CONSTRUCTION OF A 5-STOREY RESIDENTIAL BUILDING

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ABSTRACT

This Bachelor's thesis was commissioned by Evromonolit Ltd. The purpose of the thesis was to produce an overall description of the process of the construction of a 5-storey residential building and to draw up a work schedule and calculate a cost estimate of the project.

All research information was gathered from various internet resources, reference and technical literature such as government standard (GOST), set of rules (SR), building regulations (BR) and design documentation presented by Evromonolit Ltd.

One aim was to acquaint with the architectural construction section concerning the space-planning and structural solutions of the building. The technologies and organization of construction were also discussed to show how in real practice this type of project is done using the example of Evromonolit Ltd. Another aim was to draw up the cost estimate of the project and schedule for the work.

As a result of the thesis an introduction of step-by-step workflow was produced including a construction schedule and cost estimate of the example residential building. In addition, solutions were identified to save cost in the project budget.

Keywords Labor costs, estimate, schedule

Pages 53 pages including appendices 10 pages

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1 INTRODUCTION

Today, one of the most important areas of the economy of the Russian Federation is the construction industry. The construction sector is developing, in particular residential construction in Russia is reaching a whole new level.

The construction sector of Russia unites almost 7 million people who work in more than 160 thousand organizations and enterprises. Today, the construction complex is one of the real sectors of the economy, on which the solution of the housing problem, the rate of renewal of fixed assets and the structural adjustment of industry directly depend.

The main component is a major construction - the totality of all activities, ensuring the implementation of the investment process, from the pre-design stage to commissioning. The structure of this industry includes organizations that carry out construction and installation works on the erection of new buildings, structures and other objects of the national economy and reconstruction of existing enterprises, design and survey organizations serving construction.

The purpose of the thesis is to study the construction of a 5-storey building that is able to solve part of the housing problem in St. Petersburg.

Compared to brick buildings, the construction of panel buildings reduces the cost by an average of 10%, the total labor costs by 25–30%, and the construction time is faster up to 1.5 - 2 times.

A few years ago, panel houses had a number of significant drawbacks: the wretchedness of architectural solutions, rather poor thermal insulation of the premises, and were not popular among Russians. However, in panel housing construction there is one significant advantage: the high speed and relative cheapness of the construction of buildings, which forced specialists to reconsider the design and production technology of wall panels. Panel houses built using multi-layer wall panels of the new generation fully meet all modern requirements for the level of heat saving, room comfort, architectural design, etc.

Three-layer reinforced concrete panels consist of two layers of reinforced concrete: external and internal with a layer of effective thermal insulation materials in the middle.

2 ARCHITECTURAL AND CONSTRUCTION SECTION

2.1 Brief description of the construction area

Climatic characteristics are taken from the Set of Rules (SR) 131.13330.2012 for Saint Petersburg and the region. The construction zone refers to climatic region II, subarea IIB for SR 131.13330.2012.

According to SR 20.13330.2011:
- snow region - III (estimated value of snow cover weight - 180 kgf / m2);
- wind region - II (standard value of wind pressure - 30 kgf / m2).

The climate is temperate continental. According to long-term observations of the State Meteorological Service, the average annual air temperature is + 4.4 °C. February is the coldest month of the year with an average monthly temperature of -7.8 °C, and the warmest one is July, with an average monthly temperature of + 17.8 °C.

The absolute minimum is -36 °C, the absolute maximum is + 34 °C.

2.2 Composition and properties of soils

The geological structure of the site within the depth of drilling of 23.0 m includes: Modern techno genic deposits (t IV), Upper Quaternary Lake-Glacial (lg III) and Glacial Deposits (g III).
GEE-1 (Geological Engineering Element). Soil and vegetative layer with a thickness of 0.1m.

Man-made deposits (t IV):
-GEE-2. Bulk grounds: dusty dark gray sand with plant residues saturated with water. Sediment thickness is 0.2-0.3 m.

Lake-glacial deposits (lg III):
-GEE-3. Light, silt, brown loams, non-layered with sand interbedded, with a thickness of 0.8-1.8 m.
-GEE-4. Light sandy loamy brown bands with sand interlayers, weathered soft-plastic with a thickness of 0.7-1.7m.
-GEE-5. Light clay dusty loam gray ribbon with a thickness of 1.5-3.6 m.
-GEE-6. Light clay dusty loam brown ribbon-flowable with a thickness of 1.8-2.3 m.
-GEE-7. Dusty gray sandy loams indistinctly layered plastic with a thickness of 1.1-2.7 m.
-GEE-8. Dust gray dense sands saturated with water, with a thickness of 0.8-1.3 m.

Glacial deposits (g III):

-GEE-9. Light, silty loams bluish-gray with gravel, half-pebble with pebbles with sandstone fragments with a thickness of 9.3-13.4 m.

The average monthly sum of absolute values of negative temperatures was adopted according to SR 131.13330.2012.

The soil lying in the zone of freezing:
- GEE-2 belongs to the strong-kicking and excessively heaving,
- GEE-3 - to medium-volume,
- GEE-4 - to strong-kicking and excessively heaving.

2.3 **Hydrogeological conditions**

At the time of geological surveys, two aquifers and groundwater were identified. Groundwater was detected near the surface of the earth at a depth of 0.1m. (SR 20.13330.2011/2011, n.d.)

The 1st horizon was found at a depth of 2.0-3.7 m. The relative water lining is GEE-6 loam. Water is fed by precipitation. (SR 20.13330.2011/2011, n.d.)

The 2nd horizon was found at a depth of 8.5-10.5 m, the water is pressurized, and the head pressure reaches 4.0 m. The upper aqueduct is sandy eke GEE-7, the lower one GEE-9. (SR 20.13330.2011/2011, n.d.)

The following hazardous geological processes are possible on the development site:
- waterlogging associated with the manifestation of groundwater during heavy rainfall and snowmelt;
- frost swelling of soils, associated with an increase in the volume of soil at transition from thawed to frozen state. (SR 20.13330.2011/2011, n.d.)

The geotechnical conditions of the building site are satisfactory and belong to the II category of complexity.

2.4 **Master plan and transport**

The site allocated for construction is located in the Kolpinsky district of St. Petersburg. From the west, the plot borders with the territory of five-story panel residential houses; from the east a nine-story apartment building; from the north the territory of a city swimming hall and from the south a nine-story brick dotted house. L-shaped in plan, the projected house is located along the border of the site with a courtyard, facing the west side.

The master plan provides for the zoning of the territory with the allocation of a pedestrian zone and the territory that provides for the passage of fire and passenger cars. The entrances to the houses will be decorated with shrubs and small architectural forms will be installed. (SR 42.13330.2011/2011, n.d.)

All parking lots will be landscaped. Public parking is removed from the residential area by a distance corresponding to the normative distance. Playgrounds are located at the maximum distance from the economic site, parking lots and driveways for vehicles. (SR 48.13330.2011/2011, n.d.)

The project provides for fire passages, giving access to the fire trucks to every facade of the building, as well as separate entries in technical premises. Garbage bins are provided next to the designed building having an access for vehicles. They are lined with reinforced concrete barriers. (FL №123/2008, n.d.)

The drainage from the site is solved by microplanning with the discharge of storm drains into projected sewers and further to the existing rain sewage. (SR 48.13330.2011/2011, n.d.)

2.5 **Space planning and constructive solutions of the building**

The project is a 5-storey building, including the upper technical floor with an attic for laying communications, a basement for the placement of engineering equipment and laying of communications. The roof of the building is flat and insulated with an organized internal drain.

From each apartment, except to the 1st floor there is a balcony with a fence in height of 1.2m. On the 1st floor there are auxiliary and technical premises with a separate entrance from the street.

Constructive scheme consists of longitudinal bearing walls and transverse diaphragms (transverse walls, end walls, walls of stairwells). The spatial rigidity of the building is provided by the joint work of the transverse and longitudinal inner walls, outer longitudinal and end walls, combined into a single spatial system with rigid horizontal disks of interfloor overlappings and interconnection between them.

Main building products and structures are the following:
- the foundations piles;
- basement ceiling;
- external wall panels;
- internal wall panels;
- floor slabs;
- stairs;

- elevator shafts;
- communication, electrical and ventilation units;
- sanitary cabins;
- roll roof warmed.

2.6 **External utilities**

External engineering networks located in close proximity to the site allow the building to be connected to them.

2.6.1 Hot and cold water supply

The building is provided with a centralized system of combined drinking and firefighting water supply. The drinking water supply system diagrams are dead-end, with lower wiring under the basement ceiling. The hot water supply system is dead-end with the lower wiring of pipelines.

2.6.2 Sewage system

The drainage of domestic sewage from the building into the external network of sewage is provided for by a pipe with a diameter of 100 mm to the designed domestic sewage collector of household sewage.

2.6.3 Heat and vent systems

In the designed house a two-pipe passing heating system is produced. Each of the section is designed independent of the heating system. Direct water pipelines are routed through the attic and return water pipelines through the basement. Risers and pipe routing are open. The rooms of the bathrooms provide heating from the hot water system.

To ensure the established sanitary standards of air cleanliness purge ventilation with a natural impulse is provided for. To ensure the required amount of outside air, the optimal distribution of it through the rooms and the removal of air in the apartments, a natural ventilation system is used through the added ventilation units. The compensation of exhaust air is carried out through installed inlet valves in the window frames of the living rooms and from the bathroom through the ventilation grille.

2.6.4 Electricity supply

The power supply is carried out from a new block complete transformer substation through two independent mutually-redundant inputs made from two independent sources. Input power cables are carried out in the main switchboard, located in the switchboard.

2.7 **Thermal calculation of bearing and building envelope**

Thermal calculation is made in accordance with the SR 131.13330.2012 and consists in determining the thickness of the heat-insulating enclosure layer in which the inner surface enclosure temperature is above the dew point. It carried out hygiene requirements and power saving conditions.

2.7.1 Thermal calculation of bearing and building envelope

Attic exterior wall panel design:
- heavy concrete B22.5 δ = 0.06 m, λ = 2.04 m °C;
- insulation - mineral wool δ = X, λ = 0.063 m °C;
- heavy concrete B22.5 δ = 0.11 m, λ = 2.04 m °C. (SR 131.13330.2012/2012, n.d.)

Determining the required resistance to heat transfer:

$$R_0^{\text{tc}} = \frac{t_a - t_{out}}{a_{in} \times \Delta t_n} \quad (1)$$

where:

t_a - is the calculated air temperature in the classified facilities (t_a =20 °C);

t_{out} - is the calculated winter outdoor temperature equal to the average temperature of the coldest week with a security of 0.92 (t_{out} = -26 °C);

α_{in} - is the coefficient of thermal perception from internal air to the internal surface of the fence, taken for smooth surfaces equal to 8.7 W/(m2·°C);

Δt_n - is the normalized difference between the air temperatures in the room and the inner surface of the outer fence, adopted according to the design standards of residential buildings for the calculation of exterior walls of 4 °C.

$$R_0^{\text{tc}} = \frac{(20-(-26))}{8.7 \times 4} = 1.322 \ \frac{m^2 \times °C}{W}$$

Calculation of the degree-days of the heating period:

$$DDHP = \left(t_a - t_{av.h.p.}\right) \times z_{h.p.} \quad (2)$$

where:

$t_{av.h.p.}$ - the average outdoor temperature during the heating period ($t_{av.h.p.}$ = -1.8 °C);

$z_{h.p.}$ - the duration of the heating period ($z_{h.p.}$ = 220 days).

$$DDHP = (20 - (-18)) \times 220 = 4796$$

Determining the required reduced heat transfer resistance:

$$R_{0.\text{red.}}^{\text{tc}} = 1.4 + 0.00035 \times DDHP = 1.4 + 0.00035 \times 4796 = \\ = 3.079 \ \frac{m^2 \times °C}{W}$$

Since, the value of the actual reduced resistance to heat transfer of enclosing structures R_0 must not be less than the required values of R_0^{tc} and $R_{0.\text{red.}}^{\text{tc}}$, defined earlier, in the further calculation we use the larger of the specified values of the required resistance to heat transfer.
Determining the thickness of the outer wall insulation:

$$R_0 = \frac{1}{a_{out}} + \frac{\delta_1}{\lambda_1} + \frac{\delta_2}{\lambda_2} + \frac{\delta_3}{\lambda_3} + \frac{1}{a_{in}} \quad (3)$$

where:
$\delta_1, \delta_2, \delta_3 -$ the thickness of the individual layers of the structure of the fence, m;
$\lambda_1, \lambda_2, \lambda_3 -$ coefficients of thermal conductivity of materials, W/(m · °C), taken depending on the humidity conditions of operation of the fence A or B;
$a_{out} -$ is the heat transfer coefficient from the external surface of the fence to the ambient air, taken for the calculation of external walls of 23 W/(m2 · °C).

$$R_0 = \frac{1}{23} + \frac{0.11}{2.04} + \frac{x}{0.063} + \frac{0.06}{2.04} + \frac{1}{8.7} = \frac{x}{0.063} + 0.242 = 3.079 > x= \\ = 0.178 \ m$$

The thickness of the outer wall insulation is 180 mm (0.18 m). Thus, the total thickness of the attic exterior wall panel is: 0.06 + 0.18 + 0.11 = 0.35 m.
Determining the actual (thermal) resistance to heat transfer fencing:

$$R_{\phi} = \frac{1}{23} + \frac{0.11}{2.04} + \frac{0.18}{0.063} + \frac{0.06}{2.04} + \frac{1}{8,7} = 3.098 > R_0^{\text{tc}}$$

2.7.2 Thermal calculation of external wall panel

Attic exterior wall panel design:
- heavy concrete B22.5 δ = 0.06 m, λ = 2.04 m °C;
- insulation - mineral wool δ = X, λ = 0.063 m °C;
- heavy concrete B22.5 δ = 0.16 m, λ = 2.04 m °C. (SR 131.13330.2012/2012, n.d.)

Determining the required resistance to heat transfer:

$$R_0^{\text{tc}} = \frac{(20-(-26))\times 1}{8.7\times 4} = 1.322 \ \frac{m^2 \times °C}{W}$$

Calculate the degree-days of the heating period:

$$DDHP = (20 - (-18)) \times 220 = 4796$$

Determining the required reduced heat transfer resistance:

$$R_{0.\text{red.}}^{\text{tc}} = 1.4 + 0.00035 \times DDHP = 1.4 + 0.00035 \times 4796 = \\ = 3.079 \ \frac{m^2 \times °C}{W}$$

Determining the thickness of the outer wall insulation:

$$R_0 = \frac{1}{23} + \frac{0.16}{2.04} + \frac{x}{0.063} + \frac{0.06}{2.04} + \frac{1}{8.7} = \frac{x}{0.063} + 0.242 = 3.079 => x = \\ = 0.177 \ m$$

The thickness of the outer wall insulation - 180 mm (0.18 m). Thus, the total thickness of the attic exterior wall panel is 0.06+0.18+0.16=0.4m. Determining the actual (thermal) resistance to heat transfer fencing:

$$R_{\phi} = \frac{1}{23} + \frac{0.16}{2.04} + \frac{0.18}{0.063} + \frac{0.06}{2.04} + \frac{1}{8,7} = 3.123 > R_0^{\text{tc}}$$

2.7.3 Thermal calculation of attic floor

Construction of attic floor:
- Isoplast 1st layer δ = 0.003 m, λ = 0.17 m °C;
- Isoplast 2nd layer δ = 0.003 m, λ = 0.17 m °C;
- cement-sand screed δ = 0.04 m; λ = 0.93 m °C;
- clay gravel δ = 0.13 m, λ = 0.26 m °C;
- Isover insulation δ = X, λ = 0,053 m °C;
- reinforced concrete slab B22.5 δ = 0.16 m, λ = 2.04 m °C. (SR 131.13330.2012/2012, n.d.)

