of the Pomeranian rivers' potential to produce electric energy. At the end of the 19th century, electricity had a strong meaning as a symbol of a radical civilizational change, which influenced also the aesthetic aspects of architecture. This could suggest that the architecture of hydropower plants should be one of the carriers of the new progressive architecture. In fact, in the case of the Pomeranian hydropower plants, their technical solutions were among the most advanced and progressive solutions of those times, sometimes even experimental, adjusted to the diversity of local geographical conditions. Regardless of that, the architecture of the Pomeranian power plants was rather reflecting the diversity and dynamism of the aesthetic discourse of the time (sometimes even representing and adopting traditional or historical forms). The cascade of the power plants Podgaje (1928), Jastrowie (1930), and Ptusza (1930), all part of the same investment on the river Gwda, can be the example of the absorption and development of new aesthetic trends within the same stream of clinker architecture. The paper describes selected examples of Pomeranian power plants as a comparative study which could illustrate the evolution of the brick architecture of the beginning of the 20th century.

1. Introduction

The history of Pomeranian[1] hydropower plants dates back to the beginning of the era of electrification. First power plant in Soszyca was built in 1896[2] and it still produces electricity with the original equipment. It is considered as one of the oldest working hydropower plants in Europe. The tradition of using the energy of the Pomeranian rivers can be traced to the late Middle Ages [1], but the radical process of their industrialization didn't start until the beginning of the 20th century. This was the time of dynamic evolution of both technologies of production and technology of consumption of electric energy, which was the condition of their mutual development. The hydropower plants of Pomorze are well kept, and the majority of them are still in use in their original state. The technical equipment, such as turbines or generators, is still in use as it was in the beginning of the 20th century, due to careful conservation and the owners' awareness of the historic value of this industrial heritage. This is not only a unique illustration of the historical process of the development of energy production technology, but also of the history of the development of the architectural form of this kind of industrial objects. Pomeranian power plants, due to their capacity, are mainly regarded as Small Hydropower Plants[3] (SHPs). In fact, this technological ratio is connected with architecture and strictly connected with the evolution of the form of power plants. In the case of SHPs, the proportion between the damming and the power plant building is kept in balance, as opposed to high head power plants, where the dam is usually a massive, architecturally dominant element of the establishment. The architecture of SHPs was determined by two main aspects, technological and aesthetic. Technological demands determine the form and scale of SHPs, general relations between the damming system, its height, form, and span of the weir, the dimensions of the power house, etc. The aesthetic aspects, sometimes neglected or abandoned in favor of usability, sometimes seem to be the subject of the architect's solicitous concern. The architectural form of power plant had, to a certain extent, a symbolic character, which is visible in the form of decoration, in architectural details, etc. In the case of the Pomeranian SHPs, these elements reflect the stylistic tendencies of the time.

The 19th century is usually recognized as an age of electricity and steam. This could suggest that a power plant should reflect this progressive significance of electrification in its architectural form. The paradox lies in the fact that as a result of the historical trends, still present in the early 20th century, the Pomeranian hydropower plants in the early stage of development were dressed in historicist architectural costume of sorts [2]. There was no symbolic manifestation of the role of electrification by means of using avant-garde architectural forms.

This trend is well illustrated by the works of Peter Behrens, who was the leading German architect of the time and one of the founders of the Werkbund. He was the promoter of incorporating high quality design and new aesthetic ideas into the practice of mass production. The relationship between art and industry should result in quick realization of modern architectural ideas. The Werkbund organization was forming the idea of a corporate image through a complex, comprehensive visual identity. Hence AEG (*Allgemeine Elektricitäts-Gesellschaft*) products, from lamps, generators, to the architecture of industrial buildings, represented high aesthetic and overall brand quality. Peter Behrens wasdirectly involved in the process of shaping the image of the AEG consortium, and it could be expected that the architecture would reflect the new aesthetic paradigm. In fact, however, a certain inertia was visible and Behrens's famous projects for AEG (Turbinenfabrik AEG, Berlin 1908-09, Hochspannungs Fabric 1910) were still representing historic tendencies. Regardless of their rational and functional form characteristic of industrial architecture, the moderate, classical approach was still visible. This is also

[1] Pomerania (Pomorze) – the northern part of Poland along the Baltic Sea, bounded by the river Odra in the west, by the river Wisła (Vistula) in the east, and by the rivers Brda, Noteć, and Warta in the south. This area is largely a postglacial upland region; hence Pomeranian rivers have a significant energy potential.

