Saimaa University of Applied Sciences
Civil Engineering
Double Degree Programme

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The construction stages of the six-storey residential building in Saint-Petersburg

Bachelor's Thesis 2017

Abstract

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The construction stages of the six-storey residential building in Saint-Petersburg, 43 pages, 2 appendices
Saimaa University of Applied Sciences, Lappeenranta
Civil and Construction Engineering
Double Degree Program
Thesis 2016
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New construction organization is a difficult, lengthy and multi-step process. Coordinated execution of all phases provides optimization of time and material costs, avoids unpleasant problems during construction and operation.

The goal of this work was to understand the stages of residential building construction, disclosure of all stages and research the problems during the construction.

The stages of construction are accomplished in accordance with Russian norms. The building, taken for consideration of all stages, was developed by Seven Suns Development company. It designs fancy residential complexes and residential quarters in Moscow, Saint-Petersburg and other cities of Russia.

The result of the work is receiving systematic knowledge about composition, the contents and internal relationships of complex construction processes construction works (from construction site development to commissioning). The study of these issues is based on information obtained in the courses of general technical and special disciplines.

Keywords: construction, stages, building, work

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1 Introduction

1.1 Field of research

The construction of each structure is largely individual. However, in all construction projects the repetitive stages, the same elements of construction can be traced.
The construction of a multistorey building can be divided into several major steps. These stages involve the execution of all works in a professional standard, because a multistorey building is a very difficult structure. One of the main tasks during construction is to ensure the safety of residents. The creation of comfortable conditions for people living in the house and providing the maximum convenience in the use of utilities in the house is also important.

Each stage of the building construction is largely independent. Most of them are performed by specialized organizations; the completion of the stage is a significant event in the complex of works on a building object.

The sequence of works is linked with the main factors. The phased development of these factors will lead to the realization of the construction process in the end result.

The principal purpose of the thesis is to describe, understand and assimilate the construction phases of the building, learn what includes each stage during the construction, what works occur at the stage and what should be done at the end of each stage. In the thesis the stages of the particular building in St. Petersburg will be considered. The building that is considered in the thesis (it is in the red circle in Figure 1) is included in the residential complex "I'm a Romantic".

1.2 About the object

The residential complex "I'm a Romantic" includes two new residential quarters located on the alluvial areas of Vasilievsky Island in St. Petersburg. The complex is provided with the social infrastructure, which includes the following objects: residential buildings, a school, a kindergarten, parking, a retail space and an office space.

Figure 1. The residential complex plan [1]

1-9-Residential buildings
10-School
11-Kindergarten
12-Town Hall Square
13-Community Center
14-Theatre
15- Sports and dance hall
16- Center of creativity and art
17- Sound Harmony Center
18- Café
19-Parking
20-Observatory on the roof
22- Administration
23-Police

Construction end: 1 queue-III quarter 2016

2 queue-III-IV quarter 2017

Type: monolithic

Total area: 350 000 m^2

Room area: 21-81 m^2

Cost: from 1,3 million rubles [1]

The fourth building that is considered in this thesis consists of a single section height of 6 floors. The Building height to parapet is 18,50 m. The house is called The Ship Dream. The responsibility level of a building is II. The fire resistance of the building is II. Constructive fire danger class of building is C0. The service life of the building as a whole is at least 50 years (the 2nd degree of durability of structures). The life of bearing and enclosing structures is not less than 50 years. The service life of insulation for ventilated facade system is not less than 30 years. [2]

The designed building is a one-section residential six-storey building, with the technical underground. The living quarters are located from the first to the sixth floor in the building. All apartments are designed in accordance with the existing regulations of the Russian Federation and on the design task, approved by the customer.

The technical underground includes:

1. Water metering node
2. The pumping station room
3. Individual heating unit
4. Ventilation chamber
5. Room cable
6. Fluorescent lamps storage
7. Network engineering [2]

Figure 2. The model of building 4 [1]

The developer of the project is the company Seven Suns Development.
The customer is ООО «Вымпел » .
The general investor is ООО «Seven Suns Development »

2 Construction process

2.1 The selection of the land area for the construction

The first stage of structure erection is purchase of land for construction of the residential building. The most optimally located land is determined at this stage. The land should meet both the balanced construction materials supply and the structures resources for the construction period and necessary operating requirements.

It is necessary to consider a number of factors when land is selected:

1. Infrastructure. The presence of urban infrastructure and its development is the most important factor in choosing land. Proximity to central areas is desirable, but the cost of such land is very high. However, location far outside the city also does not guarantee the high interest of buyers. Based on this, you should pay attention to the plots of land for the construction of an apartment building in a rapidly growing part of the suburbs.

2. Services. This includes the proximity of the heating networks, electricity and telephone cables.
3. The environmental situation in this area
4. The density of the existing buildings
5. The density of greenery

A comprehensive assessment of the development prospects of the region is carried out to find out the scale of the potential demand for housing in this sector among the population. Land for construction of a residential building must have an impeccable legal reputation.

At this stage the sale agreement or agreement about the lease of the land is concluded.

