Organization of demolition works during production buildings reconstruction

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Abstract. The features of the development of projects for the production of works for the dismantling of production buildings of industrial enterprises are considered. The main methods of demolition work depending on the physical condition of the structures and their connecting nodes and the sequence of their implementation for the enterprise and for individual installation zones are given. The procedure for teardown of braced and constrained constructions, as well as the processes of dismantling individual blocks, is disclosed. Decisions on the choice of methods for disconnecting structures and their elements are indicated. A detailed composition of the project for the dismantling of industrial buildings is presented. Measures for ensuring the spatial stability of structures, for the use of technological equipment and removable lifting devices are given.

1. Introduction
To prepare a task for the development of design documentation for the reconstruction of industrial buildings, a preliminary examination of them is carried out [2, 8]. It provides determination of the technical condition of equipment, structures and utilities (danger of structures’ collapse, safe production of reconstruction and demolition works, etc.); identification of the conditions for the work production (a possible mode of operation of the enterprise, the degree of tightness of the territory, the availability of storage areas, etc.); setting of approximate organizational and technological parameters of the reconstruction (nomenclature and scope of work, methods and period of work execution, etc.).

Based on the results of the survey, taking into account the prospects for the development of an industrial enterprise, a decision is made whether the given industrial building is subject to reconstruction or liquidation [3, 5].

2. Materials and Methods

2.1. Features of work execution design development
In the case of a decision on the liquidation of the building, it is advisable to develop an independent work execution design. The complexity of developing such a document is caused by a number of reasons such as the lack of documentation for the object, the lack of changes in the working drawings of the object during operation, the effect of dismantled structures on the spatial structure of the frame, the uncertainty of the degree of wear of components and elements, etc. Issues arising in connection with this, as a rule, are closed down by an act of technical inspection, which discloses the structural diagram of the building, the scheme of loads’ transfer, the state of structures and their elements, the
state of communications, the influence of technological equipment on the stability of dismantled structures, ways of attaching engineering support communications to structures frame, the method of transferring the load of the wall fence to the frame, the connection diagram of the dismantled and retained structures [1, 9].

2.2. Building demolition methods
Prior to the liquidation of the building, technological and special equipment, automated and remote control units for technological equipment, instrumentation, engineering systems and networks, including electricity systems, gas pipelines, air ducts, water pipelines, steam pipelines, communication systems, are dismantled. Moreover, previously all technological and special equipment to be dismantled and located in the installation area is disconnected from all engineering systems. Disconnection of engineering systems is carried out by the organization that manages the network data and executes the relevant documents [4, 10].

The liquidation of a building may be carried out by demolition or dismantling of its structures and elements.

Demolition of the building is carried out by its collapse in one of the following ways – mechanical, explosive, special (thermal, water-blasting, electro-hydraulic, etc.). However, collapses of workshops, spans or individual structures is rarely practiced and, as a rule, in cases of dangerous emergency conditions. In addition, after the collapse, structure and elements are not suitable for further use, and the export of unsorted collapse products is an intractable problem. It should also be noted that there are other buildings and structures around the demolished building that may be damaged [6, 7].

Therefore, the main way to eliminate industrial buildings is to dismantle them bitwise or in separate blocks, depending on the physical condition of the structures and elements and their connecting nodes. Naturally, the element-wise dismantling ensures maximum safety of structures (elements), and the dismantling of the building in separate blocks is more effective in terms of the duration and complexity of the work.

2.3. The sequence of dismantling processes.
The process of buildings dismantling is carried out, as a rule, in the sequence “from top to bottom”, reverse installation of structures and elements. The traditional sequence of dismantling industrial facilities is as follows:

- dismantling of technological structures (pipelines, masts, supports, shelves for equipment, lifts);
- dismantling of enclosing vertical structures (stained-glass windows, curtain walls, gates) and horizontal ones (floor structures, roofing);
- dismantling of special structures (viewing and transition platforms, stairs, galleries, rail tracks);
- dismantling of loadbearing horizontal structures (floor and coating slabs, lights, trusses, beams, ledgers) and vertical ones (columns, bearing walls);
- dismantling of basements, tunnels, foundations.

The sequence of dismantling processes in the installation area is shown in Figure 1.
The order of structures dismantling when applying the element-by-element method should correspond to the scheme of loads transfer to the building frame structures, which take into account both space-planning decisions and the technical condition of the structures. Constrained structures must be dismantled in the first place.

