The installation features of the industrial building spatial lattice metal coating in a confined space

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Abstract. When developing a project for the industrial building spatial coverage installation, a number of tasks were solved to improve the installation method. The project’s feature was the presence of the constrained working conditions. The technology of mounting the coating blocks has been proposed. Mounting schemes with a breakdown of the spatial coverage of the building into the separate mounting blocks, followed by the enlargement assembly at the mounting mark have been developed. The use of inventory mounting devices in combination with a traverse of individual manufacture is justified. Mounting the unit using a traverse allowed to reduce the estimated height of the hook and pick up a crane with a relatively small rent cost. It became possible to apply the adopted installation scheme provided that an individual design of the beam was developed. The calculation and design of the traverse itself was performed, as well as the calculation of the enlarged unit for the installation situation.

1. Introduction
When implementing the project of expanding the storage facilities of one of the industrial enterprises in the Samara region, the author developed the metal framework project [1, 2]. The metal framework was designed as a part of columns, main beams and spatial lattice cover [3, 4]. The design feature of the project was the use of the inclined structural plate in the building’s coating. The technological feature of the project was the presence of constrained working conditions and installation of the coating in large blocks. The constrained production and construction works are due to two reasons. The first - a new building adjoins an existing department. Therefore, the approach of technology from one side of the new building is impossible. The second - the foundation of the new building is a reinforced concrete bowl with raised concrete walls to a height of more than 4 m from the floor (Figures 1, 2). Therefore, the free movement of goods inside the building was difficult. The overall dimensions of the building are 83.6 × 30 × 14.4 m (B × L × H).
2. Materials and methods

There are several known technologies for the assembly and installation of the buildings’ structural coatings [5-11] – the element fitting at the mounting mark; assembly on the ground and installation of the entire structure; assembly with large units assembled on the ground. The technical and economic analysis of the coating assembly and installation methods, taking into account the coating construction peculiarities, the features of the construction site and the needs for hoisting machines, made it possible to give the preference to the latter option (Figure 3). Installation with enlarged blocks involves their preliminary assembly on the specially prepared assembly sites, hoisting by a crane and installation at the mounting mark with subsequent fixing. To assemble the blocks, the platforms along the building under construction on the free side were provided. Enlarged blocks have an undoubted advantage, allowing them to be installed without the stabilizing devices and gadgets’ use - this is their self-sufficient rigidity in all spatial directions. The blocks have disadvantages that make their installation difficult - large dimensions and relatively large weight. The block dimensions are $30 \times 8.3 \times 2.069$ m ($L \times B \times h$), block weight 8.6 tons (Figure 4).
Since each enlarged block covers a large area, their number in the building cover is small. Installation of the coating, consisting of a small number of mounting elements, should satisfy the condition of high-speed installation. For these reasons, the authors proposed that the cranes should be mounted either pneumatically or tracked. Two schemes of slinging blocks were worked out - a four-branch sling from a crane hook; four one-branch slings from a specially made crosshead.

Installation according to the “without traverse” scheme has the following features: a large length of the sling branch (over 15 m); high elevation of the hook (due to the large length of the lines and the presence of a high wall of the foundation bowl). The analysis showed that for the accepted working conditions a crane with almost unique characteristics and a high rental cost is required.

The installation of the unit using a traverse (Figure 5) made it possible to reduce the elevation height and select a crane that did not differ in the high cost of rent by the “normal” characteristics. It is possible to apply the accepted installation scheme of blocks provided that an individual design of the beam is developed. The calculation and design of the traverse itself was performed, as well as the calculation of the enlarged unit for the installation situation. As a result, a traverse with the dimensions of 10,950 × 1,530 mm was developed. The traverse is a rectangular framework from a rolling I-beam 45B1, reinforced in the corners by braces from the equal-shelf corner 75 × 5. The calculated weight of the traverse was 1.7 tons.

The strength-stability check of the traverse-block system for the action of mounting loads in the software package operating on the basis of the FEM has been performed. Checking the first group of limit states showed that the bearing capacity of the most stressed element of the enlarged block is used
by no more than 54%. The slinging scheme of the enlarged unit with the location of all inventory links is shown in Fig. 5.