The required documents for official site registration:

- Cadastral number of the land plot. It is a cadastral registration tool of land resources. It consists of the number of the cadastral district, the numbers of the cadastral region, the cadastral number of the quarter and the number of the land plot in the cadastral quarter.
- Land survey act. It is created by a cadastral engineer after the exit of structures or buildings location. The act is necessary for the approval of places for location and construction of trails, buildings and structures.
- Delimitation and technical plans.
    - Delimitation plan is the document which is required at the initial entering of the land in the cadastral registry, various changes in the characteristics, division, merger, apportionment and other operations with the parts of the territory. It is a repository of information about the location, boundaries and other parameters of the area.
    - Technical plan is a special document, which lists all necessary information about the estate object required to make changes in the state cadastre of real estate.
- Documents establishing the right to site
- The agreement confirming the implementation of the purchase
- The statement, which is submitted to the local administration [3]

The building considered in the thesis is located in Saint Petersburg, Neva Bay, site 28 (West of Vasilievsky island, the quarter of 25, Figure 3). The cadastral number is 78:43:0000000:10. The area of land is 77032 m^2. [2]. The island has a large number of universities, schools, galleries and museums. The area is nice, quiet and peaceful.

Many apartments have the stunning views of the Finnish Gulf. The residential complex is located close enough to the underground. The nearest station is Primorskaya. It is to go about 15 minutes. Transport connection with other areas of the city is carried out by ground transport.

The area of land is a mound of sandy soil. The area is not occupied by buildings or structures.

Figure 3. Object location [4]

2.2 Design of the project

After the acquisition of land the work can begin. It is necessary to develop a feasibility study to start the work on the project.

Feasibility study is a document which presents the information from which it is inferred the expediency (or inexpediency) of the creation of a project. The feasibility study contains an analysis of the costs and benefits of any project. A

feasibility study allows investors to determine whether to invest in the proposed project.

The following items are expected to display in the feasibility study:

- Technological process
- Requirements to the production infrastructure
- Basic equipment, tools and equipment
- Staff and labor
- Consolidated cost of products
- The duration of the project
- Economic efficiency
- Environmental impact

Table 1. Technique economic index of the land area

Technique economic index of the land place		
Name	Unit	Amount
1. Land area	ha	7,7032
2. Designed land square including	m²	55 714,2
- Building area	m²	20 726,64
- The area of hard coatings	m²	12 639,56
- The green space area	m²	22 348

Table 2. Technique economic index

№	Name	Unit	Amount
1	Land area	m^2	77 032.0
2.	Construction area of the building 4	m^2	697.36
3.	Total area of the building 4	m^2	3316.32
4.	The technical underground total area of the building 4	m^2	493.40
5.	The apartments total area of the building 4	m^2	2590.44
6.	Technical underground building volume of the building 4	m^3	1156.09
7.	Aboveground parts building volume of the building 4	m^3	10891.90
8.	The number of residential floors	floors	6

At this stage a topographical survey and geological surveys are carried out. Topographical survey is accomplished with the aim of creating topographic maps and plans of location by using measurements of the testimony of geodetic points of the land plot on which the object is located.

The topographic survey is needed for:

- Obtaining permission for the construction of the building
- Designing of capital construction objects
- The communication
- The creation of the master plan [3]

Geological surveys are conducted to determine the reliability of the site. The choice of type of foundation and further design are based on data of physic-chemical properties of the soil and the hydrological regime of the site (in particular, the level of groundwater). If there is little or no data of engineering-geological investigations the probability of engineering mistakes during the design increases. Subsequently an improperly designed foundation may cause deformation and premature destruction of constructed buildings.

Geological surveys include:

- Drilling engineering-geological wells
- Sampling of soil and water for laboratory studies of the chemical and physic-mechanical properties
- Study of the geological structure of the territory that is allotted for the construction
- Study the hydrological regime, groundwater chemistry and the characteristics of soils in a given area
- Identification of existing and potential processes, which constitute a danger for the construction [5]

In the geological structure of the study area, according to the drilling and static probing to a depth of 45,0 m Quaternary sediments (QIV) participate:

1. technogenic formations (tIV) presented by fill-up soil
2. biogenic sediments (bIV), presented by peaty soils
3. sediments of lacustrine-marine (lmIV) Genesis submitted silty Sands
4. upper Quaternary sediments (QIII), glaciolacustrine (lgIII) Genesis, presented loam belt and layered, flowing, with layers temacapulin
5. glacial (gIII) Genesis submitted by ecochallenge loam, with layers of permanent soft
6. plastic sandy loam
7. loam jugoplastika, with layers of permanent soft
8. semi-solid loam with interlayers of solid underlain by Vendian deposits kotlinski horizon, represented by clays and solid stationed nedeklarirovanie [2]

Ten engineering-geological elements are identified according to the composition and physical properties in the survey area.

Hydrological conditions of the area are characterized by the presence of groundwater. A maximum multi-year amplitude oscillation of the groundwater level is 1.50-1.80 m.

The conclusion is given in the form of a document which has legal force. The conclusion has legal force when the organization has the official permission to carry out works on the construction site.