[2] Different historical sources indicate 1896 or 1898 as the date of the building of the first Pomeranian hydropower plant in the Soszyca (Muhlchen) paper factory on the river Słupia.

[3] Pomeranian power plants, due to their capacities (below 1MW), are generally classified as small and micro-power plants.

concerned with the use of unplastered brick elevations, which could be either interpreted as typical solution or rationality and sincerity of industrial (and postulated official) architecture. On the other hand, brick facades could point the relation towards the German tradition [3] of medieval architecture. Peter Behrens used to say that the power plants are the "shrines of power". So, their symbolic meaning was inevitably incorporated into the design process, making the brick aesthetic was an appropriate means of expression.

The first decades of the 20th century saw a very dynamic in overall industrial, scientific, and aesthetic development. The same concerned the development of different styles and currents within the Modern Movement in architecture. The use of brick as a means of architectural expression was also radically evolving, giving rise to an interesting process. During the two decades of the interwar period the changes were so dynamic that sometimes a few years' gap in the realization of particular object resulted in visible differences. This is not only due to the architectural stylistic reasons, but also to the quickly changing technology. The example of the Pomeranian SHPs illustrates both the evolution of their industrial form and of Modernism.

In this paper I would like to concentrate on the styles and architectural forms of hydropower plants of low and medium heads (usually of height not exceeding 15 m) typical for Pomeranian rivers. Therefore, I am not taking into consideration the factors impacting the potential differences in the scales of the objects, different solutions for damming the rivers and derivation which can vary radically and significantly influence their architectural form.

2. Brick as a means of architectural expression

In Northern Europe, brick architecture has been present for many ages due to its durability, reliability, proven advantage, and almost unlimited possibilities it provided in terms of architectural expression. In the 20th century, the most famous achievements in that area emerged in Holland, especially in the works of the Amsterdam School and such a widely recognized architect as W.M. Dudok. Among the many examples of Modern (e.g. Scandinavian or German) architecture we can find objects designed in brick aesthetic, representing different stylistic approaches. In German architecture, there are brick examples of clear, rational aesthetic of both Neue Sachlichkeit and Expressionism built during the decades of the interwar period in the manner of Brick Expressionism influenced by the Hamburg School, testifying to the widely spread influence of brick architecture. Sometimes brick was only an element of the pilasters decorating the facades, drawing on the rationality of the 19th-century industrial tradition; other times it carried a deeper message of respect for classical architecture. All these tendencies appear at the same time, adding to the diversity that characterized the time of modern change.

During the interwar period, brick architecture was widely used especially in Northern Europe, but depending on its form (sometimes on the form of subtle details) it could be a manifestation of different stylistic approaches or ideological, sometimes even political, meanings. Brick was present in different traditional and modern architectural styles, but also in the works of architects of both a leftist as well as nationalist or even fascist orientation. Regardless of the possible political affiliation, which should not necessarily be reflected in industrial architecture, stylistic differences could be observed stemming from either traditional or avant-garde approach of the architect. One of the most decisive reasons for the revolutionary change in architecture was the adoption of the functional paradigm as a consequence of the industrial revolution and the absorption of rational patterns by the mainstream of the "official" architecture. In the beginning of the 20th century, Functionalism – the radical form of Modernism – postulated function as the most important determinant of aesthetic and architectural value. The idea that the object's function should be reflected by its external form stands in opposition to the 19th-century attempt to conceal it behind the classical order of the facades, which was visible even in Early Modernism. On the one hand, this attempt at architectural grandeur was a consequence of the belief that true architecture should incorporate all elements that respect the historically established language. On the other, however, brick architecture expressed the aesthetic and ambitions of modern change. These tendencies coexisted during the first decades of the 20th century – and brick was used in both cases, quite

paradoxically, as a means of either opposing the aesthetics of modernity or representing the avant-garde Functionalism derived from industrial architecture.

3. The evolution of the technology and form of hydropower plant

The discussion of the technological aspect of the evolution of SHPs and its influence on their architectural form significantly exceeds the frames of this paper. However, generally speaking, the interwar period was the time of development and significant progress [4] in the optimization of the technology of power plants – it was also the time of the most spectacular investments in electrification on the Pomeranian rivers, called the "Golden Period" [5][4]. The "Golden Period" could be subdivided into two phases. The first phase begins in 1907 and ends with the beginning of World War I. It was the time of significant growth in the amount of local power plants (powered by Francis turbines) and local systems of energy transmission [6]. The second phase lasted from 1919 to World War II. What most significantly influenced the form of SHPs during this time was the technological change which took place in 1929. The new solutions were based on Kaplan turbines, which not only improved the efficiency [7], but also affected the architectural form of hydropower plants. The versatility[5] of Kaplan turbines determined the form of and typical solutions used in SHPs' power houses. Formerly implemented solutions, often based on a horizontal-shaft Francis turbine, required more space inside the power house. The power plants with a vertical-shaft Kaplan turbine were for many reasons superior, and what's important from the architectural point of view is that their form was optimized due to compact spatial solution [8], facilitating the disassembly of the turbine set for repairs, inspections, etc. (Figure 1).