Before mounting the coating blocks, the project provides: to install all the columns of the building in the design position; to align and fix the main supporting columns of the framework and half-timbered racks; to mount the position of the support beams; to install the floor beams of inter-workshop space; to set the vertical and horizontal stiffness bonds between the columns; to perform a system of mounting ties, a system of temporary guy ropes necessary to ensure the overall stability of the framework during the coating installation.

![Diagram of the enlarged block’s sling](image)

**Figure 5.** The scheme of the enlarged block’s sling

### 3. Results and discussions

To select an assembly crane, the characteristics of a number of automotive and crawler cranes were analyzed [12]. After a detailed analysis, taking into account the cargo-altitude characteristics and the cost of rent, the crane DEK-50 was selected.

The mounted unit together with the traverse weighs 10.3 tons. This lifting capacity DEK-50 crane has at a handling radius of 17 m. This parameter is the initial one for deciding whether to tie the crane in plan at a construction site. Using this parameter, the crane parking areas are determined. The crane penetration line was installed at a distance of 10.22 m from the row D (Figure 6). After mounting the next block, the crane moves to the next parking lot. The step of moving the crane is taken equal to the width of the mounted unit, except for the parking lots for mounting the last three blocks. Here the pitch changes due to interference from the wall structures along axis 1.

The blocks’ assembly is planned to be carried out at the sites located opposite each parking lot, perpendicular to the crane penetration (Figures 6, 7). Moreover, the crane is assembling two blocks at once - the one closest to the mounting readiness, and the one that is far from the load-carrying capacity of the crane at the crane’s outreach that has been developed according to the working conditions. After mounting the near block, the distant block is moved by a crane into the mounting strip of the near blocks with a shift forward by the block’s width.
4. Summary

1. The developed project has been implemented. The manufacture of coating structures and its installation were completed in two weeks.

**Figure 6.** Scheme of working organization on the coating blocks’ installation

**Figure 7.** Block mounting scheme. Longitudinal section
2. The proposed installation technology made it possible to perform high-speed installation of the building cover. Coating installation time was 2 days.

3. Mounting the unit using a traverse allowed to reduce the estimated height of the hook and pick up a crane at a relatively small rent cost.

4. The installation cost for the proposed technology was 8,1 €/m². It’s almost 25% less than the average cost of installation in the construction region.

References

[1] Alpatov V, Solovyov A 2017 Pilot design of a spatial lattice metal structure for the coating of an industrial building *Urban Planning and Architecture* 7 (4) 4-8.

[2] Alpatov V, Golenkov I 2002 Design and reconstruction of industrial buildings at RESAL OJSC *Actual problems in construction and architecture. Education. The science. Practice Materials of the regional 59th scientific and technical conference* 66-68.

[3] Alpatov V 2002 Production and construction of spatial coverage such as the structure of the warehouse of products of RESAL OJSC *Actual problems in construction and architecture. Education. The science. Practice Materials of the regional 59th scientific and technical conference* 69-71.

[4] Alpatov V, Soloviev A 2007 Results of the inspection of the supporting structures of the cold warehouse of RESAL LLC *Actual problems in construction and architecture. Education. The science. Practice Materials of the 64th All-Russian Scientific and Technical Conference* 477-478.

[5] All building technologies. Information on http://detalprostroy.org.ru/index.php/2010-07-20-10-52-05/2010-07-20-16-16-51-06.

[6] Educational portal "all lectures". Information on http://vse-lekcii.ru/mosty-i-tunneli/stroitelstvo-gorodskih-mostovyh-sooruzhenij/montazhkranami-bolshoj-gruzopodemnosti.

[7] Telitchenko V, Terentyev O, Lapidus A 2004 Technology for the construction of buildings and structures (Moscow, Higher School) 446.

[8] Viktorova O, Petryanina L, Zvorygina S, Matieva Yu 2013 *Designs of coverings of hall rooms* (Penza, PGUAS) 60.

[9] Gilyazidinova N 2016 *Technological processes in construction* (Kemerovo, KuzGTU) 114.

[10] Tuzhilkina P 2017 Analysis of installation methods for metal coating structures *IX All-Russian Scientific and Practical Conference of Young Scientists «Young Russia»* 1-5.

[11] Doladov Yu 2007 *Cranes for the construction of buildings and structures* (Samara, SSACU) 108.