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PROBLEM ANALYSIS OF MODULAR AND FAST-ESTABLISHED BUILDINGS AND THEIR SUSTAINABLE DEVELOPMENT

Abstract. The growing market of prefabricated modular buildings occupy an increasing share of erected structures. Fast construction speed, portability and other advantages of this solution make it competitive and sometimes indispensable in the extreme conditions of our country. At the same time, problems remain unresolved that hinder the sustainable development of this area. The authors of the article analysed the information of design solutions, the construction of such structures and the most frequent problems that arise in this case. Based on this, the requirements for the future development of the scientific environment in Russia in the studied area were formulated.

Keywords: prefabricated modular buildings, extreme working conditions, sustainable development.

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АНАЛИЗ ПРОБЛЕМ МОДУЛЬНЫХ И БЫСТРОВЗВОДИМЫХ ЗДАНИЙ И ИХ УСТОЙЧИВОЕ РАЗВИТИЕ

Аннотация. Растущий рынок быстровозводимых модульных зданий занимает все большую долю возводимых конструкций. Высокая скорость строительства, мобильность и другие преимущества этого решения делают его конкурентоспособным, а иногда и незаменимым в экстремальных условиях нашей страны. В то же время остаются нерешенными проблемы, препятствующие устойчивому развитию этой области. Авторы статьи проанализировали информацию о проектных решениях и строительстве таких сооружений и наиболее частых проблемах, возникающих в этом случае. Исходя из этого, были сформулированы требования к будущему развитию научной среды в России в исследуемой области.

Ключевые слова: модульное здание, быстровозводимое здание, экстремальные условия эксплуатации, устойчивое развитие

1. Introduction

The task of improving the production efficiency by reducing the construction time of buildings is important all over the world. In Russia, its solution is especially relevant for a number of reasons. They determine the features of construction in our country together.

There are some main reasons: many undeveloped areas; insufficiently developed

infrastructure of the developed territories; long distances (from the manufacturer to the construction area); the lack of qualified labor force; extreme climatic conditions (severe winters) in the developed regions of Siberia and the Urals and, as a result, a relatively short season, in comparison with other countries, favorable for construction work.

Use of prefabricated modular buildings is one of the solutions to this problem [1].

Prefabricated modular buildings and structures are objects which constructive solution ensures their installation within a significantly shorter time compared to the construction of buildings using traditional technology (in accordance with the standard duration of construction) [2].

The first prefabricated buildings were the dwellings of nomads from time immemorial. The fact that modular structures can make possible the satisfaction of various functional needs in number of human life spheres is the reason for the prefabricated buildings development at the present stage of human history. These buildings ensure a new level of convenience and comfort in remote areas of the Earth. So the scope of these buildings has expanded significantly [3].

There are some areas of prefabricated buildings application [4]: industrial buildings of main and auxiliary industries, workshops, warehouses, garage and car service buildings; public buildings: trade pavilions and mini-markets, expo centers and exhibition pavilions, health and fitness centers; rotational settlements; factories and residential complexes with developed infrastructure in remote areas with sources of raw materials and minerals; settlements (with residential and public buildings) for operational resettlement of the population and rescue services of the Ministry of Emergencies in areas of natural disasters and local conflicts; linear settlements for personnel during geological exploration or construction in remote areas; temporary and permanent military structures; pre-fabricated military camps; mobile complexes for the temporary basing of troops and units of other law enforcement agencies in training areas.

There is the impressive list of prefabricated and modular buildings application advantages: minimal labor intensity of installation; reduction of terms from the design beginning to operation of the construction object and, consequently, the approach of the initiation of the economic benefit from the facility operation – the period of return on investments in construction; transportability (including the possibility of transporting modular units within the

dimensions of a railroad transport, delivery by road on winter roads, also by airplanes or helicopters on an external sling); reduction in transportation costs, so the economic efficiency of delivery to the place of future operation, especially if it is located in a remote, inaccessible area; short design terms due to the use of ready solutions (it is possible to reduce the time required to prepare a set of necessary materials, including design documentation, to 2 ... 3 weeks); the possibility of abandoning the use of "wet" processes during construction; the possibility of refusal from welding at the installation; the possibility of continuous installation, including in the conditions of severe Russian winters; the possibility of refusing to use heavy crane equipment, as well as the decrease of lifting equipment use (up to installation partially manually), which is especially important during construction in remote and hard-to-reach areas; building delivery formation set at one supplier; the ability to supply engineering systems and equipment, as well as materials for interior decoration and furnishing, complete with buildings and building structures; technical and technological ease of building installation; the possibility of construction by a poorly qualified workforce; lightness of building structures, which makes it possible to build without the construction of powerful foundations; the possibility of using lightweight foundations (including concrete slabs); small volume of zero cycle works; minimal amount of preparatory work; fewer requirements to the ground under the building, and therefore less amount of survey work; seismic resistance; the possibility of redeveloping the interior space in frame-type buildings; the possibility of dismantling buildings with subsequent assembly at a new place of operation; the possibility of "building up" constructions due to modularity (according to the principle of "house-constructor"); a wide range (nomenclature) of buildings according to their functional purpose, sufficient for the settlement construction with developed infrastructure.

In general, according to experts, the cost of assembling a prefabricated building is on

average 30-40 % less than traditional buildings. These are significant savings. The costs of the zero-cycle work can be reduced by almost half, and the installation period does by 1.5-2 times.

All this makes the possibility of using BVZ attractive for the development of enterprises of both large and medium-sized and small businesses, both in the state and in the private sector of the economy.