Саморегулируемая организация
Основанная на членстве лиц, осуществляющих проектирование
(вид саморегулируемой организации)

НЕКОММЕРЧЕСКОЕ ПАРТНЕРСТВО
«Национальный альянс проектировщиков «ГлавПроект»
109341, г. Москва, ул. Братиславская, д. 23, офис 1
сроглавпроект.рф
№ СРО-П-174-01102012

г. Москва (место выдачи Свидетельства) «17» марта 2015г. (дата выдачи Свидетельства)

СВИДЕТЕЛЬСТВО
о допуске к определённому виду или видам работ, которые оказывают влияние на безопасность объектов капитального строительства
№ 1533

Выдано члену саморегулируемой организации

Общество с ограниченной ответственностью «СТУДИО-АММ»,

ОГРН 1137847210324, ИНН 7840490000, 191119, Санкт-Петербург,

ул. Боровая, дом № 32 А, пом.20-Н

Основание выдачи Свидетельства : решение Контрольно-дисциплинарного комитета
(наименование органа управления саморегулируемой организации,
НП «Национальный альянс проектировщиков «ГлавПроект» № 17КДК от 17 марта 2015г.
номер протокола, дата заседания)

Настоящим Свидетельством подтверждается допуск к работам, указанным в приложении к настоящему Свидетельству, которые оказывают влияние на безопасность объектов капитального строительства.
Начало действия с «17» марта 2015г.
Свидетельство без приложения не действительно.
Свидетельство выдано без ограничения срока и территории его действия.
Свидетельство выдано взамен ранее выданного ---------- (дата выдачи, номер Свидетельства)

Генеральный директор НП «Национальный альянс проектировщиков «ГлавПроект» (должность уполномоченного лица) (подпись) Синцов Ю. Г. (инициалы, фамилия)

Figure 4. Certificate of admission for certain types of works. [2]

Obtaining a permit is required for work in the field of engineering survey, design and construction. According to Town-Planning Code of the Russian Federation the permit has no territorial and time limits.

Further, the architects and the designers involve in the project. They create the design of the building taking into account construction norms, health regulations, and climatic features.

The next step is the project documentation development. Project documentation is prepared at the following stages:

1. Pre-design studies stage
2. Project stage
3. Working project documentation stage

(1) Pre-design studies stage (preliminary design)

Design studies are performed for urban studies of the construction objects placement and works of the existing facility renovation. Design studies set a preliminary budget, investment justification and the possibility of building or reconstruction of the facility on the site according to town-planning and historical-cultural, socio-economic and sanitary-hygienic and environmental requirements.

This phase enables preliminary study of the main parameters in the building designing. This stage of architectural design does not subject to approval with the state Supervisory authorities, and it is not regulated by the Town-Planning Code.

This stage ends with the development of optimal space-planning decisions, compositional-artistic image of the designed structure.

The preliminary design contains:

- Explanatory note
- Situational plan with surrounding areas
- General plan (scheme of the plot)
- Floor plans with explication of premises

- Sections description (walls, floors, roofs) and structural elements
- Facades
- Color and three-dimensional facade
- 3D visualization [6]

(2) Project stage

The phase is the primary approved documentation part for the building design. At the design stage drawings sets are accomplished for all sections. The stage is performed on the basis of existing state standards, norms and rules and technical tasks of the customer.

The project stage includes:

- General explanatory note
- The project stage general plan
- The architectural project
- The constructive part
- Technological part
- Solutions on engineering equipment and engineering systems and networks
- Environmental protection
- The building energy efficiency
- The construction organization project
- The estimated cost construction calculation
- Measures to ensure access for disabled persons [6]

At this stage materials for future construction are selected, the connections types, manufacture and installation methods are determined .

(3) Working project documentation stage

At this stage the detailed drawings sets of all project aspects are accomplished. The drawings are necessary for the construction and installation works performance.

Working project documentation consists of:

1. Working drawings (plans, sections, elevations, axonometric scheme)
2. Equipment, products and materials specifications
3. Sections estimates [6]

All the developed projects and estimates for buildings construction are subjected to the expertise.

Technological design.

Technological design is a part of the design documentation developed for construction of the facility. Technological designing of processes should be provided at all stages of project development.

Construction technological design includes:
• Project construction organization
• Production works project
• Technological maps
• Labour processes maps
• Operations technological scheme

Project construction organization specifies the construction duration, its cost, the need for materials and necessary equipment.

The project construction organization includes:

- Work execution schedule indicates the timing and sequence of construction of all buildings and structures comprising the complex, with the distribution of capital investments and construction-installation works. for certain constructions. Work execution schedule is executed for complex construction at preparatory period additionally
- General construction plans for the preparatory and main periods of construction. The plans include all of the existing and the construction of buildings, roads, temporary and permanent engineering networks
- Requirements in the constructions, products, materials, equipment

- The demand graph for the main construction machines and vehicles for the entire period of construction
- The demand graph for workers of the main building specialties
- Explanatory note. The note includes the conditions construction characteristic, the adopted production methods justification and the possibility of combining various work deadlines, requirements in materials, basic mechanisms, vehicles, and energy resources. The proposed construction timing of the entire complex must be justified in the explanatory note

The construction management project is required for the customer, contracting organization and organizations that provide financing and logistical support to the construction of the object.

The general contractor develops the production works project for the entire object work complex and for the preparatory period based on the project construction organization.