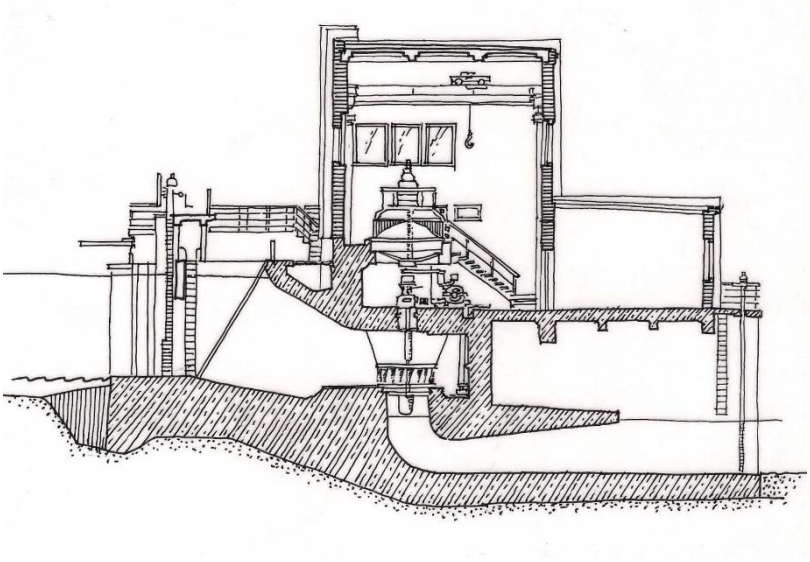

Figure 1. Ptusza hydropower plant, cross section (drawing made on the basis of documentation of WUOZ in Piła).

The vertical shaft allows to locate the generator hall above the turbine chambers; as a result, the power house is more elevated than the hydro-technical area of the building. Other devices of the intake part, i.e., inlet sluice gates, bridge, cleaning system, and regulatory mechanisms, are creating the

[4] This classification is based on historical, technological, and economic aspects.

[5] The use of Kaplan turbines significantly influences the scale of objects (Kaplan turbines with double adjustment make it possible for different flows to work under different heads, and can therefore be used in both small and large objects). The spatial form, however (regardless of aesthetic reasons), is more dependent on the fact that the generator and the turbine are interlocked on a common vertical shaft, which increases the efficiency of the hydro-technical area, at the same time reducing the size of its most significant parts – generators, transformers, and the switchgear hall.

characteristic technological look from back water. In the process of technological optimization, the architectural form tends to become increasingly compact.In the case of the Pomeranian SHPs, the image is dependent on the form of the weir and heading system as well as the architecture of the dominant element, which is usually the power house.

4. The evolution of industrial brick architecture: The case of small hydropower plants in Pomorze

4.1. CzerskoPolskie, Biesowice, and Borowo hydropower plants: The first phase of the "Golden Period"

The short overview of small hydropower plants provided in this paper could serve as an illustration of the evolution of the architectural form and language of styles realized in brick. The first two examples pertain to the first phase of the "Golden Period". One of them is Czersko Polskie (1904-07, river Brda). Regardless of the implementation of a unique technical solution, namely the drum weir[6], the architectural image of red brick walls, the functional form, the power house's steep roofs, and the architectural detail may give rise to associations with the 19th-century landscape tendencies visible in the Arts and Crafts movement (Figure 2).

Figure 2. Czersko Polskie (1904-07), river Brda, tailwater view

Figure 3. Biesowice (1904-07), river Wieprza, headwater view

The power plant in Biesowice (1910, river Wieprza) is also representative of brick architecture. Its functional form reflects the logic behind the technical solutions of the power house, transformer tower, and switchgear. The fragmented structure of the power plant (equipped with horizontal double Francis turbines) and its architectural form, kept in Early Modernist style, conveys new, modern ideas. The building owes its modern image due to the well-balanced solids of its body and the lack of historical details. The brick elevation establishes a special relation to the natural context, invoking connections with both the Arts and Crafts movement and the Red House of Philip Webb [9] (Figure 3).