When applying the method of dismantling in separate blocks, it is necessary to determine the boundaries of the blocks with all the structures and connections included in it, and then, before work, remove all the connections with other structures. Disconnection of blocks and connections should be carried out in a sequence that ensures the spatial stability of all structures.

Certain difficulties are associated with the choice of methods for detaching structures, since their nodes have undergone severe corrosion and mechanical damage in the threaded zone. Therefore, such nodes, as well as welded and riveted joints, are recommended to be disconnected by gas cutting. In cases where the bolted joints are in satisfactory condition, then the nuts should be unscrewed. If the dismountable structure is not to be reused, then it can be dismantled by gas cutting in the support zone.

Figure 1. The sequence of dismantling processes.
3. Results and discussions

3.1. Document contents
The main documents for the demolition (dismantling) of industrial buildings are as follows:
1) plans, transverse and longitudinal sections of buildings with the dimensions of the structures, workplaces and scaffolds attached to the building;
2) fragments of the general plan, indicating demolished (dismantled) buildings or their parts, nearby facilities and utilities;
3) layout and location plan indicating temporary infrastructure, including the location of containers for collection of demolition (dismantling) products, scaffolding, vehicles and loading facilities, etc.;
4) technological maps of the processes of buildings’ demolition (dismantling), indicating their methods, means of mechanization and equipment;
5) schemes and solutions for the protection of technological equipment and engineering networks for the entire period of dismantling;
6) schemes and solutions to ensure the stability of structures for the period of dismantling;
7) schedule for the production of demolition (dismantling) work, indicating the volume of labor work intensity, the composition of the brigades and means of mechanization, the duration of the work.

In addition, the documentation includes a variety of installation schemes for scaffolds and various types of fences, methods of slinging structures and elements, specifications for dismantled structures, tables of the need for mechanization tools, requirements for labor protection and safety, instructions for the performance of work.

Practice shows that in work projects, special attention should be paid to the sequence of structures’ dismantling, ensuring the spatial stability of the remaining structures. To do this, not only serial numbers of the dismantling sequence of structures, but also their nodes should be indicated on dismantling schemes, taking into account the instructions for separation methods. As a rule, to achieve the spatial stability of the structures, a wide range of technological equipment is used. They are braces, struts, clamps, racks, stops, braces, braces, conductors (Table 1).

In addition, in the dismantled structures there are no devices for slinging or they are not suitable for use due to damage. Therefore, given the wide variety of designs and elements, it is necessary to solve this issue individually in each case (Table 2).

Before dismantling, the construction organization should receive the necessary documents proving the disconnection of communications, as well as permission to disassemble the building [11, 12, 13]. In addition, the customer (enterprise management) and the design organization should draw up an act on the implementation of all preparatory measures and work and the readiness of the building for dismantling.

Table 1. Outfit for construction dismantling (fragment).

| Title, designation, designer | Designation, specification summary | Use pattern |
|------------------------------|-----------------------------------|-------------|
| Outfit                       | Temporary fixing of structural elements. |             |
| Strut                        | Length (minimum) – 1600, 2200, 2600, 3000, 3400, 3800 mm |             |
|                             | Free motion – 400 mm               |             |
|                             | Holding force – 1000 kg            |             |
|                             | Weight – 11…24 kg                 |             |
Stilt
Temporary fixing of horizontal structural elements.
Range of altitude 1800…3100 mm
Holding force – 3000 кг
Dimensional specifications:
  length – 230 mm
  width – 240 mm
  height – 1600 mm
Weight – 31 kg

End stop
Temporary fixing of structural elements from the end side.
Range of altitude – 80…280 mm
Free motion – 200 mm
Dimensional specifications:
  length – 1200 mm
  width – 400 mm
  height – 1600 mm
Weight – 27 kg

In work execution design, a special role is given to the development of special measures for labor protection. In particular, the dismantling work should be carried out under the constant supervision of an engineering and technical worker, usually appointed by order of a construction organization. Moreover, in the event of the discovery of the possibility of self-destruction of structures and elements and their collapse (loss of structural stability, cracking, etc.), workers should immediately stop work and quickly leave this working area. Similar actions should be taken in case of a mismatch between the state of structures and the dismantling scheme.

