The Use of Serial Structures for Large-Span Frames

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Abstract. The development of engineering and design, the emergence of new materials (steel, concrete, aluminum, etc.) stimulated the emergence of new types of large-span structures. The structures became lighter, this made it possible to increase the size of the overlapping area. The use of large spans is due to the operational and architectural requirements in public buildings (markets, train stations, stadiums, concert and sports halls). In industrial buildings, large spans are subject to technological requirements. The space freed from supports, covered with a large-span structure, gives the building an emotional and plastic expressiveness. The use of large-span structures makes it possible to maximize the bearing qualities of the material and thereby obtain light and economical coatings. Reducing the mass of structures and structures is one of the main trends in construction. Less weight means less material, less material to be mined, processed, transported and installed.

1. Introduction
Simultaneously with the appearance of reinforced concrete, the theory of calculation and design of thin-walled coatings appeared. Reducing the weight of structures is one of the main trends in construction. Reducing the mass means reducing the volume of the material, its extraction, processing, transportation and installation [1-2].

Together, this gave a great impetus to the development of the construction of large-span buildings and structures. The use of large-span structures makes it possible to maximize the load-bearing qualities of the material and obtain light and economical design schemes [3-4].

The development of the engineering and design field, the emergence of new materials (steel, concrete, aluminum, etc.) stimulated the emergence of new types of large-span structures. The structures became lighter, which made it possible to increase the size of the overlapping spans, the ability to implement a flexible layout, a variety of geometric shapes, materials, architectural expressiveness – this is not a complete list of features of large-span structures [5-6].

2. Methods
The use of structural schemes with large spans allows you to save construction materials by 20-30% and reduce the material consumption of buildings and structures.

The experience of designing and constructing large-span structures requires a thorough and comprehensive study for the selection and further wide use of effective design solutions, rational design forms, calculation methods, and advanced installation technologies [7-8].

During the period of active construction of large-span buildings, calculation methods and advanced technological solutions for the installation and construction of such structures were developed.
A rigorous scientific and engineering approach to design, a synthesis of design research and scientific research, and consideration of modern installation methods and technologies in the design allowed us to create a serious knowledge base for calculation and design. Modern software systems allow you to simulate the operation of large-span structures of different types [9-10].

Thanks to ongoing research, the design regulations are regularly updated. In particular, the code of rules "Loads and impacts" clarifies and supplements the design schemes of wind and snow loads for different types of structures and, accordingly, eliminates excessive reserves of load-bearing capacity of structures.

The task of such studies was to create and use effective, reliable calculation methods. The results of these calculations were in good agreement with the data of experimental studies on models and full-scale samples, and subsequently with the performance indicators of the structure itself [11-12].

Economic data (consumption of steel and concrete) confirm the effectiveness of new design solutions and allow us to draw a number of conclusions about their advantages. The efficiency of large-span structures was significantly improved due to the use of lightweight insulation materials and suspended ceilings, the installation of a waterproofing carpet directly on the insulation without traditional cement screeds, etc.

The "old" standard project documentation currently has a reference character, and it can’t be considered as current, valid or invalid. The use of standard and "old" standard documentation is allowed by the expert examination. At the same time, it should be taken into account that the standard documentation must meet the following requirements:

1. In terms of composition and content, comply with the current legislation of the Russian Federation;
2. Have a positive conclusion of the state expert examination issued no more than 7 years ago;
3. Comply with the requirements of the land use and development regulations;
4. The application of the standard documentation must be legal in terms of the exclusive right to the project documentation as an object of intellectual property in accordance with the civil legislation of the Russian Federation;
5. Re-application should be possible and appropriate.

Currently, the use of serial products exists. For example, factories of reinforced concrete products recycle old series, confirming the performance of such products with additional calculations and the release of internal technical specifications for the products [13-14].