Determining the required resistance to heat transfer:

$$R_0^{\text{tc}} = \frac{(20-(-26))}{8.7 \times 3} = 1.586 \ \frac{m^2 \times °C}{W}$$

Calculation of the degree-days of the heating period:

$$DDHP = (20 - (-18)) \times 220 = 4796$$

Determining the required reduced heat transfer resistance:

$$R_{0.\text{red.}}^{\text{tc}} = 1.9 + 0.00045 \times DDHP = 1.9 + 0.00045 \times 4796 = \\ = 4.0582 \ \frac{m^2 \times °C}{W}$$

Determining the thickness of the outer wall insulation:

$$R_0 = \frac{1}{12} + \frac{0.003}{0.17} \times 2 + \frac{0.04}{0.93} + \frac{0.13}{0.26} + \frac{x}{0.053} + \frac{0.16}{2.04} + \frac{1}{8.7} = \frac{x}{0.053} + 0.855 = \\ = 4.0582 => x \ = 0.169\, m$$

The thickness of the attic floor insulation - 180 mm (0.18 m). Thus, the total thickness of the attic exterior wall panel is 0.003+0.003+0.4+0.13+0.17+0.16=0.866 m
Determining the actual (thermal) resistance to heat transfer fencing:

$$R_\phi = \frac{1}{12} + \frac{0.003}{0.17} \times 2 + \frac{0.04}{0.93} + \frac{0.13}{0.26} + \frac{0.17}{0.053} + \frac{0.16}{2.04} + \frac{1}{8.7} = 4.063 > R_0^{\text{tc}}$$

2.7.4 Thermal calculation of basement ceiling

Basement ceiling structure:
- gypsum plasterboard δ = 0.012 m, λ = 0.36 m °C;
- Isover insulation δ = X, λ = 0.013 m °C;
- reinforced concrete slab B22.5 δ = 0.16 m, λ = 2.04 m °C. (SR 131.13330.2012/2012, n.d.)
Determining the required resistance to heat transfer:

$$R_0^{\text{tc}} = \frac{(20-(-26))}{8.7 \times 2} = 2.644\ \frac{m^2 \times °C}{W}$$

Calculation of the degree-days of the heating period:

$$DDHP = (20 - (-18)) \times 220 = 4796$$

Determining the required reduced heat transfer resistance:

$$R_{0.\text{red.}}^{\text{tc}} = 1.9 + 0.00045 \times DDHP = 1.9 + 0.00045 \times 4796 == \\ 4.0582\ \frac{m^2 \times °C}{W}$$

Determining the thickness of the outer wall insulation:

$$R_0 = \frac{1}{17} + \frac{0.012}{0.36} + \frac{x}{0.013} + \frac{0.016}{2.04} + \frac{1}{8.7} = \frac{x}{0.053} + 0.286 = 4.0582 => x \ = \\ = 0.049\, m$$

The thickness of the basement ceiling insulation - 50 mm (0.05 m). Thus, the total thickness of the attic exterior wall panel is 0.012+0.05+0.16=0.222m.
Determining the actual (thermal) resistance to heat transfer fencing:

$$R_\phi = \frac{1}{17} + \frac{0.012}{0.36} + \frac{0.05}{0.013} + \frac{0.016}{2.04} + \frac{1}{8,7} = 4.156 > R_0^{\text{tc}}$$

3 TECHNOLOGIES AND ORGANIZATIONS OF THE CONSTRUCTION

Construction and installation works in the building of residential house are maintained in a specific sequence, set design features and economic feasibility of using construction techniques and mechanisms.

Construction and installation works are provided in two stages, i.e. preparation period and the main period.

During the preparatory period, the following works and activities are carried out:
- fencing of the construction site with protective fencing;
- clearing the territory;
- creation of a geodetic center base;
- device of temporary household rooms;
- arrangement of temporary roads;
- device point washing wheels;
- removal of surface and groundwater;
- allocating a place for storage of construction waste;
- device sites for storage of materials and products;
- providing temporary power supply and water supply from existing networks.

The main period includes the following works:
- earthworks (development of the excavation and subsequent backfilling);
- piling, foundation and basement;
- the construction of the elevated part of the building;
- roofing;
- filling openings
- plumbing and electrical work step I;
- device preparation under the floor;
- finishing work;
- plumbing and electrical work step II;
- facade works;
- green building.

3.1 Choice of a mounting crane

The baseline data for choosing a crane are the space-planning decisions of the future building, the design scheme, the method of installation, the location of nearby buildings and structures, the possibility of placing warehouses with materials and the access of the installation crane to it. (RS 10-382-00/2000, n.d.) The main parameters for the selection of the crane are: hook lifting height, load capacity and jib. (GOST 12.3.033-84 /1985, n.d.)

Other characteristics include width, height, crane length, rear clearance, turning radius, installation area that are individual for each construction object. The final decision on the choice of a mechanism is made on the basis of comparing the required values of the basic parameters with the models available on the market. (GOST 12.3.033-84 /1985, n.d.)

To select a crane with a suitable load capacity, we determine the mounting weight of the heaviest element. The mounting weight of the structure includes the mass of the mounted element and the mass of all necessary accessories.

$$P_m = P_{\mathrm{f}} + P_{\mathrm{s}} \tag{4}$$

$$P_m = 1.1 \times 7.25 + 0.34 = 8{,}315t,$$

where:
-P_{f} — mass floor slab;
-P_{s} — sling mass.
In order to select a crane with a suitable hook lifting height, it is necessary to determine the maximum possible mark of the mounting structure. Mounting height includes:
- the design mark of the mounted structure;
- altitude parameter of the structure;
- the leg of the triangle, obtained from the length of the lifting device and its projection on two axes;
- the length of the tali crane, take 1 m;
- margin of height 0.5 m, intended for lifting and laying out structures.

$$H_{\mathrm{m}} = H_{\mathrm{o}} + H_{\mathrm{a}} + H_{\mathrm{l}} + H_{\mathrm{sl}} + H_{\mathrm{t}} \tag{5}$$

$$H_{\mathrm{m}} = 15.814 + 0.16 + 4 + 1 + 0.5 = 21.5m,$$

The jib of the crane hook is the distance from the axis of rotation of the crane to the middle of the sling of the mounted structure, considered in the installation position. Jib of the hook L_{cr}, m, for each of the mounted elements is determined by the formula:

$$L_{cr} = \left(A + \frac{b}{2}\right) \times \frac{H_{\mathrm{m}} - H_{\mathrm{h}}}{H_{\mathrm{t}} + H_{\mathrm{sl}}} + c, \tag{6}$$

where:
- L_{cr} – jib of hook of the crane, m;
- A - stock, take 0.5 m;
- b - the width of the element from the side of the parking crane, m;
- H_m - mounting height of the element, m;
- H_h - crane hinge height; take 1.0 m;
- H_t - tali crane height, take 1.0 m;
- H_{sl} - the slinging height of the element, m;
- c - distance from the axis of the crane to the hinge; take 1.0 m.

$$L_{cr} = (0.5 + \frac{1.3}{2}) \times (21.474 - 1)/(1 + 4) + 1$$

Based on the obtained values of the parameters the crane TC-585-01 was selected. The technical characteristics of the crane are given in Table 1.

Table 1. Characteristics of the crane TC-585-01

Parametr name	Modifications					
	00	01	02	03	04	05
Load moment, tm	260	290	240	200	180	170
Load capacity, t - maximum - at maximum boom	 10 6	 10 8	 10 4,5	 10 3,2	 10 2,4	 10 2
Maximum departure, m Departure at maximum load Minimum departure	40 26 4	35 29 4	45 24 4	50 20 4	55 18 4	60 17 4
Maximum lifting height, m - free-standing crane wind region I - II wind region III - added	 66 61 160	 66 61 160	 66 61 160	 66 61 160	 66 61 160	 66 61 160
Constructive mass, t - freestanding - added Mass counterweight Total crane weight - freestanding - added	 74,3 120 14,5 88,8 134,5	 73,7 119,4 13,8 87,5 133,8	 75,1 120,8 18,7 93,7 139,5	 75,7 121,4 18,7 94,4 140,1	 77,5 123,2 11,4 88,9 134,6	 78,1 123,8 13,8 91,9 137,6
ISO 4301/1 crane qualification group	A5					

3.2 **Technological sequence and methods of construction and assembly works**

3.2.1 Earthwork

Excavation work must begin at the lowest point on the construction site and at the same time work on the drainage system is performed.
Drainage should be made from open wells, which should be installed at a distance of 1.5 m from the edge of foundations. The water level in the wells should be maintained at 30-40 cm below the level of the bottom of the pit. (TCH 50-302-2004/2004, n.d.) Work on dewatering should be conducted very carefully, eliminating the intensive dewatering. When detecting communications that are not in the project, you should stop working and determine the actual location of the networks and approve further actions. If there are some existing cables, earthworks should be carried out under direct supervision and guidance. (SR 45.13330.2012/2012, n.d.)

Vertical planning of the construction site and the installation of the base under the road is recommended to be carried out with a bulldozer. The device for backfilling of the outer sinuses of the pit and moving the earth masses to a distance of up to 30m should be done by a bulldozer.

Excessive soil is placed in dumps for further use on backfilling of sleeves and landscaping. (SR 45.13330.2012/2012, n.d.)

3.2.2 Piles work

The foundation of reinforced concrete piles should be made using the PDM-V-6 pile driving machine. Piles are immersed by indentation. (Figure 1)

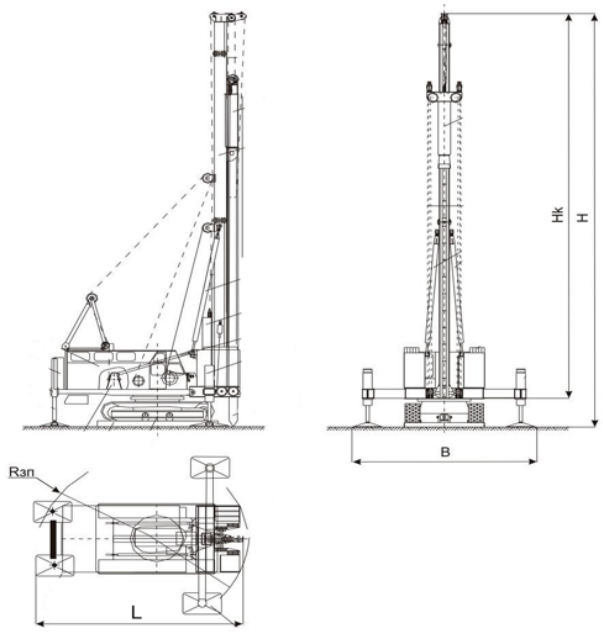


Figure 1. PDM-V-6 pile driving machine (Стройпроект n.d.)

The following work must be completed before the start of the pile driving:
- extracting of the pit and the layout of its bottom;
- installation of drains and water outflow from the working platform (the bottom of the pit);
- laying of access roads and electricity supply;
- making a geodetic breakdown of the axes and marking the position of the piles and pile rows in accordance with the project;
- making a complete set and warehousing of piles.

Stages of pile driving:
- installation of the machine to the place of immersion of the pile;
- slinging piles;
- raising the pile in the seizure of the machine;
- installation of the pile at the point of immersion and the process of centering the pile;
- the indentation of the pile.

Inserting piles allows us to achieve high performance in normal conditions. At the same time, there is no noise and dynamic effects that

are transmitted to the surrounding buildings. The external environment is not contaminated by combustion products, works are performed in a shorter time.

As a result of the use of the indentation method, the accuracy is increased and the energy consumption of piling is reduced. It becomes possible to measure the submerged pile, the working conditions are improved and the possibilities of erecting structures under constrained conditions are expanded.

3.2.3 Installation of sanitary cabins

Sanitary cabins should be installed before the next standing constructions will be mounted in order not to complicate the connection of communications. (SR 70.13330.2012 /2012, n.d.) Prior to installation on floor slabs, risks must be analyzed, ensuring that employees are familiar with the technology of work and a safety note. (BR 12-03-2001/2001, n.d.) Slinging of the sanitary cabins should be made using a special traverse (Figure 2)

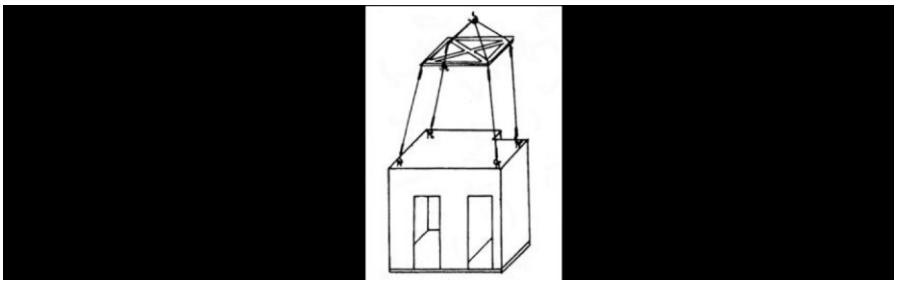


Figure 2. Slinging of the sanitary cabins (TFC 6307030131/41131 1991)

Basic technological operations as follows:
- installation of beacons;
- checking of the base on the horizontal;
- reception by installers of sanitary cabins;
- reconciliation of sanitary cabins on the risks of overlap;
- adjustment of the position of the assembly scrap (if necessary);
- final adjustment;
- connection of pipelines;
- sealing the places of the passage of communications solution;
- connection of sanitary engineering cabins to ventilation units.

3.2.4 Installation of landings and staircase

Staircases at the installation site are delivered in an inclined position using the traverse and mounted on special supports on the wall panels. (Figure3)

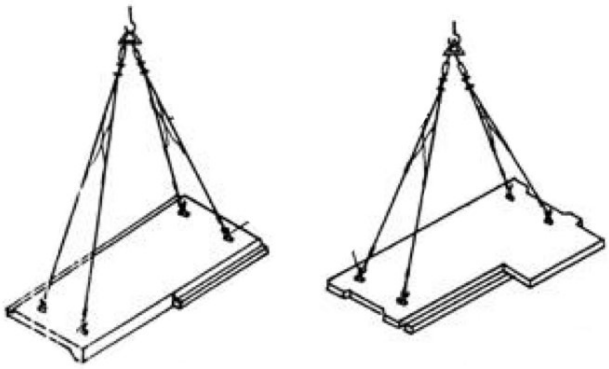


Figure 3. Stair landing slinging (TFC 6307030131/41131 1991)

Fixing of these platforms is arranged by welding of mortgage details of a platform and the panel among themselves. Floor platforms are placed horizontally on a layer of solution approximately equal to 20mm on the beacons. Using the level and a special template the accuracy of installation is checked. The installation is completed by welding the embedded march and floor slab and filling the joints with a solution. (SR 70.13330.2012 /2012, n.d.)

