Organizational and technological aspects of industrial facility renovation

Inna Zilberova, Vadim Mailyan, Irina Novoselova, Konstantin Petrov

1 Don State Technical University, 344000, Gagarin Square 1, Rostov-on-Don, Russia
2 Southern Federal University, 344006, Bolshaya Sadovaya Str. 105/42, Rostov-on-Don, Russia

Abstract. The refurbishment of industrial structures is a multifaceted, resource-intensive, and financially demanding undertaking. The process entails various challenges that necessitate thorough consideration during the design phase. Such an approach is pivotal in devising effective solutions for the reconstruction of industrial facilities, regardless of the operational conditions, and can lead to substantial reductions in construction costs. The ultimate objective of such renovation endeavors is to enhance production capacity and overall enterprise profitability, mitigate adverse environmental effects, and ameliorate the quality of urban living environments.

1 Introduction

In our current socio-economic landscape, reconstruction stands as a pivotal facet of industrial advancement [1]. Today, the primary objective of reconstruction is to enhance both the quality and quantity of manufactured goods, mitigate adverse environmental repercussions, introduce energy-efficient and resource-conserving technologies, adapt production facilities to align with the contemporary demands of the nation's populace, and utilize them for the enhancement of urban environments [2-4].

The reconstruction of industrial structures, coupled with their technical modernization, constitutes a multifaceted challenge from both an organizational and technological standpoint. Industrial development plays a fundamental role in shaping the structure and composition of cities [5]. Its impact has taken a negative turn due to the significant moral and physical deterioration of existing industrial infrastructures. This deterioration has had adverse consequences on the architectural and aesthetic attributes of buildings and structures. Furthermore, the outdated equipment and technologies in use have yielded detrimental effects on the environment [6, 7].

2 Research materials and methods

Reconstruction serves to enhance the technical and economic metrics of entities, resulting in an upswing in the economic viability of capital investments, courtesy of a reduction in the per-unit investment costs for manufactured construction products [8]. Such an outcome...
stands as a principal objective of the renovation initiative [9]. The economic efficacy of reconstruction is attained through the execution of a well-considered economic feasibility analysis. This analysis encompasses a discerning evaluation of the optimized utilization of urban space and the formulation of a systematic plan for the reconstruction of industrial facilities [10].

Another crucial objective of reconstruction is the mitigation of both physical and moral deterioration. Over the course of their operational lifespan, capital structures inevitably accrue physical wear and tear. Physical deterioration encompasses the erosion of the initial physical attributes of these structures, including the diminishing load-bearing capacity, stability, and operational dependability due to various external and internal influences, operating conditions, and the duration of the structure's existence [11]. Furthermore, it is worth noting the loss of significant qualities such as thermal insulation, moisture resistance, and soundproofing. Although these qualities may not directly impact the structural integrity of capital buildings, they remain of utmost importance in ensuring the building's functionality and maintaining sanitary and hygienic conditions within the premises [12].

The extent of physical deterioration is quantitatively evaluated as a percentage, representing the extent of degradation in structures when compared to the initial operational and technical specifications, which encompass qualities such as rigidity, strength, and stability [13]. All edifices and constructions undergo physical deterioration over time, as both structural components and engineering systems gradually degrade under the influence of operational factors. These factors encompass external climatic conditions, the regular monitoring of structures, and the timely execution of routine maintenance and major repairs [14]. However, it is essential to recognize that repairs can only decelerate the pace of physical deterioration in structures and engineering systems; they cannot fully restore all of their original attributes.

The process of physical deterioration during the life cycle of an object can be divided into three phases:

1. The initial phase involves the application of loads to the load-bearing structures, bringing the building structures to their operational state [15]. During this first phase, there is a notable acceleration in the accumulation of physical deterioration in structures. This acceleration can be attributed to several factors, including the quality of construction and installation work, as well as the presence of defects in the products, materials, and structures utilized in the construction of the facility [16]. The settlement of the foundation during the initial operational stages also assumes significance in this context.

2. The second phase is the lengthiest, accounting for approximately 50% of the building's normative lifespan. During this stage, the rate of physical wear accumulation substantially decelerates. The stresses that originated in the first phase are alleviated and counteracted through the formation of cracks and deformations in the structures [17].