The production works project can be developed for:

- Building or structure construction
- Construction of the building parts
- Certain technically complex construction works execution
- Preparatory period work

The production works project is developed to:

- Determine the most effective ways to perform construction and erection works
- Reduce all types of costs
- Reduce the duration of construction
- Use the best mechanization
- Ensure the work safety

Initial dates for the production works project development are:

- The task for designing the production works project from the customer;

- Previously developed project construction organization for the object construction
- Required project documentation (working drawings, calculations)
- The specific construction
- Documentation and calculations are carried out for the similar building construction

The period of the development of the production works project depends on the characteristics of the construction, installation works and their complexity.

The production works project includes:

- Work execution schedule establishes the sequence and timing of all work with the greatest possible in their combination, normative operation time of construction machinery, the need for labour and means of mechanization
- Construction master plan. It includes:
    - the construction site boundaries, the types of barriers
    - permanent and temporary networks and communications
    - permanent and temporary roads
    - schemes of vehicle movements and construction machinery
    - the place of construction machinery and hoisting mechanisms installations with an indication of their pathways and action areas
    - construction and temporary buildings and structures
    - washing vehicles zone
    - the domestic premises location
    - the path of worker movements, passages in buildings and structures
    - power supply and lighting sources at the construction site
    - site and facilities for materials storages
    - the location of fire-fighting water supply and hydrants;
    - checkpoints security
- Technological maps and charts for specific works or processes performance
- Products and materials receipt schedules

- The requirement graphics for workers at the facility
- Construction machines schedules
- Decisions on the geodetic works production
- Decisions on safety
- The technological equipment and tooling list for construction works execution
- Explanatory note including technical and economic indicators [6]

The production works project is designed for the building as whole, individual cycles of the construction of buildings, complex construction works. The production works project is developed at the stage immediately preceding manufacture of the works.

The object construction is allowed only on the basis of the preliminary decisions made in the project construction organization or the production works project. Technological maps are designed for complex processes and simple construction works.

Labour processes maps are prepared to execute simple technological processes. The technological schemes are designed for workers in order to clarify the optimum performance of individual operations. Construction of buildings is carried out by flow-line method with a maximum works combination performed on the buildings. Construction works beginnings in each case are shifted relative to the other for the work production duration of a zero cycle of the previous case. The sequence of construction of residential buildings is 5, 3, 2, 4, 1 (Numbers of buildings).

2.3 Expertise and project approval

Project expertise is one of the main stages provided by the construction object security. In the course of the expertise specialists reveal project discrepancies and inconsistencies with town-planning documents, scoping documents and legal requirements. Examination is carried out by the most qualified and experienced professionals in the project management field. There is state and private expertise in Russia.

The main differences:

- State expertise is carried out within 3 months, private specialists can handle it in a month.
- State companies conduct a comprehensive inspection, private companies can study the individual parts of the structure.

What structures need to be checked:

1. Facilities with floor number over three.
2. Buildings are larger than 1500 square meters.
3. Complex structures from a technical point of view

During the expertise professionals revealed:

1. Regulations and acts violations
2. Violations leading to the loss of strength and the destruction of the buildings
3. Violations leading to an emergency situation
4. Violations leading to the structures strength loss

The main areas of expertise include seven different aspects. An expert group is formed in each of the areas if it is a complex large project.

1. Commercial direction is to evaluate the project as a commercial event, giving a profit. Here the invested funds are matched with revenues and profits that allow getting the project implementation.
2. Technical direction considers such issues as the correct choice of production technology, main and auxiliary equipment procurement, raw materials procurement and other production aspects inherent in the project.
3. Institutional direction pays attention to the conformity of the project decisions to the current legislation of the country where the project is expected to be realized.
4. Social direction considers the project from the point of view of social issues in the region.

5. Environmental direction considers relationship between the project and the environment.
6. Financial direction
7. The economic direction analyses all parties and the project effectiveness feature.

What is subjected to the expertise:

1. Object project documentation
2. The results of the engineering researches executed for design documentation preparation

The considered object passed the expertise. It took 31 days. The conclusion was prepared by the expertise results. All permissions are obtained, the examination is passed, construction is begun. [7]

2.4 Phase zero

The construction phase is divided into the following major parts:

- The construction site preparation
- The axes layout of a building
- Excavation works
- Foundation works
- The exterior walls construction of the building
- Communications supply
- The roof installation
- Internal partitions installation
- Plastic windows installation
- Internal communication networks
- Floor screed device
- Interior decoration works
- Facade decoration works and renovations in all public areas [8]

Phase zero is construction site preparation, the axes layout of a building, excavation works and foundation works.

2.4.1 The construction site preparation

Site preparation is a required step. Previous preparatory works are performed to create favorable conditions for the construction work to start.