Next, to the building site staircases are served. They are transported in a position close to the design, or with a slight slope. First, mount the lower end of the march, then the upper. The last technological operation is manual welding, before which it is necessary to clean the welded surfaces and remove water in any aggregate States with a gas burner. Immediately after the end of the installation, fences of platforms and marches are installed. (SR 70.13330.2012 /2012, n.d.)

3.2.5 Installation of elevator shafts

Prior to installation of elevator shaft, you should complete all preparatory activities. You can proceed to the installation of elevator shafts when:
- the installation of the underlying floor slabs is completed;
- risk are identified;
- on the block of the shaft itself, elevators have geometrical axes;
- prepared all inventory and mechanisms.

The slinging of the elevator shaft block is produced by a universal traverse. (Figure 4)

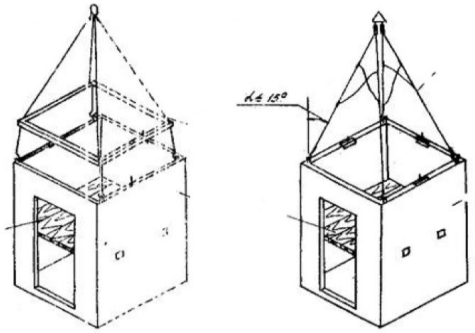


Figure 4. Elevator shaft slinging (TFC 6307030131/41131 1991)

Before installation, make sure that the doorways are fenced and that no parallel work is carried out in the shaft.

The support surface of the mounted unit and the pin outlets below the mounted unit are cleaned. The lower block outlets should also be lubricated. There are holes on the bearing surface of each block with a diameter equal to the diameter of the pin outlet. Each block is lowered to the lower one. (SR 70.13330.2012 /2012, n.d.) This method of installation allows you not to perform post-installation reconciliation of the position of the mounted element.

After the end of installation of each block, it is covered from above with a temporary board before the beginning of installation of the following block. Establish temporary protections of doorways and cut off installation loops on all blocks, except the top.

After the end of installation of all blocks of mine elevators, make installation of a plate of overlapping of mine of the elevator. The mounting loops of the elevator shaft block must coincide with the holes in the slab. The final connection is made by welding the embedded parts of the shaft block and the plate. (SR 70.13330.2012 /2012, n.d.)

3.2.6 Installation of floor slabs

The slinging of the floor slabs is carried out using a universal six-stringed sling, delivered to the installation site in the design position. (Figure 5)

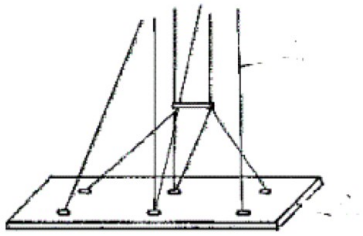


Figure 5. Floor slab slinging (TFC 6307030131/41131 1991)

Installation of plates should be made only on the wall panels fixed permanently, or temporarily, but necessarily capable to sustain installation loadings. The overlapping plate is laid on a layer of a solution no more than 20 mm, after reception by its installers and reconciliation. The first plates are mounted, located closest to the staircase block. Next, make post-installation reconciliation in the plan and horizontally. Small deviations are corrected by mounting crowbars. Next, the plates are welded together, in the joints of the plates and the outer wall panel, the thermal insulation material is installed dry, without gaps. The joints between the slabs are filled with cement mortar. (SR 52-103-2003/2003, n.d.)

At the end of installation, a protective fence is installed.

3.3 **Flow chart for the installation of exterior wall panels**

3.3.1 Application area

A flow chart (FC) is designed and developed for the installation of exterior wall panels in relation to the construction project in the city of Saint-Petersburg, Saint-Petersburg Region.

L-shaped in the plan, the projected house is located along the border of the site with a courtyard facing the west side. The projected residential building consists of one ordinary and one corner section.

The project adopted the following construction of wall panels:
- external longitudinal and end walls - load-bearing three-layer reinforced concrete panels of heavy concrete class B22.5, frost resistance F75 400 mm thick with an insulation of mineral slabs, attic panels thickness - 350mm.

Before the installation of exterior wall panels the following should be performed:
- organizational and preparatory activities in accordance with organization of construction rules;
- all installation processes on the lower tiers are completed;
- the next installation horizon;
- center axes are carried out;
- landmark risks are analyzed;
-all employees are familiar with the production technology of the upcoming work and safety;
- all the necessary tools and mechanisms are in the work area.

Installation of the crane is based on the required minimum distance between the most protruding part of the building to the crane equal to 0.7m. (SR 48.13330.2011/2011, n.d.)
The structure of works considered in this FC includes:
- installation of exterior wall panels;
- installation of sealing gaskets in vertical joints of panels;
- smearing with mastic under air insulation;
- sticker air strip;
- thermal insulation of vertical joints;
- electric arc welding of joints;
- monolithic joints.

The delivery of wall panels to the construction site is carried out by panel transporters in a vertical position or with a slight slope. The truck must be equipped with all the necessary equipment for the delivery of panels without mechanical damage. All fasteners and insulating liners are transported in separate containers. (GOST 12.3.033-84 /1985, n.d.) The delivery of the concrete mix to the construction site takes place in the concrete mixers from the nearest concrete plant, «Mostootryad-26».

Work on each tier should begin with the preparation of the workplace, which includes:
- fencing around the perimeter of the ceiling (position 1, Figure 6);
- fencing ladder node (position 2, Figure 6);
- a partial device of permanent enclosure of the staircase (position 3, Figure 6);
- closing by the inventory shield of the elevator shaft opening (position 4, Figure 6);
- closing of the holes in the floor slabs by the inventory shield (position 5, Figure 6);
- delivery of containers and boxes with tools, materials, mortar to the mounting horizon (positions 7, 8 9 10, 11, Figure 6);

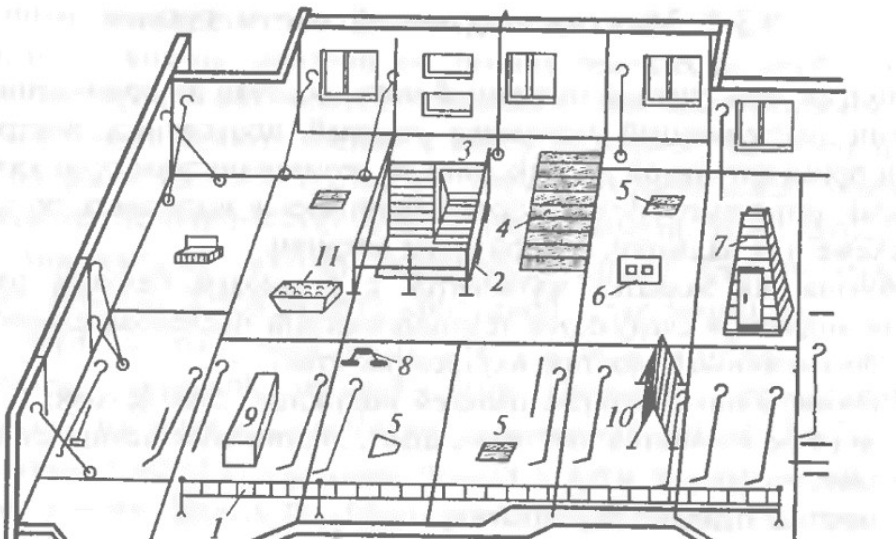


Figure 6. The organization of the workplace (Технология строительных процессов n.d.)

Installation of panels starts from the remote end of the building. Before submission of the panel, the supporting surface is aligned with beacons, which are level with the mounting horizon, and a layer of cement mortar is laid on which the panel will be installed. The panel is supplied to the installation site to a height exceeding the design mark by 0.5 m. Installers take the panel, control the accuracy of the installation panel, while the sling remains taut. The first installer controls the accuracy of the position of the risk, fixing the position of the vertical seam and the edge of the wall, the second - on the required mounting gap between the panels. Next, the installers adjust the position of the panel on the risks. After installation it is not allowed to adjust the position of the panel. In case of inaccurate installation, the panel is lifted with a crane, its bearing surface is cleared and a new layer of mortar is placed on it.

Temporary fastening of mounted panels is made by two struts (Figure 7). Each installer gets the hook of the lower part of the brace into the technological hole in the floor panel; the hook of the upper part of the brace leads to the mounting loop of the panel, after which both parts of the brace are connected, the hook of the upper part is inserted into the mounting loop, and tension nuts are installed on both sides. (SR 70.13330.2012 /2012, n.d.)

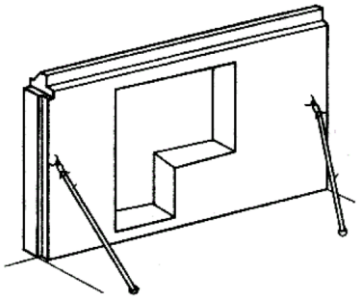


Figure 7. Temporary wall panel mounting (Технология строительных процессов n.d.)

The installer signs the driver, the driver reduces the tension of the sling, the installer proceeds to align the verticality of the panel with a plumb-line. The inaccuracy of mounting vertically is eliminated by rotating the tension nuts of the struts. After alignment vertically, the first installer removes the sling hooks from the mounting hinges of the panel, the second installer seals and cuts a layer of mortar between the plate and the panel.

The main technological operations during panel installation are shown in Figure 8.

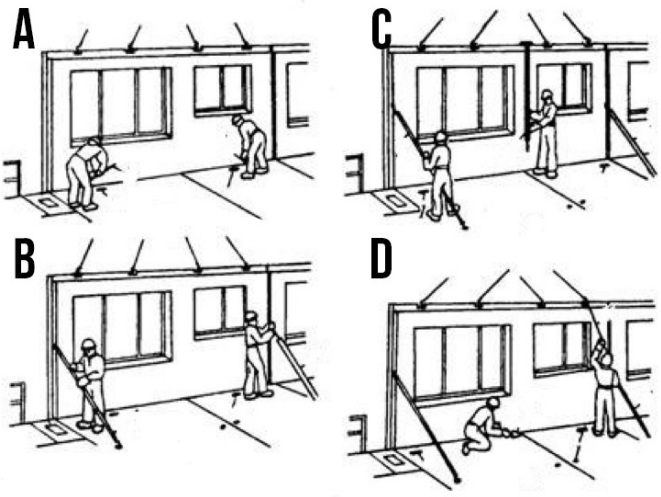


Figure 8. Technological operations during panel installation (Ремстройинфо n.d.)

- adjustment of the panels when installing it in the design position (Figure 8, a);
- temporary fastening of panels with struts (Figure 8, b);
- checking the vertical position of the panel (Figure 8, c);
- detaching the slinging, sealing and cutting the seam (Figure 8, d).

3.3.2 Calculation of labor costs

On the basis of unit standards, rates, types and volumes of works, labor costs were identified and presented in Table 2.

Table 2. Labor cost

№	Unit rates and rates	Types of works	Unit	Volume of work	Time standard		Staff	Type, brand of mechanism	Labor intensity	
					workers, man-h	machines, mach.-h			workers, man-days	machines, machine-shift
1	2	3	4	5	6	7	8	9	10	11
1	U4-1-8	Installation of exterior wall panels	element	492	1,10	0,28	Machinist 6w.; Installer 5w.-1 .; "4w.-1 .;" 3w.-1; "2 w.-1	crane	67,7	16,97
2	U4-1-27	Installation of gaskets in vertical joints	10 m	132,84	0,56	-	Installer 4w.-1;" 3w.-1	-	9,3	-

3	U7-4	Spreading of the joint surface under air insulation with adhesive mastic	100 m2	2,7552	0,65	-	Installer 4w.-1	-	0,2	-
4	U4-1-27	Sticker - air protective tape	10 m	132,84	0,78	-	Installer 4w.-1;" 3w.-1	-	13,0	-
5	U4-1-27	Thermal insulation of vertical joints	10 m	132,84	0,31	-	Installer 4w.-1;" 3w.-1	-	5,1	-
6	U2-1-6	Arc welding joints	10 m	14,76	3,30	-	Electric welder 6w.-1;" 5w.-1;" 4w.-1;" 3w.-1	-	6,1	-
7	U4-1-26	Embedment of joints of exterior wall panels	100 m	13,284	12,00	-	Installer 4w.-1;" 3w.-1	-	19,9	-

3.4 **Flow chart for the installation of roof**

3.4.1 Application area

A flow chart (FC) is designed and developed for the installation of a two-layer roll-up deposited roof made of isoplast material in relation to the construction project in the city of Saint-Petersburg, Saint-Petersburg Region.

L-shaped in the plan, the projected house is located along the border of the site with a courtyard facing the west side. The projected residential building consists of one ordinary and one corner section.

Roof structure consists of:
- reinforced concrete flat solid slab 160 mm thick made of heavy concrete class B22.5, frost resistance F50;
- leveling layer cement mortar M100;
- primer with bitumen solution BN 90/100 - 1 layer;
- ISOVER OL-P insulation 140 mm;
- ISOVER OL-TOP 30 mm insulation;
- 1 layer - Isoplast "K";
- 2 layer - Isoplast "P". (SR 17.13330.2011/2011, n.d.)

The building has a warm attic and an internal drain.

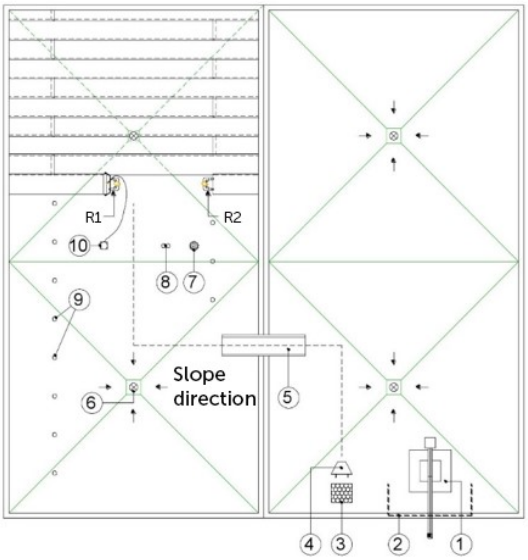
3.4.2 Organization and technology of work

In developing the flow chart, the requirements of the relevant regulatory documents, are applied:
- SR 17.13330.2011 the roofs;
- SR 20.13330.2011 loads and actions;
- SR 31-101-97 design and construction of roofs.

Prior to the installation of the roof, organizational and preparatory measures should be carried out in accordance with SR 48.13330.2011 «Construction Management».
Roof installation can be divided into the following stages:
- preparatory work;
- main works;
- device adjunctions.