3. The third phase is marked by a renewed and intensified escalation in the wear and tear level, primarily due to the accumulation of operational fatigue. Considerable structural deterioration during this stage may result in structural failures, prompting the exclusion of specific structures from operation. Such exclusions can arise from the inability of certain structures to withstand force impacts due to their advanced state of deterioration. During this stage, it becomes exceedingly challenging to arrest and mitigate the deterioration of the building. As such, it is advisable to undertake comprehensive reconstruction or, in some cases, the demolition of the facility [18]. The decision to pursue either course of action is contingent upon a thorough cost-benefit analysis and a rational assessment of the measures in question.

In addition to physical deterioration, a building also undergoes moral deterioration, which progresses independently of its physical condition. Obsolescence refers to the
outdated nature of volumetric planning solutions and engineering systems, stemming from shifts in requirements pertaining to the functionality and comfort of buildings.

Reconstruction presents an opportunity to contemporize the building, mitigate both moral and physical deterioration, and restore it to a state that aligns with contemporary standards of functionality, comfort, and structural integrity.

### 3 Results and discussion

The process of renovating industrial buildings can be notably expensive, at times even surpassing the cost of entirely new construction projects [19, 20]. To achieve cost savings, it is imperative to maximize the utilization of existing structures that are suitable for the new operational conditions in terms of their fundamental strength and deformation characteristics. Additionally, it is crucial to avoid imposing supplementary loads on the load-bearing structures of the capital construction object. This can be achieved through the adoption of lightweight modern materials for construction.

Reconstruction entails alterations in various aspects of industrial buildings and structures, including changes in parameters such as their dimensions, architectural aesthetics, production capacity, and the volume and quality of engineering and technical support [21]. During the reconstruction of industrial facilities, tasks may encompass the replacement or repair of structures exhibiting a high degree of physical and moral deterioration, the expansion of production areas, the modernization of the technological processes, and the construction of additional storage facilities, among other endeavors.

There are situations where it becomes imperative to carry out the reconstruction of existing enterprises without disrupting the ongoing technological processes. In such scenarios, a portion of the construction and installation work must be executed within confined conditions, as the production facilities are saturated with existing technological equipment, engineering networks, and communication systems. Under these circumstances, the duration of the work can extend by 1.5 to 2 times compared to new construction projects. Additionally, labor productivity may decrease by 20-30%, and the idle time of workers can increase by 1.5 to 2 times.

Reconstructing industrial buildings is an exceedingly intricate, energy-intensive, resource-intensive, and labor-intensive undertaking. To ensure that the process is expedited and carried out with optimal efficiency, meticulous advance planning of the organizational and technological procedures for all stages of reconstruction is imperative. These plans should be accurately and precisely integrated into the design and working documentation [22].

The primary factors that impact the selection of the direction for the reconstruction of industrial facilities encompass:

- The extent of physical and moral deterioration of production buildings and technological equipment.
- The sanitary and hygienic condition of industrial workshops.
- The imperative to augment production capacity.
- The necessity to alter the fundamental functional purpose.
- The compositional significance of the building within its surrounding neighborhood and urban system.
- The historical and architectural value of the object undergoing reconstruction.

There are three main directions of reconstruction of industrial enterprises, covering certain tasks and differing in the scale of works. The first direction involves the technical re-equipment of the enterprise, which includes renewing the production process and enhancing the quality of technological equipment characteristics. This direction typically entails lower non-recurring costs in comparison to the other available options.
The second direction involves technical re-equipment with comprehensive reconstruction of facilities. This includes modifications to the reconstruction process that affect the volume-planning parameters of existing buildings, the construction of new structures, and the replacement of engineering and technical infrastructure.

The third direction, radical reconstruction (repurposing and revitalization). Repurposing of production is a change in the type of activity of production, or a change in the type of products produced [23]. The need for repurposing arises due to a decrease in the profitability of enterprises, changes in product technologies, increase in the number and changes in the needs of the population. Revitalization refers to the process of reconstructing and reprofiling industrial buildings and structures, resulting in a change in their primary functional purpose. This approach offers the opportunity to repurpose underutilized industrial spaces, enabling a diversification of activities by transforming former production facilities into modern residential complexes, shopping areas, office spaces, entertainment centers, and more.

