Peculiarities of erecting walls for houses and buildings by technology of monolithic construction using permanent formwork unit

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Abstract. The article deals with constructive and organizational-technological solutions when performing works on construction of external and internal bearing walls with the use of combined permanent formwork. The technology allows to reduce the construction time by combining in the system of the retained formwork unit three technological processes, which are performed simultaneously by one group of contractors - erection, insulation and wall decoration. Depending on the thickness of the insulation in such houses and buildings, it is possible to achieve close to zero energy consumption.

1. Introduction

Saving energy and heating costs is an issue facing any community. In Europe, energy efficiency issues are covered in Directives 2002/91/EC, 2010/31/EC and EPBD (COM/2016/0765). Ukraine is moving somewhat slowly, but still in the direction of legally approved principles of energy efficiency. The Law of Ukraine “On Energy Efficiency of Buildings” stipulates that in order to gradually increase the energy efficiency of buildings, a national plan for increasing the number of buildings with close to zero energy consumption is approved. In the near future, we will have to use less energy for heating than we have used so far [1]. So, the main characteristic of the buildings of the future is low energy consumption [2].

The practice of modern construction of energy-efficient comfortable houses on the Ukrainian market is represented by various materials and technologies. The main ones are aerated concrete, bricks, houses and buildings erected by monolithic technology in permanent formwork. Permanent formwork, in turn, is represented by different options. But such important parameters of the future house (building) as: energy saving, tightness, duration of construction, durability, environmental friendliness, cost, fire danger, etc. always come to the fore [3-8]. All these requirements are met by the combined permanent ComBlock formwork that is confirmed by two patents and positive responses of customers.

The object of research is houses and buildings erected with the use of permanent formwork ComBlock of the AVcom trademark.

The subject of research is the technological regulations for construction of walls according to the technology of monolithic construction to ensure energy efficiency of the building.
The purpose of research is organizational and technological solutions in the construction of external and internal load-bearing walls with simultaneous use of insulation and decoration to ensure energy efficiency of buildings.

2. Materials and Methods.

The construction of external walls using this technology consists of the following layers:
- insulation with a thickness of 50 to 300 mm (outside);
- concrete core with a thickness of 100 mm (according to calculations);
- gypsum panel 30 mm thick (inside).

The construction of internal load-bearing walls consists of two gypsum panels 30 mm thick and a concrete core 100 mm thick (according to calculations).

The components of the permanent formwork block (insulation and gypsum panel) are interconnected by plastic adjustable jumpers, which fix the desired thickness of the concrete core with an adjustment step of 25 mm. In addition to the connecting function, jumpers are used to fix the reinforcement in the design position (Figure 1). The material of the jumper is corrosion resistant.

![Figure 1. Adjustable plastic jumper in assembled form.](image)

The permanent formwork filled with concrete forms a monolithic wall of estimated thickness depending on design loading. As insulation it is possible to use Neopor® - with density of 15 kg / m³, (EPS70), expanded polystyrene M25 with density not less than 15 kg / m³ (DSTU B EN 13163: 2012 Building heat-insulating materials - Products made from foam polystyrene (EPS). Technical specifications (EN 13163: 2008, IDT)) and mineral wool - with density of 135-145 kg / m³. On the inside of the formwork are gypsum panels that do not require further finishing (plastering, linings).

The block of permanent formwork can be ordinary and angular.

Ordinary Comblocks. The ComBlock system with a gypsum panel (Figure 2), used for construction of external bearing walls, consists of insulation panel which is from 50 to 300 mm thick and the gypsum panel being 30 mm thick, and they are connected between themselves by plastic adjustable jumpers (7 pieces per one form).

One ordinary module of the ComBlock system is 1000 mm long, 300 mm high, the thickness of module depends on the designed thickness of insulation and the concrete core of wall. The thickness of the concrete core of wall can be from 100 mm to 430 mm. No further plastering is required.
Figure 2. Scheme of the ComBlock system with gypsum panel.

The block of internal bearing wall (Figure 3) is applied to construction of internal bearing walls. The form of permanent formwork consists of two gypsum panels connected by plastic adjustable jumpers (7 pieces per form). One block is 1000 mm long, and 300 mm high. The thickness of the concrete core of the wall can be from 100 mm to 430 mm. No further plastering is required.

Corner Blocks. The internal side length of one module of the angular ComBlock for plaster panels is 250 mm and 500 mm. The length of the outer sides (insulation) and the width of the block depend on the designed thickness of insulation and the concrete core of the wall. The thickness of the concrete core of the wall can be from 100 mm to 430 mm. No further plastering is required. (Figure 4).