Before starting work related to the installation of the roof, be sure to check the acts of work acceptance and acts of hidden work. Next is quality control of the base, comprising:
- checking the strength and thickness of the base;
- checking the compliance of the actual roof slopes and bringing to the design in case of need;
- checking the level;
- checking the moisture base.

A schematic diagram of the organization of the working space is shown in Figure 9.



1- roof crane; 2- roof fencing; 3- pallet with roll roofing materials; 4- hand trolley; 5- ladder; 6- water intake funnel; 7- bucket with water; 8- fire extinguishers; 9- roll roofing materials; 10- gas bottle; R1, R2- roofers

Figure 9. Diagram of the organization of the working space

After completing the preparatory work proceed to the stage of basic work. Vapor barrier is arranged under the insulation to protect it from

moisture by water vapor, penetrating from the premises. The project provides for painting the vapor barrier with a bitumen mortar in a single layer over the entire surface. The vapor barrier should be installed on vertical surfaces to the height of the roof. Thermal insulation in the project is carried out by mineral wool plates in two layers 170 and 30 mm thick, respectively. Laying plates should start from the corner in the direction of itself. The base of the plate are attached with a bitumen. It is necessary to monitor the tight fit of the insulation plates to each other. Wide gaps should be sealed with insulating material. (SR 31-101-97/1998, n.d.)

Cement-sand mortar M150 sets the slope of the roof, exposing the rails at the desired angle. In the screeds, temperature shrinkable seams up to 5 mm wide should be arranged, dividing the surface of the screed from the cement-sand mortar into areas no larger than 6x6 m. The laying of the bottom layer of the rolls should begin with the marking of the roof, which will not displace the roll from a given direction. Roll out roll should start with the lower parts of the roof. In the case of our roof with water intake funnels. The side overlap of the rolls should be in the range of 80-100mm, butt end - 150mm. (SR 31-101-97/1998, n.d.) It is necessary to position the direction of the material so that the side overlap is located above the water intake funnel. (Figure 10)

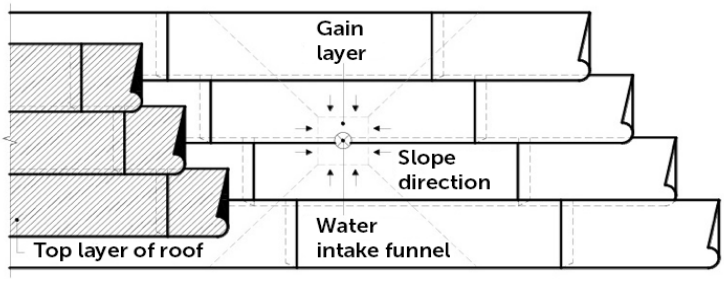


Figure 10. Side overlap over water intake funnel

Techniques for sticking a roll-up roll material are performed in the following sequence:
- roll the roll on the prepared base, try on it with respect to the neighboring ones, providing the necessary overlap of panels;
- roll to the middle;
- heat the bottom adhesive layer of the roll with simultaneous heating of the base or surface of the previously pasted layer. The roll is gradually rolled out, making sure that a bitumen-polymer binder is flowing out of the seam. When the roofing material is fusing, the roofer rolls a roll “on himself”. The roll must be rolled onto a heated bottom layer of material. Heating is produced by smooth movements of the burner so as to ensure uniform heating of the material and the surface of the base. On the inside of the deposited material there is a characteristic pattern, a sign that the

worker with the help of a torch has correctly melted the material, is a violation of the structure of this figure (Figure 11).

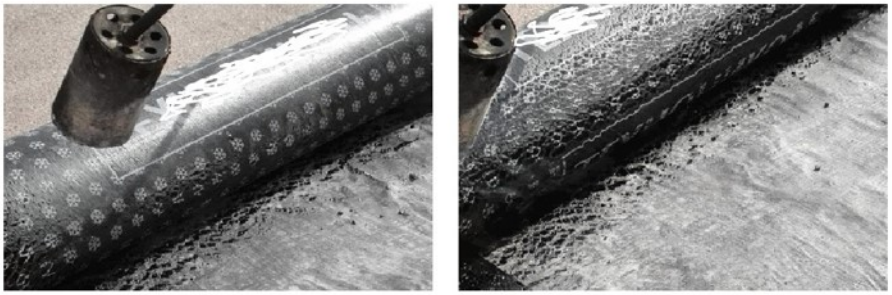


Figure 11. Violation of the pattern structure

The roof in places of junction with vertical surfaces should wind up on the vertical part above the transition side. The first additional layer should go on a vertical surface of not less than 250mm. The second layer of material with dressing should overlap on the vertical surface first at least 50mm. (SR 17.13330.2011/2011, n.d.) Connections to vertical surfaces when working with gas are performed in the following sequence:
- after laying the 1st layer, a piece of material with a length equal to the design height of the roll on the vertical surface is cut from the roll, plus 150 mm for the roll on the horizontal surface;
- roll the material into a roll to the transition side;
- evenly heat the roll and produce its roll-up from the bottom up, pressing it to a vertical surface;
- then the lower end is glued to a horizontal surface;
- after laying the top layer, the top layer of the abutment is similarly applied with overlap onto a horizontal surface of 200mm (overlapping the first additional layer of the roofing carpet on the abutment by 50mm).

The final stage is the installation of a protective gravel carpet. A layer of mastic no more than 2 mm thick is applied to the finished roll coating. Gravel crumbles onto the hot mastic, and then it is leveled. (SR 17.13330.2011/2011, n.d.)

3.4.3 Calculation of labor costs

On the basis of unit standards, rates, types and volumes of works, labor costs were identified and presented in Table 3.

Table 3. Labor cost

Nº	Unit rates and rates	Types of works	Unit	Volume of work	Time standard		Staff	Type, brand of mechanism	Labor intensity	
					workers, man-h	machines, mach.-h			workers, man-days	machines, machine-

										shift
1	2	3	4	5	6	7	8	9	10	11
1	U7-4	Base cleaning	100 m2	7,77	0,41	-	Roofer 3w.-1; " 2 w.-1	-	0,40	-
2	U7-13	Vapor barrier installation	100 m2	7,77	3,9	-	Roofer 3w.-1; " 2 w.-1	-	3,79	-
3	U7-15	Screed device (2 times)	100 m2	7,77	4,4	-	Roofer 3w.-1	-	4,27	-
4	U7-14	Thermal insulation installation	100 m2	7,77	8,7	-	Roofer 3w.-1; " 2 w.-1	-	8,45	-
5	U7-1	Sticker of two layers of deposited isoplast and device of junction points	100 m2	7,77	1,8	-	Roofer 5w-1;" 3w-2	-	1,75	-
6	U7-4	The device of the protective layer of gravel	100 m2	7,77	2,3	-	Roofer 4w.-1; 3w.-1; 2w.-1	-	2,23	-
7	U4-1-26	Embedment of joints of exterior wall panels	100 m	13,284	12,00	-	Installer 4w.-1;" 3w.-1	-	0,31	-

3.5 **Scheduling**

3.5.1 Work Formation

From the totality of simple processes, technological complexes of work can be formed. The formation is carried out on the principle of simultaneous execution of several simple technological processes. (SR 48.13330.2011/2011, n.d.) After the formation of technological complexes of work, Table 4 is compiled, where the complexes of works are indicated in a strict technological sequence. The number of types of work compared to simple processes decreases, since the technological complex of work can include several simple processes.

Table 4. Consolidated statement of types of work

Duration of work at the facility								
№	Code of work complex	Type of work	Labor intensity		Team members, pers.	Number of people in the team	Number of shifts	Duration
			man-days	machine-shift				

1	A	Earthworks (diging up)	7,0	11,9	Driver 6w-1; digger 2w-1	2	2	4,7
2	B	Piling works, foundation and basement	206,1	45,0	Driver 6w-1; installer - 2; welder -1; carpenter -1	5	2	25,1
3	C	Earthworks (backfilling)	-	65,6	Driver 6w-1	3	3	7,29
4	D	The construction of the elevated part of the building	607,5	73,5	Driver 6w-1; installer 5w-1;"3w-2; insulation fitter 4w-1; electric welder - concreter 4w-1	6	2	57
5	E	Roofing device	20,9	-	Roofer 5w-1;" 4w-1;" 3w-1; insulator 3w-1;" 2w-1	5	1	4,2
6	F	Filling openings	20,0	10,0	Driver 5w-1; carpenter 4w-1;" 2w-1	3	2	5
7	G	Plumbing work I stage	192,1	-	Plumber 4w-1;" 3w-1;" 2w-1	3	3	21
8	H	Electric installation work I stage	153,7	-	An electrician 4w-1;" 3w-1;" 2w-1	3	3	17
9	I	Floor preparation device	167,6	-	Concrete worker 3w-2;" 2w-1	3	3	19
11	J	Finishing work	1093,0	131,9	Plasterer 4w-1" 3w.-1; painter-plaster 4w-1; finisher 4w-1;" 3w-1	5	3	82
12	K	Plumbing work II stage	102,4	-	Plumber 4w-1;" 3w-1;" 2w-1	3	3	11
13	L	Electric installation work II stage	89,6	-	An electrician 4w-1;" 3w-1;" 2w-1	3	3	10
14	M	FacadeS work	38,6	-	painter 5w-1;" 2w-1	2	3	6
15	N	Green building	9,1	-	installer 4w-1;" 2w-1	2	1	5

3.6 **Construction master plan**

Construction master plan is a construction plan which contain the layout of the main facilities for a given construction stage, such as:
- location of the object under construction;

- location of existing objects;
- location and length of temporary fencing of the construction site;
- the location of the crane, dangerous and working zones of the crane;
- location and nomenclature of temporary buildings and structures;
- position of permanent and temporary engineering networks;
- the position of permanent and temporary roads, their characteristics;
- the location and size of on-site warehouses;
- the position of the lighting devices on the construction site;
- the direction of movement of workers;
- conventional signs and their designations. (SR 59.13330.2012/2012, n.d.)

The drawing is accompanied by an explication of buildings and structures, notation symbols and calculations contained in the explanatory memorandum. The construction master plan is one of the most important documents on the organization of construction. The initial data for the construction of the master plan are:
- working drawings of objects and calendar terms of construction;
- technological maps of various works;
- data on the calculation of the need for temporary premises, energy, water;
- materials that contain data on the geometric conditions of construction, the connection of the object and the existing engineering networks, roads.

The construction of materials, structures and semi-finished products, including concrete and mortar, is provided from the enterprises of St. Petersburg and the production bases of contractors. Delivery of construction materials, ready-mixed concrete and mortar to the construction site is carried out by special transport on public roads.

3.6.1 Calculation of the need for temporary buildings and structures

The choice of the nomenclature and the need for the areas of inventory buildings is calculated based on the number of the workers most involved. The total number of workers is calculated by the formula:

$$N_{tot} = N_{main} + N_{minor} + N_{engeneer} + N_{JSP},$$

where,
N_{tot} - the total number of workers on the construction site in the most busy shift or day,
N_{main} - the maximum number of workers of the main production according to the schedule of the need for labor resources in a shift or day, people. (SR 44.13330.2011/2011, n.d.)

The number of non-core workers, engineering staff and junior service staff is approximately equal to 30.6 and 3% of the maximum number of workers, respectively.

$$N_{tot} = 28\,pers.$$

According to the received number of employees involved in the construction process, the minimum required area of inventory buildings of each type is calculated (table 5).

Table 5. Calculation of the area of inventory buildings

Name of temporary buildings	Number of staff	Rate per person		Estimated area
		Unit of measurement	Value indicator	
1	2	3	4	5
Foreman headquarters	2	m2	4	8
Wardrobe	23	m2	0,6	13,8
Shower	26	per./c	8	4
WC	26	per./t	15	2
Room for heating	23	m2/per	0,1	8
Clothes drying room	24	m2/per	0,2	12
Meal room	24	m2/per	0,25	12
First-aid post	-	-	-	12

Then the catalogs select the type of building. Characteristics of the selected type of buildings are recorded in Table 6.

Table 6. Explication of temporary buildings and structures

Name of inventory buildings	Calculated area, m2	Dimensions in the plan, m	Number of buildings	Accepted area, m2	Constructive characteristic	Used project
1	2	3	4	5	6	7
Foreman headquarters	8	3x6	1	18	Container	UTS-420-13-1
Wardrobe	13,8	3,1x10,6	1	32,86	Container	Trest Leningradorg Stroy
Shower	4	3,1x8,5	1	26,35	Mobile	PD-4
WC	2	2,7x6	1	16,2	Container	UTS-420-04-23
Heating room and dryer	20	2,7x9	1	24,3	Container	UTS-420-01-13
Meal room	12	7,5x2,7	1	20,25	Mobile	VPP
First-aid post	12	3,1x7,4	1	22,94	Container	Trest Leningradorg Stroy

Temporary buildings on the construction site should be located compactly and out of range of installation mechanisms. (SR 44.13330.2011/2011, n.d.)

3.6.2 Organization of temporary water supply to the construction site

The need for water at the construction site may be required for production, household needs and fire suppression. The result of the calculation of temporary water supply is to find the required diameter of the input temporary water supply, obtained by the formula:

$$D = 2\sqrt{\frac{Q_{tot} \times 1000}{\pi \upsilon}},$$

where,
P_p – total water consumption, l/s, determined by consumer groups;
v – water velocity through the pipes (for the calculations carried out, 0.7–1.2 m/s is assumed).
The total estimated consumption of water:

$$Q_{tot} = Q_{pr} + Q_{household} + Q_{firepr}$$

To determine the water consumption for production needs, we use the formula:

$$Q_{pr} = \frac{V_{q1} k_1}{3600t},$$

where,
V – the amount of work per shift or per day for each of the construction processes that consume water, or the number of operating installations;
q_1 – specific water consumption per unit of measurement of the volume of work, l;
k_1 – a coefficient of hourly uniformity of water consumption (assumed to be 1.5);
t – the number of hours of work on the implementation of the scope of work (per shift or per day).
To determine the flow of water for household needs, we use the formula:

$$Q_{household} = \frac{N q_2 k_2}{3600 t_2} + \frac{N_1 q_3}{60 t_3},$$

where,
N – the maximum number of workers working in a shift;
q_2 – the rate of specific water consumption per worker per shift, if there is sewage, is assumed to be 20–25 liters;

t_2 – shift duration, h;
N_1 – the number of workers taking a shower N_1 ≈ 0.5N;
q_3 – the specific water consumption per person taking a shower is assumed to be 30–40 l;
t – the duration of the shower installation in minutes.

The calculation results are summarized in Table 7.

Table 7. Calculation of the need for a temporary water supply

Types of water consumption	Unit	Amount	Specific consumption of water, l	Uneven consumption coefficient	The duration of water consumption per day, h	Water consumption, l/s
Production needs						
Watering concrete and formwork	m3/day	34,78	300	1,5	16	0,27
Household needs						
Household needs	person	18	25	2	24	0,01
Shower	person	9	40	-	2,25	2,67
					Total	2,68
Fireproof						
Construction site	ha	<50	-	-	-	20
						21,47

According to the results of the calculation, we determine the required input diameter d = 117mm. The determination of the volume of water required for the needs of fire extinguishing is determined by the norms depending on the area of the construction site. Food hydrants produced from the permanent water supply, respectively, the calculation does not require. (SR 48.13330.2011/2011, n.d.)