The authors of the article have set themselves the tasks analyze the experience of the Russian market and synthesize the information obtained to form the problems of sustainable prefabricated building development by the induction and deduction method; then, based on this, form the ways of developing science to solve the identified obstacles.

2. Sustainable development problems of prefabricated buildings and structures.

There are many unsolved problems on the way to the full implementation of prefabricated and modular buildings. The authors of the article chose the company "ZMYS Plus", which has sufficient experience of prefabricated buildings construction due to being on the market of modular structures for 7 years, to conduct a study of the problem. The following problems were identified during the analysis.

2.1. The lack of a full legal framework and universal construction types of prefabricated buildings

The volume of prefabricated building construction has increased significantly over the past few years. This result was largely aided by the 'Living Steel' program launched in 2005, introduced by Pierre Bourrier, president of 'LSK'. The main purpose of this program is to increase steel consumption in construction. In particular, to make popular the prefabricated building construction with the use of lightweight thin-walled structures. There are the participants of this program: global steel concerns 'Arcelor Mittal', 'Baosteel', 'Corus', 'Ruukki' and others. The Russian concern 'Severstal' joined this

program at the end of June 2007. According to the estimates of the research company 'Research.Techart', based on statistics on the development of related industries, manufacturers data, also considering the indicators of the construction of non-residential premises, about 7.3 million sq. m of prefabricated building construction was built in 2007 in Russia, based on metal structures.

The large-scale development of the field of prefabricated buildings has led to the formation of many companies. However, each company is working according to its own projects, assortments, is forming nodes of "own production". This information was checked by the company independently at best and were not checked and calculated at all at worst.

2.2. Lack of material regulation used in the prefabricated building construction operated in extreme conditions

Due to the presence of many various material manufacturers, including paints and varnishes, manufacturers have established themselves on the market, if they have proven themselves well with using their products under normal conditions. The company "ZMYS Plus" LLC produced a modular building for the conditions of the Far North according to the technical specifications,



Figure 1. Violation of the integrity of the paint coating

where the paint was provided, which proved itself in the manufacturer's market. Due to the lack of standards governing the influence of extreme conditions on the design of prefabricated buildings, this technical task at the construction stage was undeniable. However, when this paint was supplied in conditions of extremely low negative temperatures, the integrity was broken, which will lead to inevitable corrosion in the future (Figure 1).

2.3. A very large influence of various initially unforeseen factors on the structure of prefabricated modular buildings (power and non-power)

As a confirmation, there are amount of administrative and household complex structures, which imply the possibility of dismantling with subsequent installation, but these processes are unregulated and can be dangerous for structures, because of many factors: exposure to chemical factors (gas fumes) at the location of buildings; the impact of failure loads for dismantling and reassembling, for which were not designed

structure; changing the complete shell of the building; the environment influence on the interior of the building directly during the installation process before sealing the joints.

For example, the operating administrative building company has supplied ventilation system, which breaking the shell of the building (figure 2). Consequently, the service life of the internal wooden structures was reduced, and because of the entire building.

2.4. The presence of a stereotypical way of thinking and ideas about modular container housing

The concept of modular buildings has historically been associated with unaesthetic, poorly equipped buildings with bad living conditions (Figure 3a). However, modular buildings have already moved to a new level (Figure 3b), and such stereotypes about the lack of aesthetics deteriorate the process of introducing prefabricated systems into housing construction



Figure 2. Violation of the building envelope integrity



Figure 3. Aesthetic growth of modular buildings
a. Historical stereotype of modular homes
b. An example of the modern application of modular building

2.5. The high fire hazard of light metal structures requires extensive preparatory work on the fire protection of structures

2.6. The impossibility of using flammable insulation

The use of flammable heaters (polystyrene, etc.) is prohibited due to the requirements of fire hazard. Therefore, mineral and stone wool is used, which is not designed for extremely low temperatures and crumbles. In such cases, it is most justified to use sandwich panels, but their thermal conductivity is higher. These conclusions lead us to the problem that there is no ideal solution for thermal insulation at extremely low temperatures, both material and structural.

2.7. Lack of regulated (typical) foundation structures for modular and collapsible structures.

This problem leads to the use of inexpediently expensive foundation structures, and sometimes non-technological units of adjoining the foundation to the structures, with further disruption of the building thermal envelope and the ingress of unintended moisture inside the structures.

2.8. The impossibility of using high-strength steels to save material in extreme conditions.

Foreign experience in Europe and the US is talking about a successful constructive solution with the high-strength steel use of in the construction of prefabricated buildings,

but high-strength steel is not justified in the extreme conditions of the Far North because of its fragility at low negative temperatures.

3. Science development directions for solving problems

Today, it is possible to formulate the following requirements for the development of science and technology, the implementation of which will lead to the solution of the prefabricated building problem.

- Develop a complete regulatory framework for the calculation of metal structures fabricated buildings;
- Create universal joints for light metal structures with the possibility of further calculating their compliance
- Create full building classification by the presence of operating hazards both power and not power, with further attendant requirements for the materials, which can be used in extreme conditions.
- Form the growing trend of the modular structure of development and improving the aesthetic qualities of structures for breaking stereotypes.
- Create standard solutions for foundation structures of modular and prefabricated buildings
- Create clear requirements for the operation of buildings, depending on their reliability class.

4. Conclusion

Analysis of information and systematization of problems in the field of pre-fabricated buildings and structures allows

to correctly formulate tasks for future scientific research in this area, which require theoretical generalization and solutions.

The result of solving this strategic task should be the scientific and technical foundations for the creation of prefabricated complexes and the directions of their development (improvement) in the future.

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