SELECTED CONSTRUCTIONAL PROBLEMS RELATED TO RENOVATION OF HISTORIC INDUSTRIAL BUILDINGS FROM 19TH CENTURY IN LOWER SILESIA (POLAND)

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Abstract. In the south-western areas of Lower Silesia various industries for exploitation of local natural resources developed in the nineteenth century. A characteristic feature of this region is the multiplicity of industries present in considerable dispersion in rural and urban areas, generally in the form of small factories, especially the textile and mining ones. An important role in the region plays the exploitation of mineral waters, lasting hundreds of years. Many spas were created in these areas in the past, in which numerous industrial facilities were built, associated with the extraction and processing of mineral waters. Basing at the case of historic buildings of mineral water bottling plant analysis of applied structural and material solutions which combine stone, brick, reinforced concrete and timber is presented in the paper, as well as a methodology used to assess the buildings’ current technical condition. There are described planned renovation technologies and method of drying and anti-dampness insulation of walls, which is of particular importance in one of the buildings due to the contact of its entire rear façade to a wooded soil embankment.
1 INTRODUCTION

Issues related to the rehabilitation of industrial buildings, erected at the turn of the nineteenth and twentieth century, create currently very serious problems for the owners of these buildings, as well as for architects and civil engineers [1, 2, 3, 4, 5, 6]. These objects are often part of the national heritage, and much of them are, as a whole or partially, under conservatory protection. They are typical examples of the development of creative thought both of architects and construction engineers, but also the skills of workmanship [7]. The analysis of material, structural and constructional solutions used for their erection also allows studying the development of methods of calculation, designing and construction of various types of industrial buildings [8, 9, 10].

In the area of Lower Silesia, located in the south-western part of Poland, both in large cities and in smaller towns still can be found interesting post-industrial or public service buildings, from the late nineteenth or early twentieth century. Rehabilitation or reconstruction of these objects gives an opportunity to preserve them for further use, both in maintaining the old functions (although often to a limited extent) and, what is most common, with a complete change in their functional program. In these objects, one can often find very interesting design and material solutions, which at times of construction of these structures were innovative and were often were a challenge for both designers and contractors.

Some of these historical industrial buildings are used continuously since their beginning, were repeatedly subjected to the refurbishment and because of that are in continuous use (Figs 1 & 2).

![Figure 1: Textile plant in Leśna - archival view from 19th century ([11]).](image1)

![Figure 2: Textile plant in Leśna - current view ([11]).](image2)
Part of these buildings, interesting both from the point of view of an architect, dealing with the history of the architecture, and also a structural engineer, underwent rehabilitation many years ago and are still in operation, though often with a change of function (Figs 3 & 4). Some of them are undergoing design process or awaiting the renovation to be done (Figs 5 & 6).

Unfortunately, a significant number of these objects, which do not meet any of the structural safety requirements and not giving the possibility of changing the utility functions, were left to the natural destruction, or were simply demolished (Fig 7).

Figure 3: Former cigar plant in Wrocław – currently judicial archive.

Figure 4: Former textile factory in Wrocław – currently drug plant.

Figure 5: Former brewery in Wrocław constructed in 1911.
2 GENERAL RULES OF TECHNICAL CONDITION EVALUATION AND REPAIR METHODOLOGY

For monumental buildings of historical value there exist recommendations for reconstruction process defined by ICOMOS/ISCARSAH [12]. They consist of set of principles and guidelines for the analysis and restoration of such buildings. These Recommendations define three main phases in the study of historical constructions:

- diagnosis,
- safety evaluation,
- design of intervention.

In case of post-industrial buildings’ revitalization their function very often must be changed due to different nowadays requirements, both structural and exploitation ones. In case of introducing the new utility program prior careful examination and analysis that are basis for evaluation of their serviceability for new function have to be done [8, 9].

From structural engineer point of view, basing on the detailed information contained in the Recommendations [12], the most important element of the reconstruction process is evaluation of the technical state of the building to be repaired. Simplifying, this process can be executed in the following way:

- analysis of archival documentation (historical research),
- architectural and structural survey,
- conservatory opinion,
- geotechnical study,
Selected Constructional Problems Related to Renovation of Historic Industrial Buildings from 19th Century

- material examination,
- definition of level of technical deterioration,
- structural expertise (cause of damage, structural and strength calculations, etc.),
- definition of repair technologies,
- definition of structural safety during repair,
- monitoring of structure during repair.

Thus, before building repair is commenced, the archival documentation must be examined. In case of Wrocław, the formerly German building archives still keep a lot of historical plans and drawings which contain information on most of the city buildings or civil engineering structures. Based on these plans, an architect or engineer can state how the analyzed object designed or whether it was rebuilt or extended in the years of its exploitation and how the functional and spatial arrangement changed. This stage is highly associated with architectural and conservatory survey and also gives some information on structural layout of the objects.

After doing the archival research, an assessment of the technical condition of the building must be made. In this assessment, damaged parts are determined as well as soil and material examination. The latter is very important because provides not only values of material strength needed to structural calculations and estimation of structural bearing capacity, but also gives data on quality of material used and their durability. The level of building wear also has to be specified. An evaluation of the technical wear of any building or its element can be made by methods with different numbers of details in respect to observation and description of the building.

Depending on the degree of structural deterioration, the building can qualified for repair, major repair or demolition, if other factors (social, maintenance or functional) do not decide about this. Then, depending on the gathered funds and having all formal arrangements, a modernization of the building can be commenced.