3.6.3 The device of temporary roads

The traffic on the construction site is a through movement, with an entrance from the street Red partisans. When leaving the construction site is arranged point washing wheels. Internal temporary roads are designed from reinforced concrete slabs with a width of 4m. The radius of curvature is 18m, based on the dimensions of the panel transporter trucks. The distance between the roadway and the warehouses should be at least 1.5m, between the roadway and the temporary fence - at least 1m. (SR 48.13330.2011/2011, n.d.)

3.6.4 Organization of workplaces

Employees' workplaces must meet sanitary and hygiene requirements and regulatory requirements. Concentrations of harmful substances in the air of the working area, as well as noise and vibration levels at workplaces should not exceed the established sanitary norms and hygienic standards. Microclimate parameters must comply with sanitary rules and standards for hygienic requirements for the microclimate of industrial premises. (SR 12-135-2003/2003, n.d.) Machines and mechanisms should be operated in such a way that they do not violate the maximum permissible noise level. To reduce the impact of noise should be applied:
- technical means reducing noise coming from the source;
- the use of technological operations, implying a reduced noise level;
- remote control;
- personal protective equipment. (SR 51.13330.2011/2011, n.d.)

The construction site with a noise level of 80 dBA and above should be accompanied by warning signs. Work on these sites without the use of PPE of the auditory organs is not allowed. In areas with a noise level of 135 dBA and above, the presence of workers is prohibited. To reduce the impact of vibration on workers. The following should be provided:
- reduction of vibration to sources by constructive methods;
- the device of vibration isolation and vibration absorption;
- personal protective equipment. (SR 51.13330.2011/2011, n.d.)

Zones intended for the preparation of toxic substances (adhesives, mastics, paints) must be ventilated, and mechanical ventilation must be provided in enclosed spaces. Workplace lighting must comply with the established requirements of the sanitary rules. In the process of construction and installation work, it is necessary to monitor not only the adherence to process technology but also the compliance with sanitary and hygienic standards. (FL RF/2002, n.d.)

4 COSTS OF CONSTRUCTION

4.1 **Determination of the estimated cost of construction**

4.1.1 Local estimate calculation for general construction work

Within the framework of the project being carried out, a local estimate for general construction work was carried out (Table 8). All calculations are carried out in the base prices of 2000 with the subsequent transfer using the appropriate coefficients to the level of June 2019.

The local budget for civil works is compiled from collections of territorial unit prices (TUP-2001) for St. Petersburg and the St. Petersburg Region. To determine the cost of work that is missing in the TUP collections, rates from federal collections are used.

The source document for determining the estimated cost of construction work is the statement of physical quantities. The calculation of physical volumes of work by type and structural elements was made according to the project drawings and specifications for them.

The consumption of materials is determined by the standard indicators given in the table of unit rates. Prices for materials are accepted at the current level or in the base (as of January 1, 2000) according to the compilation of average estimated prices (AEP).

The estimated cost of general construction works is defined as the sum of direct costs, overhead costs and estimated profits.

Direct costs are recalculated to the current price level using regional indices of cost items: labor costs, machine operating costs (including the driver's salary), materials costs. Indexes are in the magazine "Pricing and budget normalization" (PBN).

4.2 **Estimate calculation of construction costs of the project**

The estimated cost of construction of the facility as a whole is determined by an estimate of the project, which is compiled for individual types of work and costs. It includes the cost of construction and installation work, equipment, inventory, furniture, and other expenses.

The estimate calculation is formed by combining the data from the corresponding local estimate calculations. Local estimates for all types of work, except for general construction, are calculated at aggregated rates. For the calculation of applied "Territorial enlarged prices for structures and types of housing and civil construction."
The estimated calculation of the project of the cost of construction is summarized in table 12. Local estimates for plumbing and sanitation, heating and ventilation, and the installation of electroslag devices are summarized in tables 9-11, respectively.

Estimated cost: 236665.93 thousand rubles
Means of remuneration: 36054.067 thousand rubles
Regulatory complexity: 18525.5 people / day

Table 8. The local estimate for general construction work LE1

№	Material codes	Name of works and costs, units	Amount	Estimated cost, rub.		Total estimated cost			Labor costs of workers / drivers, person-hour / mach-hour	
				Total	machines explication	total (direct costs)	Salary of workers	machines explication (total)		
				workers salary	drivers' salary			drivers' salary	per unit	total
1	2	3	4	5	6	7	8	9	10	11
Section 1 Earthworks										
1,0	01-01-013-14	Development of soil with loading on dump trucks with excavators with a bucket capacity: 0.5 (0.5-0.63) m3, soil group 2	1,1	5011,1	4861,0	5462,1	156,6	5298,5	15,1	16,4
				143,7	689,2			751,2	43,6	47,5
2,0	01-02-057-02	Manual soil excavation in trenches up to 2 m deep without mounts with slopes, soil group: 2 (100 m3 of soil)	0,6	1201,2	0,0	690,1	690,1	0,0	154,0	88,5
				1201,2	0,0			0,0		0,0
3,0	08-01-002-01	Base device for foundations: crushed stone (1 m3 base)	123,0	35,0	11,5	4302,5	2822,9	1413,3	2,3	282,9
				23,0	2,6			313,7	0,3	35,7
4,0	408-9040-001П	Crushed stone, fraction 40-70mm, m3	147,6	129,6		19126,0	0,0	0,0		0,0
								0,0		0,0
5,0	01-01-033-01	Backfilling of trenches and pits with soil displacement up to 5 m with bulldozers with a capacity of	0,4	705,5	705,5	269,2	0,0	269,2		0,0
					120,8			46,1	4,2	1,6

		59 kW (80 hp), soil group 1								
6,0	01-02-061-01	Manual backfilling of trenches, pits and holes, group of soils: 1	0,4	1028,0	269,2	435,9	321,7	114,1	82,8	35,1
				758,8	92,1			39,1		0,0
7,0	408-0127	Career sand (including delivery by supplier)	466,4	99,0		46173,6	0,0	0,0		0,0
								0,0		0,0
8,0	01-02-005-01	Soil compaction with pneumatic rammers, soil group: 1-2,100m3	4,2	307,3	176,6	1303,0	554,1	748,9	12,5	53,1
				130,7	36,8			156,2	3,4	14,4
Total on section 1 Earthworks						77762,4	4545,4	7844,0		476,1
								1306,2		99,2
Section 2 Piling works										
9,0	05-01-003-05	Dipping of reinforced concrete piles with a diesel hammer on a crawler pile: up to 12 m in soil group 1	502,2	320,8	276,0	161125,8	15784,1	138617,2	2,7	1355,9
				31,4	23,3			11716,3	1,3	657,9
10,0	403-1045	Solid reinforced concrete piles, square cross-section with non-stressed reinforcement, m3	310,0	2101,5		651474,3	0,0	0,0		0,0
								0,0		0,0
11,0	05-01-010-01	Cutting concrete from reinforced concrete cage: piles with a cross-	310,0	52,8	35,6	16352,5	5053,0	11039,1	1,4	434,0
				16,3	7,8			2405,6	0,6	198,4

		sectional area of up to 0.1 m2 (1 pile)								
Total on section 2 pile works						828952,6	20837,1	149656,3		1789,9
								14121,9		856,3
Section 3 Device of grillage										
12,0	08-01-002-02	Base device for foundations: crushed stone, m3	30,3	36,0	11,5	1089,0	724,9	347,8	2,4	72,6
				24,0	2,6			77,2	0,5	16,3
13,0	408-0010	Crushed stone from a natural stone for construction works brand 1000, fraction of 10-20 mm, m3	39,4	192,0		7555,2	0,0	0,0		0,0
								0,0		0,0
14,0	06-01-001-01	Concrete preparation device, m3	30,3	5921,4	1818,1	179223,6	51920,0	55028,1	180,0	5448,1
				1715,4	285,9			8653,3	18,0	544,8
15,0	401-0003	Concrete heavy, class v7,5 (m100), m3	30,9	498,0		15383,2	0,0	0,0		0,0
								0,0		0,0
16,0	06-01-001-22	The device of strip foundations: reinforced concrete with a width on top of up to 1000 mm, 100 m3	1,4	14594,6	4220,9	19877,8	6579,3	5748,9	446,0	607,5
				4830,6	475,3			647,3	28,8	39,2
17,0	204-0002	Hot-rolled reinforcing steel, smooth, class a-I, t	4,1	7120,0		28907,2	0,0	0,0		0,0
								0,0		0,0
18,0	204-0022	A-III, diameter, t	5,5	7770,0		43045,8	0,0	0,0		0,0
								0,0		0,0
19,0	401-0207-009П	Concrete hydrotechnical class	137,1	762,2		104493,5	0,0	0,0		0,0
								0,0		0,0

		B20 (m250), W6, F100, m3								
20,0	07-05-001-01	Installation of basement wall blocks (100 pieces of prefabricated structures)	371,0	4507,1	2989,4	1672135,3	309140,7	##########	77,0	28567,0
				833,3	495,4			183776,1	26,3	9764,7
21,0	401-0006	Heavy concrete, class B15 (m200), m3	1,5	440,0		668,8	0,0	0,0		0,0
								0,0		0,0
22,0	403-0074-004П	Foundation concrete blocks, m3	61,1	733,2		44759,5	0,0	0,0		0,0
								0,0		0,0
Total on section 3 device of grillage						2117139,1	368364,9	##########		34695,2
								193153,9		10365,1
Section 4 Installation of basement walls										
23,0	07-05-022-04	Installation of wall panels in basement buildings	1,0	37105,2	8478,7	37476,3	4701,1	8563,4	404,7	408,8
				4654,5	1350,6			1364,1	82,1	82,9
24,0	403-1160	Socle panels, m3	207,7	2049,5		425619,6	0,0	0,0		0,0
								0,0		0,0
25,0	403-6000	Balcony walls, m3	5,4	1488,9		7965,7	0,0	0,0		0,0
								0,0		0,0
26,0	26-01-041-05	Insulation of foam products with dry cold surfaces of coatings and floors (1 m3 of insulation)	16,0	132,0	23,1	2111,8	1742,6	369,3	9,5	151,5
				108,9	3,6			57,0		0,0
27,0	104-0111	Extruded polystyrene plates, m3	16,3	583,1		9515,7	0,0	0,0		0,0
								0,0		0,0
28,0	08-01-003-07	Lateral waterproofing with bitumen in 2 layers, 100m2	11,4	151,7	59,2	1729,3	2813,9	675,3	21,2	241,7
				246,8	2,3			26,2		0,0

Total on section 4 Installation of basement walls						484418,4	9257,5	9608,0		802,1
								1447,3		82,9
Section 5 Installation of basement floor slabs										
29,0	07-05-011-02	Installation of floor slabs, 100 pcs.	0,5	11077,8	5201,4	5760,4	2022,2	2704,7	346,3	180,1
				3888,8	817,6			425,2	50,2	26,1
30,0	403-1100	Floor slabs, m3	151,5	2648,2		401300,7	0,0	0,0		0,0
								0,0		0,0
Total on section 5 installation of basement floor slabs						407061,1	2022,2	2704,7		180,1
								425,2		26,1
Section 6 Installation of structures 1-5 floor										
32,0	07-05-022-04	Installation in frameless-panel buildings (with a cut to the floor) wall panels of exterior, 100 pcs.	4,9	37105,2	8478,7	182557,6	22900,2	41715,0	404,7	1991,3
				4654,5	1350,6			6645,1	82,1	404,0
33,0	403-1160	Exterior wall panels, m3	1837,3	2049,5		3765550,6	0,0	0,0		0,0
								0,0		0,0
34,0	07-05-035-06	Installation of ventilation units, 100 pcs.	2,2	8687,5	5866,0	19373,1	5589,3	13081,2	228,5	509,5
				2506,4	932,5			2079,5	59,0	131,6
35,0	403-8125	Vent blocks, m3	328,6	504,1		165653,8	0,0	0,0		0,0
								0,0		0,0
36,0	07-05-023-03	Installation of interior wall panels, 100pcs.	5,5	15237,0	6831,5	84108,0	21256,1	37709,7	330,8	1826,1
				3850,7	1087,2			6001,5	66,6	367,8
37,0	403-1160	Interior wall panels, m3	1272,5	2049,5		2607860,8	0,0	0,0		0,0
								0,0		0,0
38,0	07-05-030-07	Installation of partition walls, 100 pieces.	1,8	6129,9	3916,2	10788,6	2866,2	6892,4	141,6	249,2
				1628,5	604,6			1064,0	38,1	67,1
39,0	403-6000	Balcony walls, m3	115,0	1488,9		171210,9	0,0	0,0		0,0
								0,0		0,0
40,0	07-05-	Installation of large-	3,5	9333,9	3848,0	32668,7	8529,9	13468,1	207,1	724,7

	024-02	panel reinforced concrete partitions (100 prefabricated structures)		2437,1	594,3			2080,0	36,8	128,9
41,0	403-0400	Partition Panels (m3)	237,0	176,3		41766,0	0,0	0,0		0,0
								0,0		0,0
42,0	07-05-035-01	Installation of sanitary cabins (100 pcs.)	109,0	1488,1	7763,3	1622802,9	369989,6	846194,3	298,5	32540,9
				3394,4	1237,7			134910,4	76,8	8369,0
43,0	403-0341	Sanitary cabins (m3)	149,1	1460,0		217703,5	0,0	0,0		0,0
								0,0		0,0
44,0	07-05-014-02	Installation of landings, t (100 pieces of prefabricated structures)	0,3	1052 1,8	6892,9	3367,0	1026,1	2205,7	282,0	90,2
				3206,7	1078,1			345,0	67,8	21,7
45,0	403-0325	Landindgs (м3)	67,1	2162,3		145066,0	0,0	0,0		0,0
								0,0		0,0
46,0	07-05-014-05	Installation of staircase: with welding (100 pcs. prefabricated structures)	0,7	1110 6,7	5809,2	7219,3	1787,9	3776,0	241,9	157,2
				2750,6	948,5			616,5	56,1	36,5
47,0	403-0289	Stair flight (m3)	25,3	3135,0		79441,7	0,0	0,0		0,0
								0,0		0,0
48,0	07-05-011-02	Installation of floor slabs (100 pieces of prefabricated structures)	5,2	1107 7,8	5201,4	57161,3	20066,4	26839,2	346,3	1786,9
				3888,8	817,6			4218,8	50,2	258,8
49,0	403-0693	Reinforced concrete floor slabs (m3)	1503,3	3307,0		4971590,5	0,0	0,0		0,0
								0,0		0,0
Total on section 6 installation of structures 1-5 floor						1418589 0,3	454011,7	991881,6		39876,1
								157960,9		9785,5