Figure 3. Scheme of the inner load-bearing wall Comblock.
Figure 4. General view of the corner ComBlock with gypsum panel.

The ends of the outer and inner panels of the Block are made with spikes and grooves, which provides density when combined, prevents the flow of concrete mix through the joints, and prevents the formation of cold bridges.

3. Approval of the Research

Technological regulations for the construction of buildings and structures using permanent formwork ComBlock are to assemble blocks of permanent formwork; to install the whole course of them into the design position; to install reinforcement; and to fill it with concrete.

Installation of the course of permanent formwork blocks begins with mounting of corner blocks being leads for the process (Figure 5). During installation, the vertical and horizontal position of gypsum panels and insulation ones, as well as the horizontal position of gypsum panels and insulation ones relative to each other are checked.

Figure 5. Installed corner block with plasterboard.
When installing the next courses of ComBlock, a 250 mm bond is required according to the technology. Corner blocks are left and right, made asymmetrically (inner plasterboard is shaped like the capital letter "L" and has dimensions of 250x500 mm).

After mounting of angular blocks, installation of ordinary blocks (1000 mm long), with controlling their position on cords, is started. And, thus, the first course of blocks of external and also internal walls is completed (Figure 6).

After installation of the course of formwork blocks, vertical and horizontal fittings should be installed (Figure 7).

Mounting of horizontal fittings begins with the installation of working rods.

Reinforcement with vertical rods is carried out taking into account the spatial location of the reinforcement in the wall structure. Vertical working rods are installed with the connection of the lower ends to the free length of reinforcement bars and combining them with clamps. Next, from the bottom to the top other clamps are put in, fixing the vertical rods.

After installation of the course of ComBlocks, and horizontal and vertical armature, laying of concrete mix starts according to the project.

The concrete mixture is prepared in a concrete mixer in the immediate vicinity of the site where it is laid.

When laying the concrete mixture, it is pierced or compacted with a low-power vibrator to avoid violating the integrity of the blocks of permanent formwork.
Particular attention in the system of fixed formwork Comblock is paid to ensure tightness when installing door and window openings. In places of execution of window or doorway openings the ordinary block is cut to the size required by the project. In the ends of the concrete core of wall on the side of the opening, formwork of insulation, or template-formwork is installed, which is fastened with wooden struts (Figure 8).

Installation of the window block can be carried out in two options:
• fastening of the window block with external exposing of thermoinsulation;
• fastening of the window block without external exposing of thermoinsulation.
For "mounting with external exposing" in the outer layer of insulation in the lower part of the window opening a recess is cut, in which trioterm insulation (or its analogue, which is dense, with a bulk density of 200 kg / m3) is inserted, unfastened and concreted in the design position, which is the basis for
installation of the window unit in the area (body) of the insulation. Trioterm is additionally fixed on metal brackets which are monolithic in concrete walls that provides reliable fastening of the window block.

In the case of "mounting without external exposing ", the window block rests on the concrete part of the wall. In this case, you need to lay insulation at the ends, as well as at the bottom and top of the window unit (if it is designed so).

Conformity of thermal and sound insulation characteristics of enclosing structures made with the use of technology of fixed formwork Comblock, allows to achieve resistance to heat transfer much higher (Table 1) than the requirements of regulatory documents of Ukraine [2].

**Table 1.** Dependence of heat transfer resistance on insulation thickness in Comblock system.

| Thickness of insulation, mm | 100  | 150  | 200  | 300  |
|-----------------------------|------|------|------|------|
| Thermal transfer resistance | R, (m²-K)/W | 3.48 | 5.04 | 6.6  | 9.73 |

The use of permanent formwork in the construction of walls speeds up and simplifies construction by combining several processes in one technological cycle (load-bearing wall with a designed heat transfer resistance is erected in one technological cycle). The design of the permanent formwork provides tightness, and concrete in it, after setting and gaining strength, becomes a structural part of the finished wall.

The floor from ComBlock is erected in 10-12 days (walls + insulation + plaster) by a team of 4 people, while brick walls are erected in 25-30 days without insulation and plastering.

Due to such thermal insulation, this construction system allows to save energy resources significantly when heating buildings and houses, which becomes especially important when energy prices are constantly rising.

4. Conclusions.

Construction with the permanent formwork of the Comblock has a number of advantages:

- the insulation is only exposed to the outside;
- a significant reduction in heat loss during the operation of buildings and buildings;
- reduction of construction time due to uniting three technological processes in the block system of permanent formwork performed simultaneously by one team of contractors - erection, insulation and wall finishing;
- possibility of application of the ComBlock permanent formwork technology in seismic areas.
- the ComBlock system makes it possible to obtain high indices of heat transfer resistance with minimum expenses of the customer.

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