Old post-industrial buildings are characterized by the fact that they were heavily exploited in unfavourable conditions caused both by technological loads and environmental influences, arising from production processes. In the repair procedure of revitalization of these buildings their function is very often changed, which requires carrying out a number of demolition and reconstruction as well as strengthening works. Often only the foundations, exterior and interior walls are left, and the remaining elements are demolished and new structural elements are erected using new technology. In these processes is very important to ensure the safety of structural components at each stage of construction works.

3 CASE STUDY – RENOVATION OF HISTORIC BUILDINGS OF MINERAL WATER BOTTLING PLANT

3.1 Description of renovated buildings

Building which is a subject of the rehabilitation process forms a main part of the production plant of mineral water and was erected in the beginning of the twentieth century. The entire industrial plant consists of the main building, in which mineral water bottling plant is situated (Fig. 8), warehouses with offices and workshops (Fig. 9). The main part, located on a rectangular plan has three floors above ground (ground floor, first floor and attic) and also a basement under its main part. From the north side to the main building there are adjacent outbuildings, while at the south side of the workshop building there are adhered one-storey small buildings with flat roofs. From the east side of the main building and workshop there is situated a natural soil embankment (Fig. 10). Parts of the embankment are located directly adjacent to the walls of these buildings but partially are separated by a concrete retaining wall and
channel lightening. Foundations and walls of the mineral water bottling building are made of full brick on lime mortar. The floor of the basement is the masonry one, based on the I-shaped steel beams, while the floors above the ground floor and the first floor are reinforced concrete ones, based on the reinforced concrete main beams (Fig. 11) and masonry exterior walls. In the middle of the building, beams are supported additionally on reinforced concrete columns. Roof rafter is timber, and a gable roof is covered with tiles.

Figure 8: View of the main building.

Figure 9: View of the workshops.

Figure 10: View of the natural soil embankment adjacent to workshops.
3.2 Technical state assessment

According to the essential points of the methodology to be followed during the evaluation of the technical condition of rehabilitated buildings, the history of the objects and the archival structural documentation (Fig. 12) were analyzed.

Figure 11: View of the reinforced concrete floor over ground storey.

Figure 12: Archival documentation.

Figure 13: Foundation exposure.
Also thorough visual examination of objects and a detailed photographic documentation were carried out, both aimed to document damages as well as an architectural and conservation inventory. A number of structural exposures (Figs 13 & 14) were made and also material examination (e.g. strength of concrete in RC slabs and beams, steel strength), and the calculations of bearing capacity of structural elements, including reinforced concrete slabs, were conducted.

The synthesis of this research can be summed up in the following conclusions, which were the basis for the action of repair:

• The fundamental cause of poor technical state of analyzed buildings was their long-term exploitation without performing appropriate overhauls.
• Masonry floors over cellars in the bottling building were in the pre-failure condition (Fig. 15): there were large, local cavities and strong corrosion of brick vaults, corrosion and delamination of steel beams (what is a characteristic feature of the old German steel produced in the early twentieth century).
• The static calculations (Fig. 16) demonstrated that the maximum load of a reinforced concrete slab above the ground floor of the bottling building can be as 500 kg/m$^2$ and 700 kg/m$^2$ for the slab over the first storey.
• The walls of the buildings were heavily damp - especially wall, which is adjacent to the embankment, and also the exterior walls do not meet current requirements for thermal insulation.
3.3 **Structural intervention project**

Based on the developed synthesis of structural condition of mineral water bottling plant buildings and modification of production technology there was overworked the refurbishment project, both in constructional and architectonic range. The main objective of this project and further construction was to extend the lifetime of the plant’s historical objects and maintain their values of industrial monument (Fig. 17).

The following construction works were foresaw to be performed:

- repair or partial replacement of the masonry floor over the basement;
- repair of RC slabs above the ground floor and the first floor - reprofilation of concrete;
- repair of timber roof structural elements;
- replacement of roof covering made of tiles or roofing tar;
- execution of water horizontal insulation of all walls of buildings;
- execution of water vertical insulation of buildings’ walls adjacent to the embankment;
- construction of rainwater collector from the side of the embankment;
- construction of new floorings on the ground floor;
- execution of thermal insulation of all the buildings.

The most specific method was designed to be adopted for water insulation of masonry walls adjacent to the soil embankment (Fig. 10). In such case an internal (negative side) basement walls waterproofing is a standard solution. However, the soil of embankment could not be excavated due to high cost of excavation, inevitability of cutting-off the trees growing at this area, and also because of a road passing close to the building. Finally, it was decided to
use a so-called curtain injection. This method is based on using special resin (gel) which is dispersed over the outside surface of the wall by injections made through holes bored in the masonry. The injection material reacts with water and binds it resulting in a waterproof, elastic and also crack bridging layer. In the presented study case a solvent-free, water activated polyurethane gel Koster KB-PUR® Gel [13] was approved to be used.

4 FINAL REMARKS

Examples of post-industrial buildings from 19th and 20th century, interesting from engineering and architectural points of view, can still be found in many regions of Lower Silesia (Poland). Some of these historical structures are still in use and some are under process of rehabilitation and adaptation to new functions. Evaluation of technical state of such buildings is a very important task for structural engineers, whose task is to ascertain their constructional suitability for the designed changes. Basing at the case of historic buildings of mineral water bottling plant analysis of applied structural and material solutions as well as the methodology used to assess the buildings’ technical condition and range of repair works were presented in the paper.

REFERENCES