Section 7 Sealing of the joints										
59,0	07-05-039-01	Device for sealing horizontal and vertical joints of wall panels with glue pads (100 m seam)	37,0	1655,9	85,6	61242,5	2598,5	3165,1	6,3	234,1
				70,3	1,1			41,2		0,0
60,0	07-05-039-06	Device for sealing horizontal and vertical joints of wall panels with mastic (100 m of seam)	37,0	1669,4	436,8	61742,2	7713,8	16153,1	18,8	694,9
				208,6	45,6			1687,6	3,7	135,7
Total on section 7 sealing of the joints						122984,7	10312,2	19318,2		929,0
								1728,8		135,7
Section 8 Roof										
61,0	12-01-015-04	The device vapor barrier: coating in one layer (100m2 of the insulated surface)	7,8	466,0	28,8	3620,7	873,8	224,0	10,5	81,7
				112,5	1,3			10,4	0,1	0,5
62,0	12-01-013-03	Thermal insulation of slabs: from mineral wool (100 m2 insulated coating)	7,8	964,8	119,7	7496,8	4118,8	930,0	45,5	353,8
				530,1	11,9			92,5	0,6	4,3
63,0	104-0111	Roofing insulation mineral wool “ISOVER” (12292.25 / 1.18) (m3)	24,0	583,1		14005,3	0,0	0,0		0,0
								0,0		0,0
64,0	12-01-	Thermal insulation	7,8	525,7	115,3	4084,5	3189,0	895,5	35,4	274,7

	013-04	of slabs (100 m2 insulated coating)		410,4	11,9			92,5	0,6	4,3
65,0	104-0111	Roofing insulation mineral wool m3	112,1	583,1		65368,0	0,0	0,0		0,0
								0,0		0,0
66,0	12-01-014-02	Thermal insulation of coatings: expanded clay (1 m3 of insulation)	84,3	55,6	26,7	4688,5	2441,6	2246,9	3,0	256,2
				29,0	4,7			397,8	0,3	28,7
67,0	406-0018	Expanded clay gravel, fraction 10-20 mm, grade 600 (m3)	86,8	232,0		20142,2	0,0	0,0		0,0
								0,0		0,0
68,0	12-01-017-01	The device leveling screed: cement-sand 15 mm thick (100 m2 screed)	7,8	1327,0	163,2	10310,7	2233,4	1268,3	27,2	211,5
				287,4	26,9			209,2	1,9	15,1
69,0	12-01-007-10	Complex of works on the built-up rolled materials for buildings from 12 to 24 meters wide: in two layers (100 sq.m of a roof)	7,8	1823,7	134,2	14170,3	6407,3	1042,6	74,3	577,2
				824,6	19,7			152,8	1,1	8,7
70,0	101-1961	Isoplast 4.5 (m2)	901,9	48,6		43814,3	0,0	0,0		0,0
								0,0		0,0
71,0	101-1962	Isoplast 4.0 (m2)	886,3	42,0		37224,6	0,0	0,0		0,0
								0,0		0,0
72,0	12-01-002-11	Protection of flat roofs by gravel on bitumen mastic (100 m2 of roofing)	7,8	547,8	177,2	4256,7	839,9	1377,2	9,4	73,0
				108,1	19,3			149,7	1,1	8,7

Total on section 8 roof						229182,8	20103,9	7984,4		1828,2
								1104,9		70,2
Section 9 Floor										
73,0	11-01-011-01	The device of cement screed (100 m2 screed)	58,3	1179,3	37,3	68738,5	22362,4	2176,0	39,5	2303,0
				383,6	16,5			964,1	1,3	74,0
74,0	11-01-014-01	The device of concrete floors, 100m2	69,7	4811,3	296,3	335541,5	24871,4	20666,1	30,3	2113,1
				356,6				0,0	11,0	768,5
Total on section 9 floor						404279,9	47233,8	22842,0		4416,2
								964,1		842,6
Section 10 Filling openings										
75,0	10-01-034-01	Installation in residential and public buildings of window blocks made of pvc profiles, 100m2	7,6	16692,9	322,6	127200,2	13922,0	2458,5	170,8	1301,1
				1827,0	64,0			487,5	1,8	13,4
76,0	203-8013	Single-sash window blocks (m2)	168,9	1408,6		237915,9	0,0	0,0		0,0
								0,0		0,0
77,0	203-8027	Double-sash window blocks (m2)	488,1	1322,6		645572,9	0,0	0,0		0,0
								0,0		0,0
78,0	10-01-035-02	Installation of PVC window stools: in panel walls (100 linear m)	6,7	3407,2	14,4	22896,3	1490,1	96,4	21,3	142,9
				221,7	2,8			19,1	0,1	0,3
79,0	101-2904	Window stool PVC, width 200mm (m)	672,3	72,3		48614,0	0,0	0,0		0,0
								0,0		0,0
80,0	10-01-041-01	Installation of pvc blocks in external and internal	1,4	5735,1	1360,9	8029,2	2427,1	1905,3	160,1	224,1
				1733,7	207,8			291,0	11,6	16,3

		doorways: balcony in stone walls (100 m2 of openings)								
81,0	203-0178	Single-floor balcony door units with flat glass and double-glazed windows (m2)	140,9	676,2		95276,6	0,0	0,0		0,0
								0,0		0,0
82,0	10-01-039-01	Installation of blocks in external and internal doorways (100 m2 of openings)	13,1	5420,1	1330,1	70786,4	15294,0	17371,0	104,3	1361,9
				1171,1	202,2			2641,0	11,4	148,2
83,0	203-0205	Double door units (m2)	1307,1	223,0		291483,3	0,0	0,0		0,0
								0,0		0,0
Total on section 10 filling openings						1547774,8	33133,2	21831,2		3030,0
								3438,5		178,3
Section 11 Interior Finishing Work										
84,0	15-02-016-04	Plastering of the ceilings cement-lime or cement mortar 100 m2	55,8	2073,8	145,0	115766,9	55850,9	8092,1	87,0	4856,6
				1000,5	81,9			4574,1		0,0
85,0	15-04-005-03	Improved water-based paintwork: on plaster ceilings of 100 m2	57,2	585,9	10,8	33504,8	26914,2	618,2	42,9	2453,5
				470,6	2,0			113,8	0,0	1,1
86,0	101-2143	Water-dispersion polyvinyl acetate paints, t	3,6	16,3		58,6	0,0	0,0		0,0
								0,0		0,0
87,0	15-02-016-03	Plaster of the walls of cement-lime or cement mortar, 100m2	158,3	2044,4	145,0	323573,5	156237,8	22942,8	85,8	13585,9
				987,2	81,9			12968,6	6,3	995,5

90,0	101-0256	Glazed ceramic tiles for interior wall cladding multi-color, m2	0,3	76,5		21,5	0,0	0,0		0,0
								0,0		0,0
91,0	402-0070	A mixture of dry glue reinforced for tiles based on cement, t	0,1	2687,5		283,0	0,0	0,0		0,0
								0,0		0,0
92,0	402-0071	Dry grouting mix white cement-based, t	0,0	9675,0		135,5	0,0	0,0		0,0
								0,0		0,0
93,0	15-06-001-02	Pasting of walls wall-paper, 100m2	122,2	684,3	1,0	83604,6	63668,9	116,1	47,0	5735,9
				521,2	0,3			30,5	0,0	1,2
94,0	101-1830	Wallpaper on glued paper base, 100m2	140,4	492,4		69125,9	0,0	0,0		0,0
								0,0		0,0
Total on section 11 interior finishing work						626074,2	302671,8	31769,2		26631,8
								17687,1		997,9
Section 12 Facade work										
96,0	15-02-016-1	Plastering of cement-lime or cement mortar of surfaces walls, 100 m2	8,8	1682,9	139,2	14725,6	7323,2	1217,6	75,4	659,8
				836,9	79,0			691,5	6,1	53,1
97,0	15-04-012-2	Facade painting with surface preparation: silicone, 100 m2	8,8	809,1	8,6	7079,9	1397,6	74,9	14,4	125,9
				159,7	1,4			12,1		0,0
	113-0405	Silicone enamel, t	26,3	45,7		1199,6	0,0	0,0		0,0
								0,0		0,0
Total on section 12 facade work						23005,2	8720,9	1292,5		785,7
								703,6		53,1
Total on estimate						21054525,5	12812147,7	##########		115440,4

					394042,5		23492,8
	CSRS 05/18	Allocation to current prices					
		Salary of workers	18,8		24075306,1		
		Machine operation	8,5		########		
		including the payment of drivers	18,8		########		
		Materials	6,7	14152852,4			
		Total direct costs at current prices		18629831,4			
	MDC 81-33.2004	Overhead costs 95% of PF		29905771,1			
		Salary in overheads 19% of OC			4574308,2		
		Labor overhead costs					9270,8
		Estimated cost		216204085,9			
		Estimated profit of 65% of PF		20461843,4			
		Total on estimate		236665929,2			
		Estimated wages			36054067,2		
		Labor costs on the estimate					148204,0

Estimated cost: 1539.36 thousand rubles.
Means of labor remuneration: 206.04 thousand rubles.
Regulatory complexity: 111.88 man-days

Table 9. The local estimate for the heating and ventilation LE2

№	Material codes	Name of works and costs, units	Amount	Estimated cost, rub.		Total estimated cost			Labor costs of workers / drivers, person-hour / mach-hour	
				Total	machines explication	total (direct costs)	Salary of workers	machines explication (total)		
				workers salary	drivers' salary			drivers' salary	per unit	total
1	2	3	4	5	6	7	8	9	10	11

1	IPtc-32-01-001-01	Heating and ventilation, 100m3	100,5	1471,4	10,1	147870,7	9062,1	1014,0	8,2	826,1
				90,2	1,8			180,9		0,0
Total on section						147870,7	9062,1	1014,0		826,1
								180,9		0,0
	CSRS 05/18	Allocation to current prices								
		Salary of workers		18,8			170285,6			
		Machine operation		8,5				8611,3		
		including the payment of drivers		18,8				3399,3		
		Materials		6,7		993986,7				
		Total direct costs at current prices				1172883,6				
	MDC 81-33.2004	Overhead costs 128% of PF				222316,7				
		Salary in overheads 19% of OC					32354,3			
		Labor overhead costs								68,9
		Estimated cost				1395200,3				
		Estimated profit of 83% of the PF				144158,5				
		Total on estimate				1539358,8				
		Estimated wages					206039,2			
		Labor costs on the estimate								895,0

Estimated cost: 10,041,951 thousand rubles
Means of remuneration: 993.11 thousand rubles
Regulatory complexity: 516.88 man-days

Table 10. The local estimate for the water and sewer LE3

№	Material codes	Name of works and costs, units	Amount	Estimated cost, rub.		Total estimated cost			Labor costs of workers / drivers, person-hour / mach-hour	
				Total	Total	total (direct costs)	Salary of workers	machines explication (total)		
				workers salary	drivers' salary			drivers' salary	per unit	total
1	2	3	4	5	6	7	8	9	10	11
1	IPtc - 33-01-	Water supply	109,0	7343,3	61,2	800414,3	43735,2	6671,9	34,9	3803,0

	002-01	and sewage with centralized hot water supply in houses equipped with sanitary cabins (without the cost of sanitary cabins)		401,2	7,4			805,5		0,0
2	403-0343	Sanitary cabins, m3	109,0	2753,0		300072,6	0,0	0,0		0,0
								0,0		0,0
Total on section						1100486,9	43735,2	6671,9		3803,0
								805,5		0,0
	CSRS 05/18	Allocation to current prices								
		Salary of workers		18,8			821827,4			
		Machine operation		8,5				56657,7		
		including the payment of drivers		18,8				15136,3		
		Materials		6,7		7397472,9				
		Total direct costs at current prices				8275958,0				
	MDC 81-33.2004	Overhead costs 128% of PF				1071313,6				
		Salary in overheads 19% of OC					156147,2			
		Labor overhead costs								332,1
		Estimated cost				9347271,5				
		Estimated profit of 83% of the PF				694679,9				
		Total on estimate				10041951,4				
		Estimated wages					993110,9			
		Labor costs on the estimate								4135,1

Estimated cost: 46982.05 rubles
Means of remuneration: 4384.31 thousand rubles
Regulatory complexity: 2001,62 people

Table 11. The local estimate for the works on low power networks of LE 4

№	Material codes	Name of works and costs, units	Amount	Estimated cost, rub.		Total estimated cost			Labor costs of workers / drivers, person-hour / mach-hour	
				Total	Total	total (direct costs)	Salary of workers	machines explication (total)		
				workers salary	drivers' salary			drivers' salary	per unit	total
1	2	3	4	5	6	7	8	9	10	11
1	IPtc - 37-01-001-01	Electric low-voltage devices 1-room apartment (1 apartment)	45,0	15820,1	638,8	711905,9	71449,7	28745,1	134,9	6070,5
				1587,8	210,8			9486,0		0,0
2	IPtc - 37-01-001-02	Electric low-voltage devices 2-room apartment (1 apartment)	36,0	16630,0	691,5	598679,6	60706,4	24893,6	143,3	5157,7
				1686,3	235,6			8482,3		0,0
3	IPtc - 37-01-001-03	Electric low-voltage devices 3-room apartment (1 apartment)	24,0	175110,7	770,7	4202655,6	43290,0	18495,8	153,3	3678,0
				1803,8	273,8			6570,5		0,0
Total on estimate						5513241,1	175446,1	72134,6		14906,2
								24538,8		0,0
	CSRS 05/18	Allocation to current prices								
		Salary of workers		18,8			3296807,5			
		Machine operation		8,5				612566,9		
		including the payment of drivers		18,8				461108,6		
		Materials		6,7		37060006,6				

		Total direct costs at current prices	40969380,9				
	MDC 81-33.2004	Overhead costs 95% of PF	3570020,3				
		Salary in overheads 19% of OC		626393,4			
		Labor overhead costs					1106,7
		Estimated cost	44539401,2				
		Estimated profit of 65% of the PF	2442645,4				
		Total on estimate	46982046,6				
		Estimated wages		4384309,5			
		Labor costs on the estimate					16012,9

Estimated cost: 46982.05 rubles
Means of remuneration: 4384.31 thousand rubles
Regulatory complexity: 2001,62 people

Table 12. Project estimate calculation

№	Estimate number and calculations	Name of work and costs	The estimate, thousand rubles					Estimated wages, thousand rubles	Standard labor intensity, thousand people-hour.	The cost of 1 m3 building rub.
			Construction work	Assembly work	Equipment, furniture, inventory	Other costs	Total			
1	LE1	Civil works	236665,929				236665,93	36054,07	148,20	7850,45
2	LE2	Heating and ventilation	877,435	123,149	538,776		1539,36	206,04	0,90	
3	LE3	Plumbing and sewage	9138,176	150,629	753,146		10041,95	993,11	4,14	
4	LE4	Low-voltage electric device		13624,794	33357,253		46982,05	4384,31	16,01	
5		Total	246 681,54	13 898,57	34 649,18		295229,29	41637,53	169,25	9793,06
6	ГСН81-05-01-2001	Temporary buildings and	2 713,50	251,56			3247,52	753,64	1,86	

		facilities (1.1%)								
7		Total	249 395,04	14 150,14			29847 6,81	42391, 17	171,1 1	
8	ГСН81-05-02-2001	Winter appreciation (1.2%)	2 992,74	169,80			3581,7 2	508,69	2,05	
9		Total	252 387,78	14 319,94			30205 8,53	42899, 86	173,1 6	
10	МДС81.35 .2001	Contingency reserve (1.5%)	3 785,82	214,80			4530,8 8			
11		Total	256 173,59	14 534,74			30658 9,41			
12		VAT 18%	46 111,25	2 616,25			55186, 09			
13		Total	302 284,84	17 150,99			36177 5,50		21645 ,26	12000 ,46

4.3 **Technical and economic indicators of the project**

Overall, in Table 13 presented all main indicators of the project. Table 13 provides data on the size of the building, the cost of the project, the construction time of the project.