The construction site preparation includes:

- The temporary roads construction and access roads to the construction site
- Temporary services laying
- Areas for construction machinery parking
- The construction site fence
- Temporary premises preparation [9]

The construction site is shielded with solid protective guard fence according to GOST 23407-78. The temporary fence sections are accomplished with profiled sheet using polymer blue coating. The height of the section is 2.0 m, length is 2.7 m. Swinging gates are accomplished with profiled blue sheet. The height is 2.6 m, the width is 6.0 m. [10]

Temporary fencing of the construction site is performed after receiving the permissible documentation in the following sequence:

1. mark the installation of the fencing location
2. deliver fence elements to the installation place
3. install a wooden rack
4. install metal corrugated sheets
5. install gates [10]

The entrance to the construction site is an important step in the preparatory works beginning on the construction site. Proper placement of the roads leading to the construction site saves time for construction and supply of equipment and construction materials. Building roads should have traffic circles, on dead-end hallways reversal sites are arranged. In the considered object temporary concrete slabs are installed on the access and temporary roads. The size of the slab is 3000x1750x180 mm. [2]

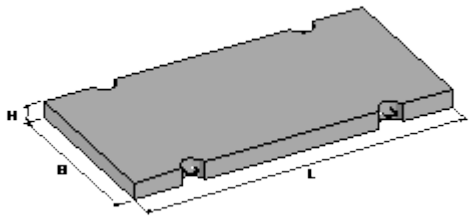

Figure 5. Slab 3000x1750x180 mm [2]

The access road's width for two-way traffic is 6 m, the roadside width is 1 m.

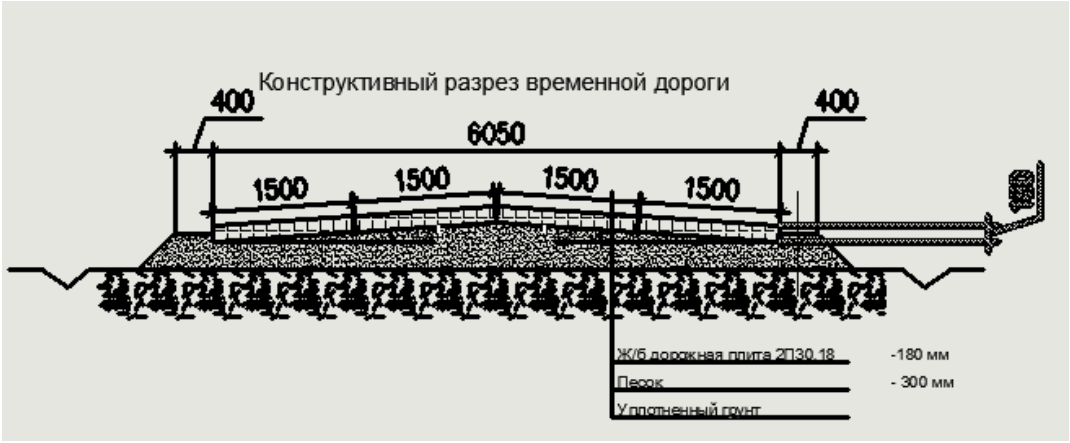

Figure 6. Temporary road section [2]

In the preparatory period temporary services are established. The services include temporary water supply, including fire water supply, heat supply and power supply with electricity connections to all premises.

The area for parking and repair of earthmoving and other machineries is allotted at the site. There are a mandatory fencing and appropriate signs and labels.

The construction site is equipped with temporary buildings including checkrooms with cabins, dining hall, showers, office contractor, bathrooms, warehouses for construction materials, tools, sheds storage. The site for temporary buildings is tentatively designed to ensure surface water runoff. It is advisable to use buildings carriage, block and container types for temporary buildings. Mainly buildings of the container type are used at the considered object.

Temporary inventory buildings are located in the North-Eastern part of the construction site at the entrance. [2]

Upon construction completion, the territory occupied by residential compounds and parking equipment, as well as temporary warehouse of the materials is subjected to reclamation, landscaping and gardening. The container is set near to the sanitary buildings for household waste from the builder life.

Preparation of site for construction involves land clearing of debris, cutting green spaces, relocation of existing transit services. It is further assumed adding to the site to the relief design points, taking into account road structures and the layer of fertile soil in areas of landscaping. As there are no hazardous geological processes at the site special measures for the protection of the territory and objects are not required.

2.4.2 The axes layout of a building

Modern industrial construction requires a reliable geodetic support. Multi-storey monolithic buildings are characterized by high requirements for erection structures accuracy. Noncompliance of specified tolerances, variances, and errors accumulation complicate the works production. It leads to bearing capacity reducing and stability of individual elements and the building as a whole.

The basis building construction accuracy is the geodetic works complex. Part of which relates to the preparatory period works, and the second part is carried out during the construction of the building. It includes:

- The geodetic plan establishment with axes consolidation on the building with the possibility of moving the axes to the floors
- Axes transfer to each storey floor (a new mounting horizon)
- Installation of intermediate and auxiliary axes on each mounted storey floor
- The mounting horizon definition on the storeys
- Drafting floor executive schemes

Marking is carried out by using accurate modern measuring devices.

2.4.3 Excavation works

The main type of earthwork in the construction of a multi-storey building is the foundation pit digging. The excavation includes trenching for communication. At this stage special equipment, such as excavators and bulldozers is utilized.

Excavation can be divided into two stages: preparatory work and directly digging for construction. Preparatory works are the most important. All further stages in the construction and operation facility safety depend on preparatory works.

For proper excavation and construction works it is important to clearly define the volumes of embankments and excavations. Machine selection is also important for the correct execution works. Equipment is selected in accordance with geodetic data determining the difficulty of the excavation level.

After the preparatory works are finished, the second stage is ensued. At this phase a pit is dug. Initially the fertile layer soil top is removed. In the future it will be used for the adjacent territories improvement.

