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REVIEW OF ENERGY-EFFICIENT PRECAST FRAME STRUCTURES FOR RESIDENTIAL BUILDINGS

Each building type requires a different building system with suitable structural elements. At the beginning of the planning stage, it is necessary to determine which building types are built in order to find the most energy-efficient building system apart from the building type, climatic conditions like wind loads, seismic loads, temperature etc.

Every building system has its specific guidelines and regulations which need to be considered in order to use it efficiently. In some countries, norms and guidelines need to be adapted to the precast concrete construction method or be established in the first place.

The precast concrete construction method takes into account the entire costs for the shell, like material savings, lower costs for site equipment due to a shorter construction time, earlier utilization of the buildings, less maintenance etc. and not only the m² of wall or floor as it is done for other building materials.

The use of precast frame structural systems for residential construction is one of the best ways to increase their energy efficiency. This improvement is possible due to the possibility of applying of materials with the lowest thermal conductivity for the frame fillings. This raises the problem of finding the most optimal frame structure that would satisfy the needs of housing construction, namely: providing free planning of apartments and transforming apartments for any purpose, ensuring the autonomy of its heating.

Among the frame structural systems that meet these requirements to some extent are the following: Deltabeam Frame [1], Dycore System [2], Filigree Wideslab System [3], Uncapital Ungirder Frame Structure [4] and others.

Deltabeam Frame is a composite slim-floor system for multi-storey buildings of any kind. It allows flexible lay-outs through the whole life cycle of the building, and easy HVAC installation. The Deltabeam Frame is formed by Deltabeam Composite Beams and Composite Columns, which are connected using standardized connections, and other steel structures required for the building's frame. Deltabeam Composite Beam is designed to be used as a structural element combined with all general concrete slab types: hollow-core slab, filigran slabs, composite steel decking, trapezoidal steel decking slabs, and cast-in-situ concrete slabs. It enables the usage of shallow element structures and strengthens the frame structure inside the slab [1].

The key precast elements of Dycore System include shallow soffit beams, high strength Dycore floor slabs, and multi-story columns cast with blockouts at the beam level. The precast beam and floor members serve as stay-in-place forms for composite cast-in-place concrete. Connections are also composed of cast-in-place concrete [2].

The Filigree Wideslab System employs reinforced precast floor panels that serve as permanent formwork. The panels are composite with cast-in-place concrete and contain the reinforcement required in the bottom portion of the slab. They also contain a steel lattice truss, which projects from the top of the precast unit. The steel truss ensures composite behavior between precast and cast-in-place concrete and provides the unit with stiffness during erection [3].

Uncapital Ungirder Frame Structure is one of the modern systems that have achieved excellent results in construction in a large number of countries in the world in general and in Ukraine in particular. This structural system is a flat reinforced concrete slab directly con-

nected to the columns by progressive decisions of their joints. Beams, columns, consoles and capitals are absent in Uncapital Ungirder Frame Structure. It allows the fast transform a space for the new designation, provides automation of heating. The use of this structural system is also one of the ways of renewal industrial production for manufacturing of precast reinforced concrete that will significantly save energy.

Interfloor overlapping used in buildings with Uncapital Ungirder Frame Structure (Fig. 1) consists of three types of precast concrete slabs: overcolumned (2), intercolumned (3) and middle (4). Overcolumned slabs (2) are fixed by welding embedded casing in slab to the reinforcement of columns (1) and the assembly formed intervals of 20 mm between columns and slab casing and between the slabs are filled with a high-strength finegrained concrete. In this case, in concreted spaces keys are formed, concrete of which is self-reinforced due to the work in conditions of full compression.

The vertical load-bearing elements of the frame are multi-story reinforced concrete columns, and partially reinforced concrete stiffening diaphragms. Jointing of columns is compulsory due to entering the bar-lock of the bottom end of the upper column in slot of the top end the bottom column.

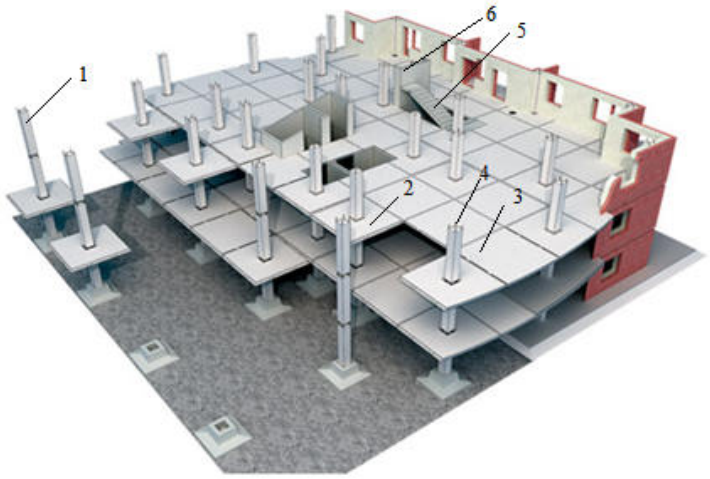

Figure 1. Scheme of Uncapital Ungirder Frame Structure for residential building:
1 – column; 2 – overcolumned slab; 3 – intercolumned slab;
4 – middle slab; 5 – staircase; 6 – diaphragm

A comparative analysis of these and other structural systems has shown that Uncapital Ungirder Frame Structure is the most suitable for energy-efficient residential construction in Ukraine. Practice has confirmed its significant advantages in architectural planning and design solutions of residential buildings in comparison with other structural systems.

References

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