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Modular buildings in modern construction

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Abstract

The article considers temporary methods of using modular units in construction. The advanced world experience in the construction of modular buildings is analyzed. It is emphasized that modular construction has the potential to shorten project design and engineering time, reduce costs and improve construction productivity. The installation of modular buildings is cost-efficient, safe and eco-friendly. Modern modular systems are based on using not only large elements such as «block rooms» but various small 3D building elements. The analysis result of Russian developments in the construction of modular buildings proves that Russia has great experience in the development of 3D reinforced concrete modules. As the research results the article shows promise for developing of modern modular construction systems in order to provide the population with affordable, comfortable and eco-friendly housing. The paper describes the prospects and relevance of introducing modular prefabricated units not only into low-rise but into multi-storey and high-rise construction as well.

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1. Introduction

In a number of studies and reports of «Habitat's UN» it is emphasized that rapid urbanization is accompanied by aggravated housing problem. The cities are growing disproportionately to the rates of economic development thus increasing the gap between the poor and the rich. The megacities with the over 10 million population are the symbols of our time, but, unfortunately, they mostly do not mean such concepts as comfortable living environment,

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equal opportunities for all population groups, healthy micro-climate, etc. The world community is worried by the fact that 26 out of 34 existing megacities are in developing countries. These cities face such problems as urban sprawl, slums and spontaneous development. According to statistics in 2005 every third habitant of a city lived in unfavorable conditions. To satisfy the world needs in urban housing it is required to build about 35 million apartments a year (approximately 95 thousand apartments a day) [1, 2].

The development of mass affordable housing construction is relevant for many countries. Economically it can be justified only as the result of applying modern industrial construction methods that are based on standardization, unification and typification. Modern materials and construction systems are introduced under the condition of extensive use of energy saving technologies [3-11]. The efforts of specialists are aimed at searching the ways of reducing the construction costs. It should be noted that nowadays the construction from offsite fabricated modules, in other words, modular construction is one of the most promising and high-tech directions of architectural and construction development in the world.

Modular technologies are widely used in low-rise buildings of different functional purposes: office and household, warehouses, sanitary and special purpose premises, etc. However, in recent years, they have been introduced in multi-storey and even in high-rise construction. Modular construction combines various technologies based on rapid construction principles. The concept «modular building» should be focused on. In modern understanding, talking about the modular components of the system, two main directions in the construction of modular buildings can be distinguished: the use of separate elements of a frame system (beams, columns, floorings, wall panels, etc.) that are produced offsite and assembled onsite; the use of 3D elements (block containers) including necessary internal engineering facilities, interior and exterior finishing and built-in furniture and equipment. It is proposed to consider these directions in detail on the examples of advanced world experience in modular construction.

2. Prefabricated building construction systems

Prefabrication, pre-assembly, modularization, a system building and industrialized buildings are the terms which are used in the correlation and individually for describing the advanced technologies in rapid construction of buildings when structural components are produced at a plant and the construction site is used only for assembling. In this section special attention is paid to systems based on separate structural elements produced at a plant.

The first example is the unique technology developed in China by the BROAD Group founded in 1988. Its production complex is based in Changsha. In 2008 its subsidiary company Broad Sustainable Building (BSB) was established with the production (BSB Central Factory) in Xiangyin, Hunan. 7 principles of sustainable development are in BSB construction technology: 1 – it is the only enterprise in the world where 90 % of modular system components are offsite prefabricated elements (production wastes – 1 %); 2- energy consumption efficiency is 5 times higher than in traditional buildings; 3 – unique microclimate inside buildings with specially purified air; 4- seismic resistance (withstands the earthquake of magnitude 9); 5 – land saving (focuses on high-rise construction); 6 – saving of materials (metal structures from recycled steel); 7- durability.

The structural system is based on type-design practice of all elements: steel columns, beams (crossbeam), floorings and curtain wall panels. The most interesting module is the floor section of approximately 12.5m x 4.1m (see Fig. 1a). They are produced and equipped with necessary engineering facilities and finishing at a plant: electrical cables, concealed air outlet ports of central air conditioning and ventilation systems, heat and sound insulation, finishing details, etc. The standard height is 3.0 m. The produced modules are delivered to a construction site and assembled by bolted and welded joints. Typification of elements, high quality offsite fabrication and perfect logistics (production, storage, delivery, assembly) allow reaching amazing construction rate [12, 13].

The corporation has constructed over 30 buildings since its establishment. The following buildings are among them: a15-s torey hotel built in 6 days; a 30-storey hotel «T30 Hotel» (2012, 99.9 m) in Changsha (China) built in 15 days. Not stopping on the achieved results, BROAD Group has started an ambitious project: the construction of a building «Sky City» (838m) using their modular system (see Fig. 1b). This skyscraper is presented as a real «vertical city» of 202 floors. 83% of the building area must be used as residential apartments for about 17000 habitants. Besides, offices, a hotel, 5 schools, a hospital, stores, restaurants, 17 helipads, 6 basketball courts, 10 tennis courts and other things are provided. But the height of the skyscraper is not the most important component of the construction revolution. The unique fact is that it is planned to be built in an enormously short period of 90 days.