When there is a need to address issues related to the social and cultural aspects of the population within an existing urban area, revitalization emerges as an optimal and contemporary solution. These issues may include the growing demand for leisure and recreational facilities, a shortage of residential spaces, the environmental impact of industrial structures on the city, and the influence of old buildings on the overall attractiveness of urban spaces [24].

The process of revitalizing an industrial enterprise typically follows a structured algorithm, which can be delineated into three stages:

1) The initial stage involves conducting a comprehensive study of the primary aspects of the city's daily activities and analyzing the data collected. Using the findings of this analysis, a strategic vision for the key areas of urban development is established, and a revitalization plan is created. This plan encompasses a range of functions that are intended to be incorporated within the industrial facility's premises.

2) Design. During this stage, a comprehensive assessment of the building's structural integrity, including detailed and instrumental examinations, is conducted. Additionally, engineering surveys are carried out. The outcome of these activities is a comprehensive report that outlines the feasibility of revitalization, the extent of physical and moral deterioration affecting load-bearing and enclosing structures, as well as the engineering and technical systems within the building. The report also specifies the maximum permissible loads. Furthermore, potential challenges that could negatively impact the reconstruction process are identified and addressed. This careful assessment serves to streamline the remodeling process, reducing both time and expenses. Based on this data and the provided project requirements, project documentation is then prepared.

3) Implementation of the approved project is the most long-term, costly and time-consuming phase. It includes all preparatory, construction, installation and commissioning works.

Consider the revitalization of already inactive industrial complexes located within the city limits. Basically this process requires:

• reinforcement or replacement of building structures;
• changes in the volume-planning parameters of the building for the required functional purpose;
• development, improvement and landscaping of industrial areas;
• changes in the architectural appearance of buildings.

A considerable portion of industrial facilities in Russia is situated in densely populated urban areas. This can be attributed to the rapid industrial expansion during the Soviet era when numerous production facilities were constructed, often accompanied by the development of nearby settlements [25]. As cities expanded and infrastructure evolved,
these industrial plants found themselves encircled by residential neighborhoods, public structures, and more. Consequently, challenges emerge when undertaking revitalization efforts in such contexts:

- with the storage and removal of construction waste;
- with delivery of construction materials to the site and their storage;
- with construction and installation works in cramped conditions;
- with delivery of heavy construction equipment to the site;
- with an increased risk of harm to the health of citizens.

The solution to these problems is detailed and clear planning of the works. A revitalization project should take into account:

- the location of production in the city;
- time intervals when there is mass movement of people in the city;
- the possibility of assembling some building structures "on wheels";
- use of small-sized construction equipment.

Hence, the revitalization of industrial facilities stands as a key focus, not solely for industrial sector advancement but also for urban planning. Nevertheless, executing such projects is intricate due to the multitude of constraints tied to technological processes, uninterrupted production, and urban planning regulations.

4 Conclusion

The construction industry in our country continues to progress, notwithstanding economic crises that may potentially slow down its growth. This development is largely driven by the persistent demand for high-quality industrial and civil facilities. However, amidst the construction of new buildings and structures, there are still many older Soviet-era constructions in use. Many of them have already lost their operational properties, lost the relevance of their main functional purpose and have been re-equipped, also the structures of objects have accumulated significant physical deterioration, and volume-planning solutions - moral.

To address these issues and extend the lifecycle of these buildings while ensuring comfortable operation, renovation plays a crucial role. Major repairs, reconstruction, including revitalization, are paramount priorities for builders and engineers, alongside new construction endeavors. This extends beyond merely replacing engineering equipment and also involves strengthening or replacing load-bearing structures, enhancing thermal insulation properties of enclosing structures, increasing the load-bearing capacity of foundations, expanding building areas and volumes, and more.

The ultimate goal of industrial building reconstruction is to boost production capacity and enterprise profitability, reduce adverse environmental impacts, and enhance the overall living conditions in urban residential areas. This, in turn, contributes to an improvement in the quality of life for the population.

References


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