The brick power plant in Borowo (1916, river Drawa) [10], on the other hand, is an example of a more industrial mannerism. The brick facades are split vertically by pilasters. This vertical rhythm is emphasized by the vertical window axes, subdivided, depending on the level, into two or four rectangular window openings. Only the bottom windows above the outflows are arch-shaped. The jambs are formed stepwise in brick. The simple, regular shape of the building has accents in the form of

[6] First drum weir (or roller drum gate) was built in 1903 on the Main river, Hassfurt, Lower Franconia, Bavaria, Germany.

protruding staircases which are built on an octagonal plan. This historic forms seem to be a continuation of the forms and aesthetics of well-known Hochspannungsfabrik AEG in Berlin designed by Peter Behrens (Figure 4).

Figure 4. Borowo power plant. On the left: tailwater view; on the right: side elevation

4.2. Cascade of Podgaje (1929), Jastrowie (1930), and Ptusza (1932) small hydropower plants on the river Gwda: The second phase of the "Golden Period"

The cascade of the SHPs on the river Gwda is an example of mature and advanced technical solutions which, in principle, are still being built in this form to this day. The investment was made by Ueberlandzentralle Pommern Stettin A.G. [11], which also led the investment process on site and supervised the construction of all power plants by Eng. J. Gruenwald from Jastrowie [12]. All three plants were created almost simultaneously, based on the same design assumptions and technology, equipped with two (twin) vertical-shaft Kaplan turbines (which at the time became common in the industry) manufactured by J.M. Voith. Therefore, the buildings of the power plants were compact, placed on the turbine spiral chambers, and made of reinforced concrete. The power house's highest part is the turbine hall, which also houses the gantry. The height of the buildings is determined by the height of the vertical turbine set and the space required for its dismantling. The social rooms, battery room, control room, and switching device are located on the tailwater side, over the outflows. The plan is regular, rectangular, and is subject to the hydro-technical part of the plant. Slabs, pillars, beams, and staircases remain fully visible. End walls are faced with clinker bricks. The weirs in all three objects are also made of reinforced concrete and in the same modern technology, which is reflected in their modern architecture.

4.3. Podgaje small hydropower plant (1929)

The example of cascade on the river Gwda confirms the widespread presence of Functionalism in the architecture of the end of the 1920s and the beginning of the 1930s, which at the same time resulted in a new architectural approach – turning to simplicity, modest and reduced details – and in a shift from vertical to horizontal accents and divisions. Despite the reduced details, the plants' elevations are decorated with colorful bricks, in the expressionistic manner characteristic of northern German tradition. What is the most interesting is that the time difference between their erection (1929, 1930, 1932), which did not exceed two years, is clearly visible in the stylistic approach, showing how quickly the evolutionof style was proceeding within the same language of brick architecture. Worth noting is the high quality of the architecture, which emphasizes the value of mutual architectural consistency of all three power plants that makes them memorable.

The rational cubic forms determined by the technical solution, characteristic of the International Style, are clearly visible in the form of all three power plants of the cascade. Carefully constructed brick

facades (whose colours vary from red to black), architectural details characteristic of the early phase of Functionalism and legacy of Expressionism are visible in the details of the brick window jambs and bands, gently jutting out over the wall face. Stepped jambs and portals, characteristic of the early phase of Functionalism and common in public and housing architecture of the late 1920s, disappear in the 1930s [13]. The building, in accordance with the style it pertains to, is enriched with classic relics in the form of a stepped crowning cornice, underlined by a flat frieze, decorated with diagonal texture of brick ornament. The same applies to the panels under the windows (Figure 5).

Figure 5. Brickwork detail of the Podgaje SHP

4.4. Jastrowie small hydropower plant (1930)

This plant is the centerpiece of the cascade. It is where the main switch and distribution building are located. The same solutions were implemented here as in the Podgaje and Ptusza SHPs. The significant difference is the dominant part of the switch and distribution building was asymmetrically added to the power house. The complete plan of this plant is similar to other Pomeranian SHPs (e.g. Rejowice on the river Rega) built by the same investor. The architectural style of this plant, built one year later than the Podgaje SHP – the overall composition of the facades and the form of detail – is kept within the same style of brick architecture. We can find both similarities and differences. There is a stepped cornice on the top of the building, but without the frieze. A visible change in the simplified detail took place, characteristic of the Neue Sachlichkeit style.