**Table 2.** Loose lifting gear (fragment).

| Title, designation, designer | Designation, specification summary | Use pattern |
|------------------------------|-----------------------------------|-------------|
| Cross frame                  | Dismantling of walls and partitions. Carryng capacity – 5000 kg | |
|                              | Carrying capacity – 5000 kg      | |
|                              | Dimensional specifications:      | |
|                              | length – 2800 mm                 | |
|                              | width – 780 mm                   | |
|                              | height – 2500 mm                 | |
|                              | Weight – 9 kg                    | |
| Pin grasp                    | Dismantling of walls and partitions with holes. Carrying capacity – 6000 kg | |
|                              | Carrying capacity – 6000 kg      | |
|                              | Dimensional specifications:      | |
|                              | length – 515 mm                  | |
|                              | width – 100 mm                   | |
|                              | height – 230 mm                  | |
|                              | Weight – 7 kg                    | |
Harness
Dismantling of structural components.
Carrying capacity – 1600...8000 kg
Length – 1500...4500 mm
Weight – 4...60 kg

The level of external constraint should be taken into account. This level is expressed by the ratio of the free area of the construction site to the area needed to accommodate the temporary construction infrastructure

\[ K_c = \frac{F_1}{F_2}, \]

\[ F_1 = F - (F_1^1 + F_1^2 + F_1^3 + F_1^4); \]

\[ F_2 = F_2^1 + F_2^2 + F_2^3 + F_2^4, \]

where \( K_c \) is the level of external constraint;
\( F_1 \) is the free area of the territory of the reconstructed enterprise;
\( F \) is the total area of the reconstructed enterprise;
\( F_1^1 \) is the built-up area with existing buildings and structures;
\( F_1^2 \) is the area of overhead engineering networks;
\( F_1^3 \) is the warehouses and roads area;
\( F_1^4 \) is the hazardous area;
\( F_2 \) is the area required to accommodate temporary construction infrastructure;
\( F_2^1 \) is the area of warehouses for building structures, products and materials;
\( F_2^2 \) is the area of the household towns of builders;
\( F_2^3 \) is the area of roads and sites necessary for the reconstruction period;
\( F_2^4 \) is the area of construction machinery operation.

4. Discussions and conclusions

The complexity of developing a project for the dismantling of industrial buildings is caused by a number of reasons such as the lack of documentation for the object, the absence of changes in the working drawings during its operation, the effect of dismantled structures on the spatial stability of the frame, and the uncertainty of the degree of components’ and elements’ wear.

The main methods for dismantling of buildings of industrial enterprises is their disassembly by elements or in separate blocks. With the element-by-element dismantling, the maximum safety of the structures is ensured, and when dismantling the building in separate blocks, a significant reduction in the duration and labor costs is achieved.

The sequence of structures dismantling must fully comply with the scheme of transfer of loads on the frame structure, which allows taking into account the characteristics of space-planning decisions and the technical condition of structures.

The composition of the project documents for the dismantling of industrial buildings, and the procedure for development and approval are basically the same as for installation work. However, there are a number of specific features for ensuring the spatial stability of the structures, for the use of a wide range of technological equipment, individual removable load-gripping devices, and difficult working conditions.
References

[1] Base M 2011 *Architecture and construction in Russia* 7 pp 18–24
[2] Buzunov K 2010 *Architecture and construction in Russia* 11 pp 19-28
[3] Devyataeva G 2006 *Building reconstruction and modernization technology* (Moscow) p 250
[4] Yershov M, Lapidus A, Telichenko V 2016 *Technological processes in the reconstruction of buildings and structures* (Moscow) Volume 9 p 160
[5] Konovalov V 2011 *Zhilishchnoye stroitel'stvo* 3 pp 42-44
[6] Korgin A 2004 *Building materials, equipment and technologies of the 21st century* 12 71
[7] Oleynik P, Brodskiy V 2005 *Organization of reconstruction of industrial buildings and structures* (Moscow) p 116
[8] Rimshin V 2004 *Inspection and testing of buildings and structures* (Moscow) p 447
[9] Snitko A 2008 *Industrial and civil engineering* 2 pp 19-22
[10] Oleynik P, Cherednichenko N *JOP conference Series: materials science and Engineering* http://iopscience.iop
[11] Kuzmina T 2012 *Adaptation of the technical customer's activity in market conditions. Extended abstract of dissertation in support of candidature for a technical degree* (Moscow)
[12] Oleinik P, Kuzmina T 2018 *21st International Scientific Conference on Advanced in Civil Engineering FORM 2018* IOP Conference Series: Materials Science and Engineering p 062016
[13] Oleinik P, Kuzmina T 2017 *Izvestiya vuzov. Tekhnologiya tekstilnoj promyshlennosti* 3 369 pp 11-16