Table 13. Technical and economic indicators

№	The name of indicators	per unit	Amount	Note
	1. Space planning indicators			
1.1.	Total area	м2	7 711	project passport
1.2.	Effective area	м2	7 037	project passport
1.3.	Living space	м2	3 214	project passport
1.4.	Construction volume	м3	30 147	project passport
1.5.	$K1=\frac{\text{living space}}{\text{effective area}}$		0,46	project passport
1.6.	$K2=\frac{\text{construction volume}}{\text{total area}}$		3,91	project passport
	2. The estimate indicators			
2.1.	Estimated cost of the object	thousand roubles	361 775,50	Estimate of the project
2.2.	Estimated cost of general construction works	thousand roubles	236 665,93	Local cost estimate № 1
2.3.	Estimated cost of 1 m3 building	rub.	12 000,46	Estimate of the project
2.4.	Estimated cost of 1 m2 of living area of the building	rub.	112 573,24	p. 2.1./p. 1.2.

2.5.	Estimated cost of 1 m2 of the total area of the building	rub.	46 915,59	p. 2.1./p. 1.1.
	3. Labor cost indicators			
3.1.	Total labor costs	man-days	21 645	Estimate of the project
3.2.	Labor costs per 1 m2 of total area	man-days	2,81	p. 3.1/p. 1.1
3.3.	Labor costs for general construction work	man-days	18 525,50	Local cost estimate № 1
3.4.	Production of 1 worker per day	rub.	12 775,1	p. 2.2/p. 3.3
	4. Project manufacturability indicators			
4.1.	Standard duration of the construction site	month		BR 1.04.03-85*
4.2.	Planned duration of the construction site	month		Calendar progress chart

5 CONCLUSION

The correct implementation of a construction project requires very careful preparation, vast experience, excellent knowledge and impeccable understanding of reinforced concrete structures. People participating in such events must be qualified and professional in order to succeed. However, this implementation can only be possible if it is performed together as a well-coordinated team.

Preparatory work and construction phases of the project were studied in this thesis, the basic skills and huge amount of experience in project planning and cost estimation were gained. The ways on how to organize the construction site with the all necessary calculation facilities were acknowledged and gathered in the contents of the produced description. The principles and working methods of Evromonolit Ltd were investigated.

The main result of this thesis was to understand how to do the correct work scheduling and calculate the budget for such projects through the example of firm Evromonolit Ltd. It may serve as an example for getting better acquainted with scheduling and cost estimation. In addition, it can be useful for students to identify the sphere where they want to work after university.

Based on this, it can be concluded that planning methods and then further work performance of Evromonolit Ltd are resultative and reliable.

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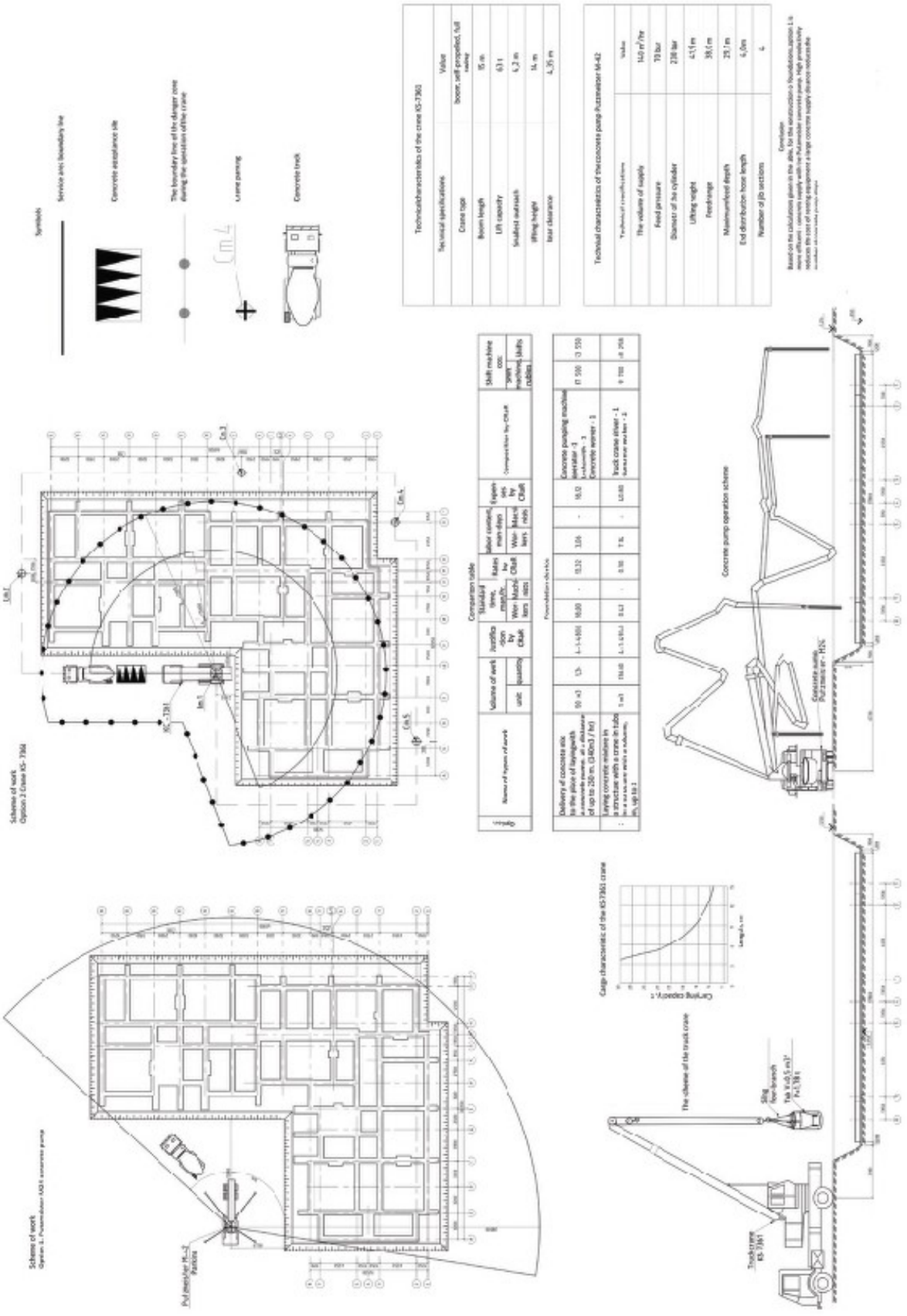
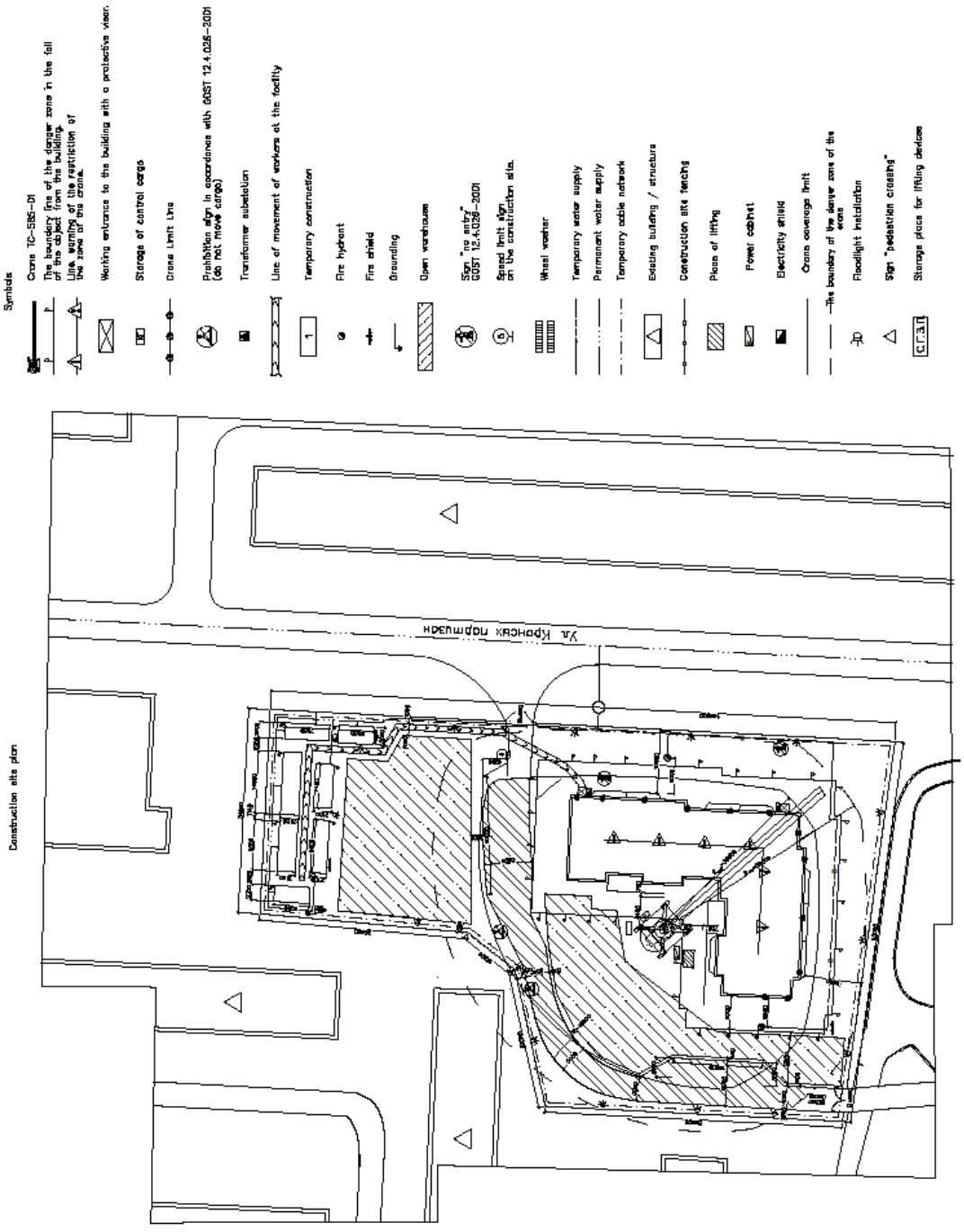
Appendix 1