During the excavation works the mass is removed and transported in a pre-prepared point. Slopes are cut, the pit bottom is planned. The passage is performed in one layer. The level of parking excavator on the earth's surface is above the level of the developed ground. The maximum excavation depth is 2.5 m from the ground surface. It is essential to seal the pit base for the device monolithic reinforced foundations.

In case of water occurrence in the pit the lowering of the groundwater level is provided by open drainage with the device of drainage ditches around the excavation perimeter and sumps in the pit corners from precast concrete rings Ø 1 m, with holes at 1 m below the pit bottom. Pumping water is implemented by means of pumps. [2]

Different physic-chemical properties of soil, climatic characteristics and their impact on the soil are taken into account. Cementation, silicification, or chemical fixation is used to consolidate the soil.

Excavation works on the trenches and pits developments are accomplished in accordance with the rules. Before the production works begin the consolidation on the ground of characteristic (turning) route points of underground utilities is required.

The trenches bottom is flat. The bottom is covered with a compacted sand layer with 150-200 mm thickness before the pipes lying. The trench bottom inspection is carried out, trench bottom parts are aligned and their compliance with the project is also controlled. The inspection results are documented in the act on hidden works. The water should not accumulate in the trenches. Before laying the pipes, connecting parts and elements are subjected to inspection to detect, cracks, chips, deep cuts, punctures and other damages. [11]

2.4.4 Foundation works

The pile foundations construction is envisaged in the project. The foundation consists of driven piles with section 350x350 mm and monolithic reinforced concrete grillage slab with 800 mm thickness on the 100 mm concrete preparation. [2]

For equipment descent into the pit for the period of piling and grillage the descent is arranged with crushed stone using a reinforced concrete pavement slabs coating with inclination angle 10°. Over the entire pit area a sandy preparation is arranged with 300 mm thickness for the drilling rig and crawler crane movements.

Piles installation is permitted only after receiving positive results of static tests sample piles. Tested piles are determined by the supervision. Piles in accordance with the project are driven by using special equipment designed for piling with a length of 16 m.

Before the monolithic reinforced concrete structures' installation the following preparatory work should be accomplished:

1. Required machines, tools, fixtures and equipment, as well as reinforcing steel and formwork elements are delivered to the construction site
2. The building axis and benchmarks are fixed and adopted according to the act

Before concreting the foundation slab the following preparatory work should be accomplished:

1. The withdrawal of ground and surface water is organized
2. The base is prepared for the concrete reinforced slab
3. Formwork and reinforcement works are completed and accepted by the act

The formwork is placed around the monolithic foundation reinforced concrete slab perimeter. Formwork installation starts with the corner points. After positioning the formwork elements are immediately propped up with struts.

The slab concreting is performed by a special pump. The concrete mix should be laid in horizontal layers with the 1.5-2 m width of the same thickness without gaps. After the basement construction the inner walls surface and foundation slab are coated with two gluey waterproofing layers and insulated with mineral wool slabs.

The excavation backfill is accomplished by special equipment. The compaction coefficient is bigger than 0,98. Monolithic reinforced concrete foundation slab backfill is provided by coarse-grained sand, the frozen lumps contents should not exceed 20%. [12]

Not allowed:

1. Wood, rotting or construction debris contents in soil
2. The presence of snow and ice in the backfill

2.5 Construction

2.5.1 Legal issues

At this stage the contract business participation is signed between the developer and the customer. According to this contract the customer invests in the multi-storey building construction, the developer after construction delivers to the buyer the apartment in the building.

The contract guarantees:

- Protection against double sales. The contract is registered in The Federal service for state registration, cadaster and cartography. This means that the state has recorded client right after payment to obtain the apartment. Therefore, it will not be able to sell it again to another client.
- The right to receive financial compensation for the late apartment transfer. In case the developer does not give the apartment on the date specified in the contract business participation, the client requests a fine for each day of waiting.
- The right to terminate the contract. In case the developer does not perform its obligations or performs them badly, the customer cancels the contract without any fines to get money back, as well as compensation.

The contract business participation includes:

- The object construction definition
- Apartment characteristics in accordance with the design documentation (the address, apartment number, size, layout)
- Transfer period of the apartment to the customer
- The contract cost, the terms and procedure of the contract payment
- The warranty construction period
- The way in which the developer will ensure obligations according to the contract business participation

The first contract business participation payment is paid strictly after the state contract registration. The apartment purchased at the construction stage of the building, is on average 30 percent cheaper than in the finished building. [13]

2.5.2 Structures concreting of the aerial parts

Precast concrete construction is one of the most advanced technologies used in the construction of buildings and structures. Monolithic construction process is the construction of different components from mixtures containing concrete and special formwork. Formwork is a special structure with a special form for concrete laying. The construction acquires strength, stiffness and resistance to changes in shape, size and other concrete structure properties.

The monolithic construction advantages:

1. Construction completion time is short
2. Building costs are much cheaper
3. Monolithic structures possess unique values of sound conductivity and heat saving
4. The construction has a higher strength and lighter weight
5. The minimum equipment amount is required for the construction
6. Installation process has a simpler form
7. The finished construction does not require the preparation for final cleaning
8. Architectural solutions variety

The monolithic construction disadvantages:

1. The difficulties emergence arising from the weather factor impact, difficult to work with concrete
2. All construction works are carried out in an open space. The bad weather conditions create some discomfort in the builder labor conditions. [14]

Concrete for construction is prepared on-site. It significantly reduces the preparing and delivering concrete costs and as a result, and to save on the final construction cost. It is the monolithic construction distinctive feature.