There are no stepped window jambs and no portals, but we can still find vertical accents, such as the shape of the windows, framed with brick belts jutting out of the wall face. The overall composition is still kept in classical order, we can easy separate the base part of the ground floor, *piano nobile*, and attic. The vertical elements are balanced by strong horizontal accents, such as the row of steel transformer doors or the loggia for the power-line outlet. This is not only an element of articulation, but a spatial form co-creating the rhythm and tectonics of the facade. These horizontal elements are characteristic of the 1930s Functionalism. More importantly, technical elements are replacing the stylistic historical decoration in the creation of an architectural image (Figure 6).

4.5.Ptusza small hydropower plant (1932)

The third and youngest power plant of the river Gwda cascade is thePtusza hydropower plant of low and medium heads, equipped with twin vertical Kaplan turbine sets. The single-storey part of the building on the tailwater side along with the turbine hall co-create the structure of this power plant, which became a typical power plant solution. The difference between this solution and the solutions of the former

decade, usually based on a horizontal-shaft Francis turbine set, is its inverted arrangement, in which the dominant part of the power house is located on the side of the outflows.

Figure 6. Jastrowie power plant. On the left: tailwater view; on the right: headwater view

The Ptusza power house, with its cascade-like spatial arrangements, stays in line with the form of the dam and the shape of the weir cascades (Figure 6). The three years between the erection of the power plants in Podgaje and the power plant in Ptusza resulted in a distinctively different architectural design, despite a similar spatial form and, especially, the same material used (clinker elevation brick). Functionalism in its mature form is found in the horizontal windows, modest detail, and flat roofs hidden behind the walls of the attic. There is no cornice crowning the building. The windows of the turbine hall are arranged horizontally in the corners of the building, which is characteristic form of the expressionist Functionalism. The horizontal edges are underlined and accentuated by concrete mouldings, often visible in the works of expressionist architects, i.a. E. Mendelsohn. The headwater elevation of this power plant shows articulation of two brick pilasters. Its sharp form shaped by diagonally laid brick is characteristic of the architecture of the Hamburg School (Figure 7). These pilasters are emphasizing the two vertical axes as a clear reflection of an inner arrangement – the technical solution based on two vertical Kaplan turbine sets (Figure 1).

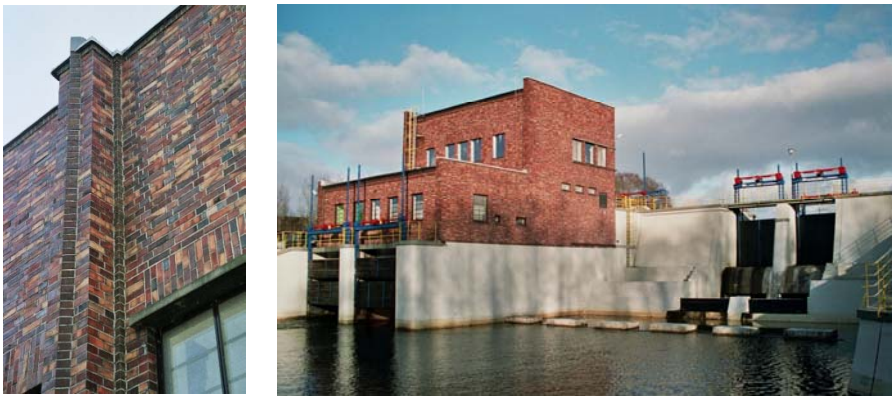

Figure 7. Ptusza hydropower plant (1932), river Gwda. On the left: headwater view; on the right: tailwater view

This feature shows probably the most important aspect of the change that took place in Modernist architecture design. The external form and the internal solution became coherent. The facade no longer communicates a different message than the inside of the building itself. This mutual sincerity became the paradigm of modernity. The structural elements of the interior are made of reinforced concrete, but we can still find brick elements in the walls supporting the crane rails, visible from the inside. The

architectural details, such as the modernistic railings of the stairs and the mechanical devices, are an integral part of architectural expression corresponding with the outside of the building.

Among other Pomeranian power plants, this example is exceptional because it integrates functionality with meeting technical requirements, evolving toward functionalist architectural forms. In addition, it draw attention to the value of elegance, simplicity, and establishing an excellent relationship with the surrounding landscape.