Comparison of concrete works



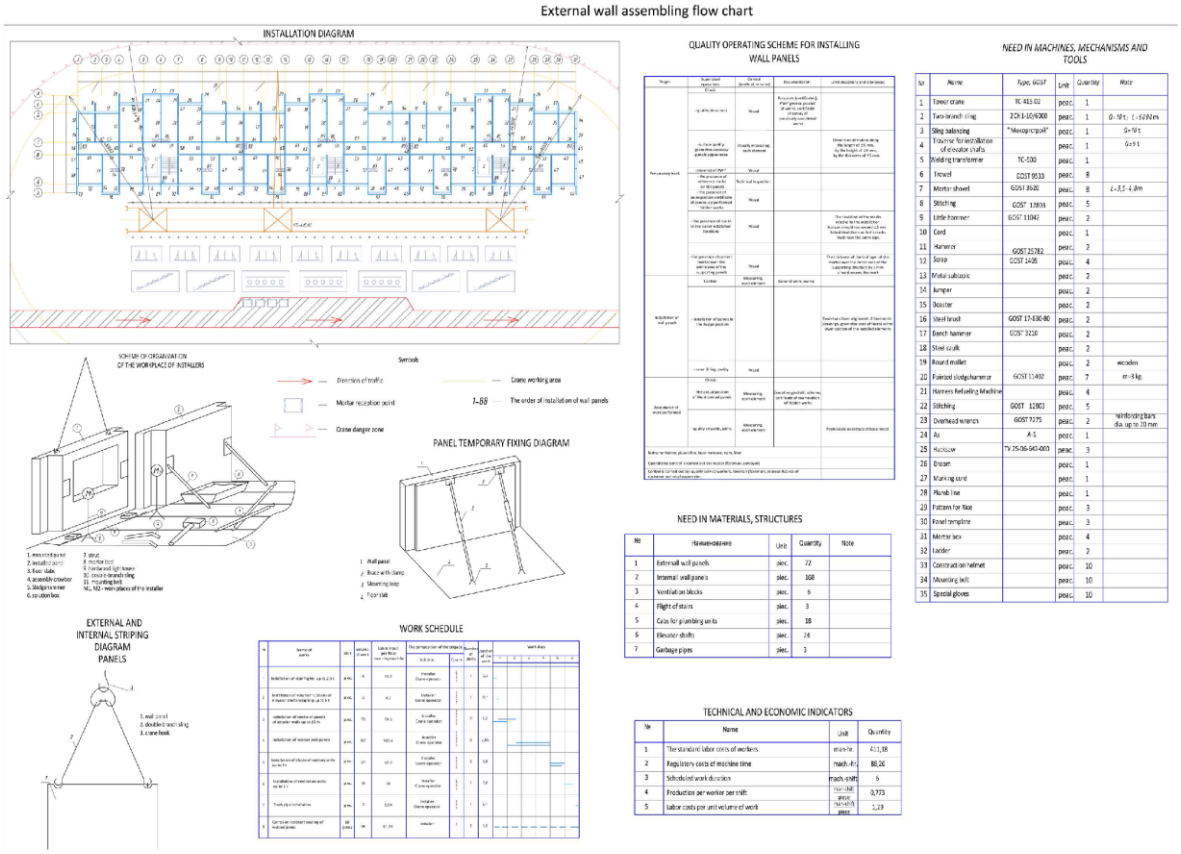
Appendix 2

Construction site plan



Appendix 3

External wall assembling flow chart



Appendix 4

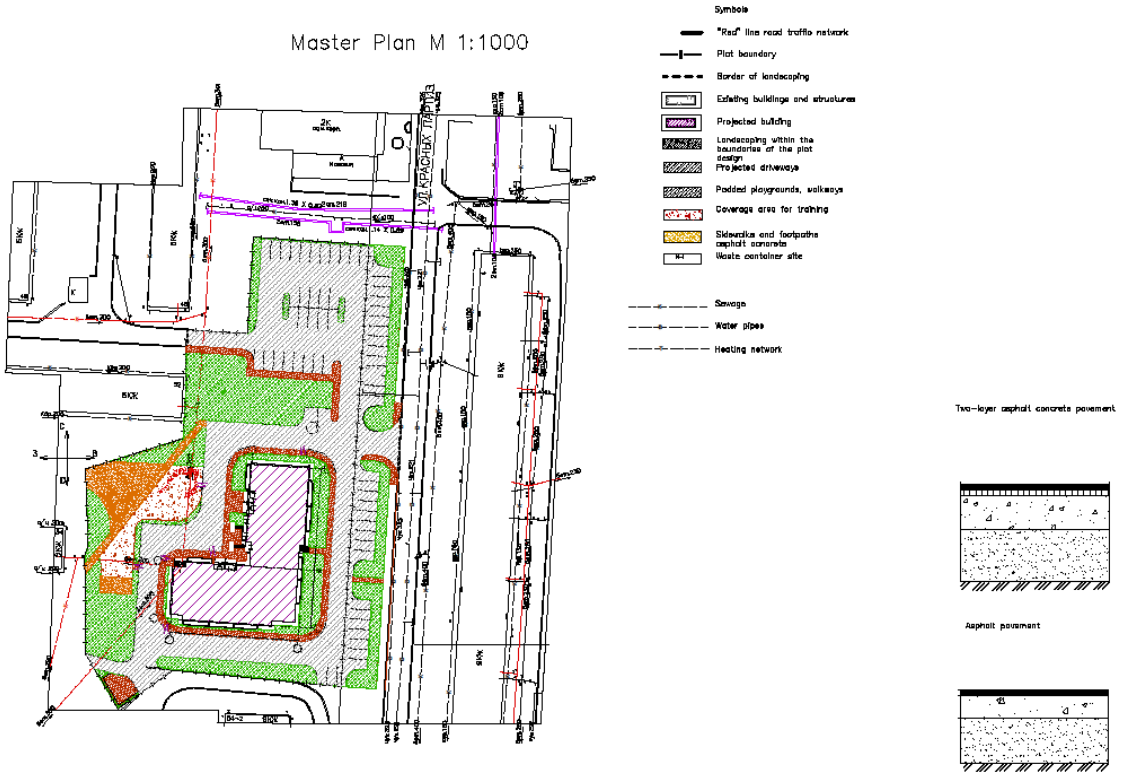
Facades

Facade 16-1

Facade P-A

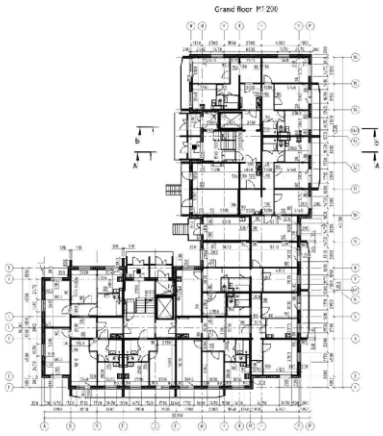
Appendix 5

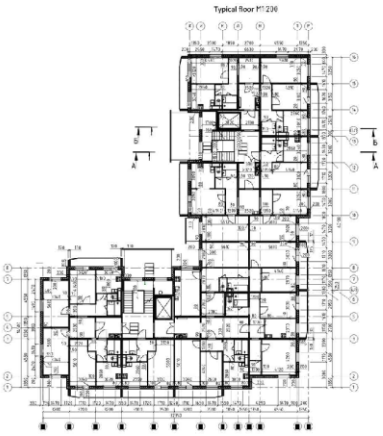
Master Plan

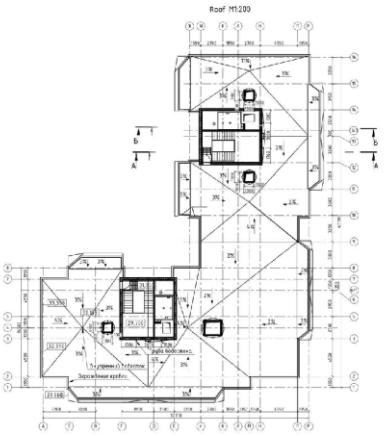


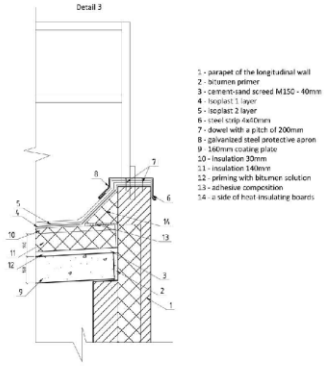
Appendix 6

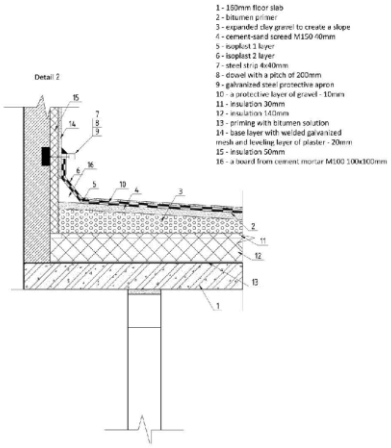
Plans

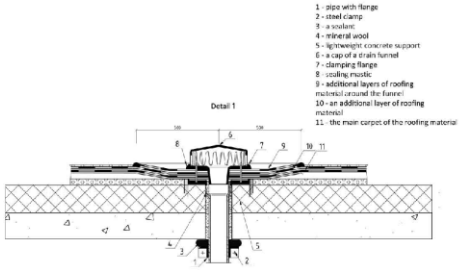






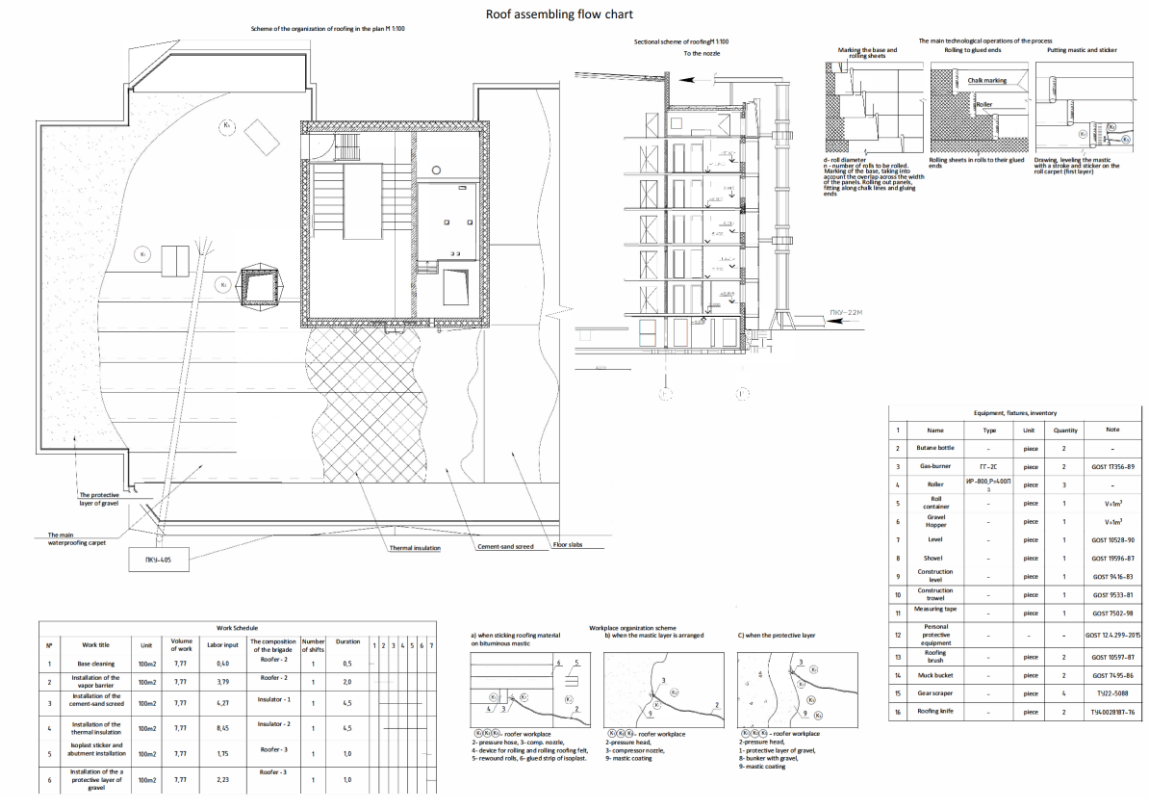






Appendix 7

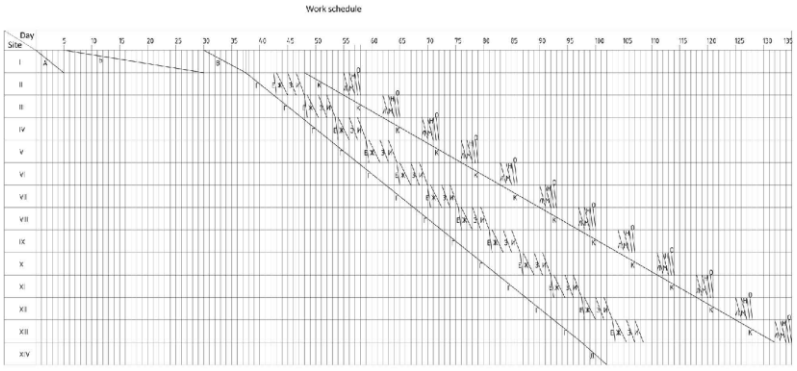
Roof assembling flow chart

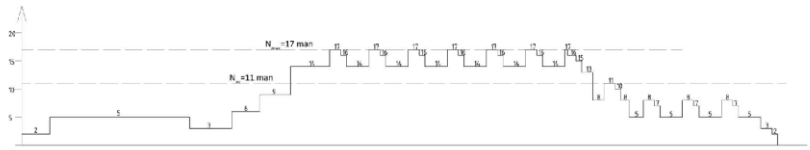


Appendix 8

Schedule

Work schedule



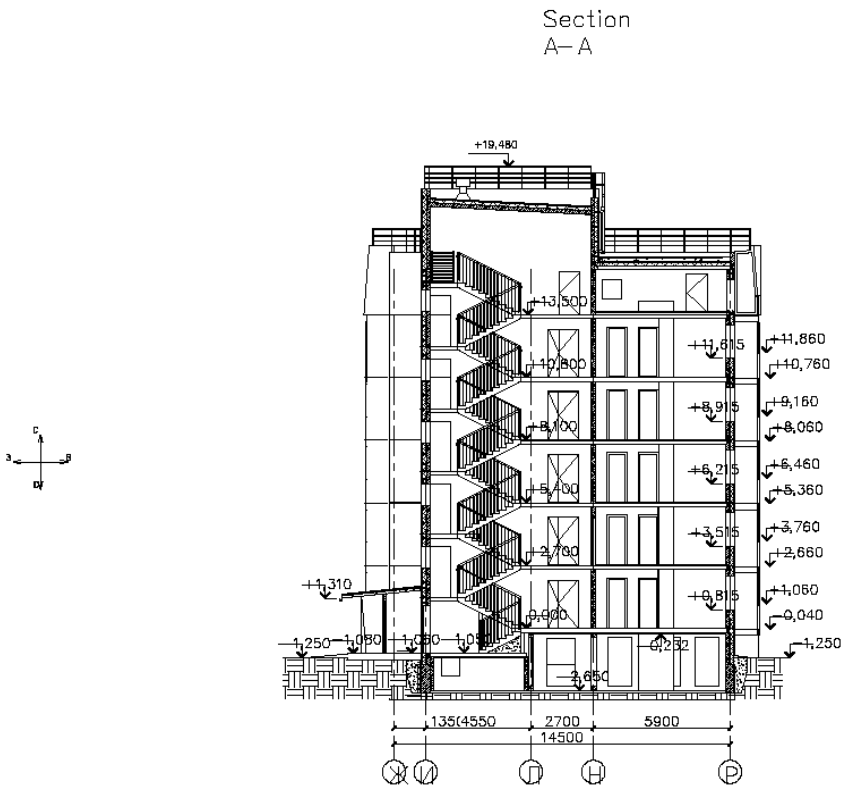


Complex	The name of the types of work	Laboriousness		Team composition, man	The number of people in the team	Machinery		Number of shifts	Duration
		person-days	machine-shifts			Name	Number		
A	Earth works	6,98	11,89	Machinist - 1 Earth worker - 1	2	Bull-dozer DZ21, back-water	1\1	2	5
B	Pile works, foundation and basement member	236,12	44,98	Machinist - 1 Installer - 2 Welder - 1 Carpenter - 1	5	Pile driver, Crane TC-585 -01	1\1	2	25
B	Earth works (backfilling)	-	65,5	Machinist - 1	1	Bull-dozer DZ25	1	1	7,5
Г	The construction of the overlapping part of the building	307,53	73,48	Machinist - 4 Installer - 1 Welder - 1	6	Crane TC-585 -01	1	2	63
Д	Roof assembling	20,89	-	Roofer - 3 Installer - 2	5	-	-	1	4,5
Е	Filling openings	20,03	10,42	Machinist - 1 Carpenter -2	3	Crane TC-585 -01	1	2	6
Ж	Plumbing works I stage	192,69	-		3	-	-	3	24
З	Electric works I stage	153,67	-		3	-	-	3	18
И	Floor preparation device	161,59	-	Concrete worker - 3	3	-	-	3	18
К	Finishing works	1092,97	191,85	Plasterer -3 Painter -2	5	-	-	3	84
Л	Plumbing works II stage	132,45	-	Plumber - 3	3	-	-	3	12
М	Electric works II stage	89,64	-	An electrician - 3	3	-	-	3	12
Н	Facade works	38,55	-	Painter - 2	2	-	-	3	6
О	Green construction	9,13	-	Installer - 2	2	-	-	1	6

Technical and economic indicators of the calendar plan:
Average number of workers - 11 man
Maximum number of workers - 17 man
Estimated construction time - 135 days
Indicator of uneven use of workers - 0,65

Appendix 9

Section A-A



Appendix 10

Technical and economic indicators

Technical and economic indicators

1. The volume of planned indicators
   1.1. Total area - 7711 m^2
   1.2. Living area - 3214 m^2
   1.3. Construction volume - 30147 m^3
   1.4. K2 = construction volume / total area - 3.91

2. Indicators of estimated cost
   2.1. The estimated cost of the facility is 361775.5 thousand rubles
   2.2. The estimated cost of civil works is 236,665.93 thousand rubles
   2.3. The estimated cost of 1 m2 of the living area of the building is 112573.24 rubles
   2.4. The estimated cost of 1 m2 of the total building area is 46915.29 rubles
   2.5. The estimated cost of 1 m3 of the total area of the building is 12,000.46 rubles

3. Indicators of labor costs
   3.1. Labor costs, total - 21645 man - days
   3.2. Labor costs for general construction work - 18525.5 man-days
   3.3. Labor costs per 1 m2 of the total area - 2.81 man-days
   3.4. The production of the first worker per day is 12,775.1 rubles

4. Indicators of the technological effectiveness of the project
   4.1. The standard construction period is 192 days
   4.2. Estimated construction time - 135 days