Concrete works include the in-situ reinforced concrete walls, columns, floors and staircases. Monolithic reinforced concrete structures installation is carried out in accordance with the production rules.

The operation sequence in the monolithic structures construction:

- The formwork installation
- The reinforcement installation
- Concrete laying
- Formwork dismantling [15]

The floor concreting is performed with the use of inventory formwork. The formwork must possess strength, stiffness, shape stability and invariability in the operating position and in the transportation and installation conditions.

The individual formwork panel assembling is produced on site according to the assembly drawings. Individual panels are connected by means of keys, locks and studs in the formwork panel assembling. Formwork panels are connected with clamps. Formwork elements fit tightly to each other during assembly. The slots on the butt joints are less than 2 mm. Formwork supply is performed with tower and crawler cranes. [16]

Area for reinforcement must be provided with the necessary equipment and a canopy over the manufacture works place to perform the reinforcement work on site. The reinforcement preparation must be completed before the formwork works start. Reinforcement is delivered to the construction site as the individual rods.

The armature is hot-rod, periodic profile A400 Hw and A240 Hw for monolithic structures reinforcement. Reinforcement is produced as flat grids. Separate rods of the additional working armature are installed at the upper and lower flat grids zones. [2]

Reinforcing frames and grids are manufactured with a binding wire at the rods' intersection. Space frames are assembled from flat frames by cross rods and binding stirrups.

The reinforcement is installed in the sequence ensuring its correct position and fastening. Mounted reinforcement is secured against displacement and protected from damage.

The reinforcement frame installation step allows highly economical building for the shortest time. The future building shape is formed depending on the reinforcing frame shape. Reinforcing the frame provides the building an additional reliability and durability. Covering base, installation correctness and formwork fastening correctness, mechanical means availability are verified and accepted before the concrete mix is laid. [14]

Ordinary concrete mixture is used for the building construction. The mixture is responsible for the future building wall formation. Concrete sealing is performed with vibration. Concrete sealing in slabs is produced by means of deep concrete vibrators with a flexible shaft and in subsequent surface elements with concrete screeds. The vibration duration should ensure sufficient concrete mix compaction (air bubbles cease the discharge from the mixture).

During rain the concreted area should be protected from water penetration in the concrete mix. Accidentally blurred concrete must be removed.

The optimum concrete curing conditions are:

1. Temperature is 18°C
2. Humidity is 90%

Stair flights and landings are carried out after the concrete sets to 70% strength.

The concrete is left for a few days for solidification. After the concrete has stiffened the formwork is removed. [15]

2.5.3 Load-lifting mechanisms' work

The construction of the above-ground parts and the building materials' supply are carried out with the help of tower crane Liebherr 180 EC-H10 with a boom length of 50.0 m and a capacity of 10,0 3,15 tons. Tower crane selection is based on three main parameters: load capacity, radius and hoisting height.

The maximum suspension hook crane height is determined from the installation level of the crane vertically and consists of the following indicators:

1. the building height from the level from the foundation slab to the upper level of the building (construction) (top mounting horizon) m
2. stock height equal to 2.3 m from the conditions for safe works production on the upper level of the building, where there may be people
3. maximum transported cargo height (at the position at which it is moving) subject to attached to the cargo mounting fixtures or structures gain
4. length (height) of the gripping device in operating position

The safety distance from the transported cargo bottom to the most protruding building or structure parts in vertical is bigger than 0.5 m, and to floors and areas where people might be is bigger than 2.3 m.

The danger area boundaries are marked on the ground with signs, warning about the crane operation. Signs are installed at the visible areas of the danger zone. Boundaries are illuminated in the dark. Signs are installed on fixed racks to prevent the risk of their falling on the people passage and equipment movement. On the danger area border in people passage locations (roads and footpaths) signs warning about the crane operation are established. [2]

2.5.4 Walls and partitions arrangement

Masonry is a construction, consisting of stones laid on mortar in a certain order. Masonry supports loads from self-weight and other structural elements, resting on the masonry and loads attached to the elements.

Bricks, lightweight aggregate concrete blocks and mortar submission on the outrigger platform are produced with the tower crane.

Masonry is conducted with careful vertical and horizontal seams filling with a mortar. The filling with broken bricks is forbidden. It is necessary to monitor the mortar for compressive strength in accordance with Russian norms constantly, regardless of the motor passports availability.

In the execution of masonry process the work acceptances are occurred. The following elements are subject to the acceptances:

1. masonry waterproofing
2. installed reinforcement in reinforced masonry structures
3. embedded parts installation

Completed works of the brick structures construction are monitored on:

1. Seams bandaging correctness, their thickness and filling as well as masonry horizontal rows and vertical angles
2. Ventilation channels correctness
3. Structure’s geometrical dimensions and position

The masonry brick storeys construction is occurred after the monolithic floors constructed storey installation.