4.6.Tryszczyn small hydropower plant on the river Brda (1956-62)

The Tryszczyn power plant is an example of fully matured post-war Functionalism, with all the characteristic features of this style. As opposed to the previously discussed buildings, it is built with white brick. This power plant, geographically located in Pomorze, was built under different political conditions, which translated into a different architectural tradition. The choice of white brick as the elevation material can carry an ideological message. This power plant was designed by the Warsaw Office of Energetic Projects "Energoprojekt" (as was the power plant in Koronowo). In Poland, red brick architecture was often associated with the German tradition [14]. It does not mean that brick architecture with expressionistic elements did not exist in the Polish tradition. In Warsaw and in Central Poland we can find numerous excellent examples of white brick architecture.

The Tryszczyn power plant is a rectangular, flat-roofed block with an asymmetrical composition of the facade that corresponds to the building's functional arrangement (two vertical Kaplan turbine sets). The facades are made of white brick; its texture and plasticity, with the regular pattern of diagonal, projecting and receding bricks, introduce a play of light on their surface. This effect is even strengthened by the use of dark, over-burnt ceramic bricks contrasting with the white background (Figure 8). Large windows of the turbine hall in the backwater elevation and the protruding facade of the front elevation (of the distribution block – tailwater) create harmoniously proportionate, simple, plain, and clear divisions. This harmony is also maintained by the balanced contrast between the large transparent windows and the soft texture of the brick surfaces. The composition of the facade reflects the functional organization of the power plant. The readability of its functions is also reflected in the precise articulation of the elevation with such technical elements as transformers, transmission lines, switches, outflow chambers, gates, etc. There are no artificially added stylistic details. The architecture is self-justified by its function. The only decorative element is the geometric pattern of the brick elevation.

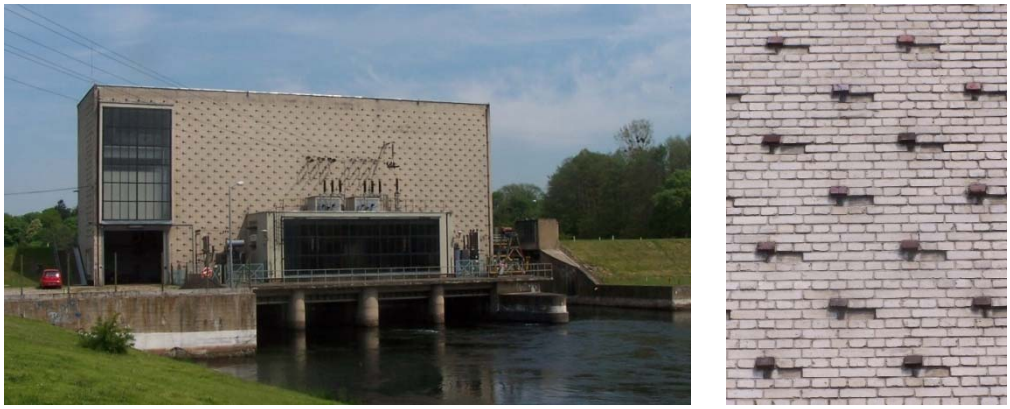

Figure 8. Tryszczyn power plant (1956-62), river Brda. On the left: tailwater view; on the right: brickwork detail

5. Conclusions

The architectural tendencies of the first decades of the 20th century found their reflection in the architecture of the Pomeranian small hydropower plants. The presented examples could serve as an illustration of the evolution of brick modern industrial architecture. We find an interesting spectrum of changes reflecting the evolution of architectural styles, sometimes representing very subtle stylistic

differences. The revolution caused by electrification had a symbolic meaning, which coexisted with the spirit and aspirations of Modernism. Although this could suggest that the form of power plants should express the avant-garde design approach, it seems not to be true. This overview shows that if the Pomeranian hydropower plants are not instances of avant-garde architecture, they clearly reflect the dynamism of the evolution of currents and styles exemplified by the whole diversity of aesthetic forms and details of Modernism. The cascade of hydropower plants on the river Gwda, which was built within the period of three years, is an interesting illustration of the dynamism of the evolution of brick architecture, but also the aesthetic of Modernism in a wider context. Modern architectural trends of the interwar period were formulating a new architectural language by integrating functional aspects and assimilating the aesthetics of industrial architecture. The expressive possibilities of the tradition of brick architecture, usually associated with historical buildings, proved attractive also for modern architecture. The presented examples of SHPs show the evolution of the style within the brick aesthetic. Modernism revolutionized the understanding of the sense of beauty. The evolution of the form and architectural image of power plants seem to illustrate well the dynamic process of change, in which brick proves its eternal value as a means of unlimited expression.

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