If we talk about the application of the series not on products, but on entire structures and buildings, then here designers are looking for other ways out of the situation. Serial solutions were used for certain technological capabilities. At the present time, the equipment of factories with technical means and personnel is different. Based on this, we can distinguish two directions for creating serial solutions:
- construction of buildings for the capabilities of specific plants;
- building structures made of rolled profiles.

Technical characteristics of the frame:
- dimensions: 36x60x7,2 (H) meters (height to the bottom of the load-bearing structures);
- spans: two-span (2x18 meters)
- column pitch: 6 meters;
- frame: frame type based on rolled I-beam, roof slope 10%,
- roof and wall purlins: rolling channel.

An example of such a transformation is the adaptation of the 1.420.3-15 series "Steel structures of Kansk-type frames of single-storey industrial buildings with the use of load-bearing frames made of rolled wide-field and welded thin-walled I-beams" [15-16]. Developer: "Central Research Institute of Industrial Buildings and Structures", "Central Research Institute project steel construction" fig. 1

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Figure 1. Steel frame structures of the "Kansk" type of single-storey industrial buildings.

The main advantage of the updated series is:
- easy to manufacture metal frame structures;
- speed of execution of the frame parts;
- simple connection nodes;
- application of widely used metal rolling profiles.

3. Results and discussion
The exclusion of the welded thin-walled I-beam from the design allows you to significantly reduce the release time of the frame structures. [17-18]

The minimum possible number of welds allows you to produce finished products with minimal labor costs and maximum speed.

The components of the frame are designed in such a way that the frame can be manufactured in production facilities with any degree of technical equipment [19-20].

| Table 1. Comparative table of indicators of the Kansk and Obninsk series. |
|---------------------|---------------------|---------------------|
|                      | The existing Standard line "Kansk" | Standard line "Obninsk" type-1 | Standard line "Obninsk" type-2 |
| Weight, tons         | 67,6                 | 57,2                 | 65,2                 |
| The peculiarity in the complexity of manufacturing | A 4x900/10/200 thin-walled welded beam with a wall thickness of 4 millimeters is used, which can only be welded by a highly equipped factory. There are a large number of stiffeners, which further complicates the manufacture of the ridge knot. | Standard rolling I-beam. There are small difficulties in the manufacture of the ridge knot. | Standard rolling I-beam. Easy to make. |
manufacture of metal structures.

Use of standard rolled metal
Partly because partially welded metal structures are used
Completely made of long products, which allows you to produce these buildings on less equipped metal structures plant
A competent technologist is required
It is completely made of long products, which allows you to produce these buildings at a less equipped metalwork plant.

Column bases
Column bases with traverses
Due to the fact that we do not use the traverses of the columns the manufacturability of the frame increases
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Assembly welding
Mounting welding is used
Installation welding is not used due to this: 1. increases the speed of installation of metal structures; 2. increases the quality of installation of metal structures
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| Table 2. Analysis of the welding time of a single frame in different types of Kansk structures. |
|---------------------------------------------------------------|
| Operation                                      | Kansk | Obninsk type-1 | Obninsk type-2 |
| Welding of frame beams on an automated I-beam welding machine, hour. | 5,00  | no             | no             |
| Welding of the ridge assembly in manual mode in a CO₂ environment, part. | no    | 6,24           | no             |
| Welding of stiffeners in a CO₂ medium, part.               | 2,50  | no             | no             |
| Welding of flange assemblies in the CO₂ environment, part. | 8,37  | 2,86           | 2,86           |
| Total time to weld one frame                            | 15,87 | 9,10           | 2,86           |
4. Conclusions
Based on the comparison of characteristics, it is obvious that the redesigned series is relevant and easy to manufacture and use. The frame with the reduced labor intensity of manufacturing is applicable for performing metal structures in most factories.

But this edition of the series can not be called fully meeting all the new requirements. The issues of progressive collapse, the work of structures in accidents were not solved in a specific example.

Thus, it is obvious that when processing the series for large-span structures, all factors must be taken into account. The calculation should take into account the changed climatic data of the country's regions, new requirements for steel grades by design groups, and the operation of the building as a whole in emergency situations.

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