Stone structure’s positive qualities are:

1. high fire resistance in comparison with other materials
2. chemical stability
3. resistance to weathering
4. durability

These qualities are due to that the aggregates have a dense structure.

Factors influencing on the masonry strength:

1. Masonry stress state. Vertical cracks will appear in the individual bricks if the load gradually increases on the masonry to a value higher than the tensile strength of it (Fig. 7, a). The cracks will be located mostly under the vertical seams where tensile stress and bending concentrate. With load increasing the crack will grow. The cracks will divide walls to the columns (Fig. 7, b). The final masonry destruction is occurred due to the columns buckling. The result is the stability loss (Figure. 7, c).

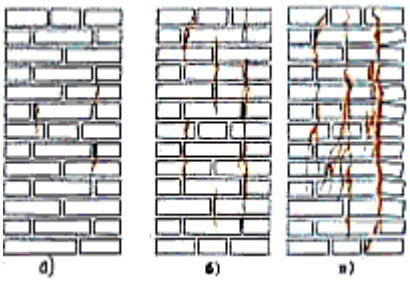

Figure 7. Masonry stress state [16]

2. Mortar properties. To get a more strong masonry the mortar used in construction should have the high mark.
   However, mortar strength increasing slightly increases the masonry strength. The mortar plasticity is more important. Plastic mortar is better spread on bricks. Plastic mortar provides more uniform seam thickness and density. The masonry strength is increased, bending stresses and shear in the individual bricks are reduced.
3. The stone materials' size and shape. The number of horizontal joints in the masonry is decreased and bending resistance is increased proportionally to the stone height square with the stone height increase.
4. Quality masonry joints [17]

2.5.5 Cover and roof building

Profiled steel decking is galvanized steel panel with additional anti-corrosion coating steel sheets. The thickness is from 0.8 to 1 mm, the length is from 6 to 9 m and the width is from 0.7 to 0.85 m.

Decking is enlarged to card size from 6x3.4 to12x12 m on the horizontal stands when coatings are installed. Profiled decking enlarged card is raised with the traverse. The card is attached to the trusses and joists with construction gun or with the help of self-tapping bolts. The distance between fixing points is from 500 to 600 mm. [2]

A vapor barrier of plastic film and dry hard mineral wool slab insulation are placed on the profiled decking top.

Thermal insulation slabs are placed in such a way that through-gaps are not formed between the slabs. Roofing is produced by rolling rolls. The used material is isoplast. [18]

2.5.6 Interior decoration work

Internal decoration works are carried out after the wall surfaces and ceilings acceptance by the Commission with subcontractors representatives participation involved in decoration works.

The following work should be done before decoration works commence:

1. Windows and door blocks coupling space are sealed and insulated
2. Light openings are glazed
3. Embedded parts are installed; heat and water supply systems, heating and ventilation are tested and connected.

Plastering and cladding (project) surfaces in the products' sanitary systems installation must be performed before their installation.

The inner cladding elements are fixed on a cement-sandy mortar. Stucco and smooth concrete surface with irregularities which do not exceed 3 mm are veneered on the mastics and glues.

Glazed ceramic tiles are cut using special devices. Tiles stick to surfaces with special construction adhesives/mortars. They are produced from dry mixes at the facility.

Paint composition preparations and their delivery to the object are provided in a centralized order and ready to use. Only water-based paints are used. Priming and putty are the main activities for preparing the surface. Solid putty is a leveling layer. It is applied with putty units or spatulas. Primer surfaces should be done before painting compositions are applied. The primer must perform an even, continuous layer without gaps. Coloring should be done after the primer has dried. Paint compositions should be applied in a continuous layer. The application of each painting should start after full drying of the previous layer.

Screeds should be used to align the floors and platforms preparations. [19]

External decoration works (wall insulation with mineral wool 100 mm thick, artificial stone cladding and 20 mm plastering) are underway with scaffoldings. The height is to 100 m. [2]

Before starting work on scaffolds the following items must be done:

1. Repaired and graded scaffolding elements are delivered to the installation place
2. Base cleaning
3. Signal fence is established around the work site

Control over scaffolds in their operation is provided every day. In the event of any adjustment, alteration, removal or individual elements replacement the scaffolds are subject to an additional acceptance.

Elevation setting for insulation materials layout is produced using laser, theodolite or measuring equipment. Insulation slabs are installed in a staggered vertically way next to each other so that there are no through-gaps between the slabs. Each insulation slab must be fixed to the supporting wall with special disc dowels.

The walls plastering and painting are performed after mineral wool slabs are fixed. Insulation work of the outside walls is carried out from bottom to top. Facades plastering and painting are directed from the top floor to the bottom. Scaffolding constructions of the upper floor are disassembled and get down using the stairs as the works were performed at the upper storey.

Basement facing works are accomplished with stone from ground level after plastering and painting work and scaffolding dismantling. [19]

2.5.7 Territory accomplishment

The developer must also take care of the local area regeneration to realize the apartments in the erected multi-storey building in accordance with the town planning regulations. Playgrounds, the greenery presence, flowerbeds, paving

or pavement laying in front of the entrances, providing access routes for vehicles, parking arrangement for residents and their guests and street lighting arrangement are established in many projects for the convenience of the residents.

The project provides the territory improvement and landscaping within the boundaries of the improvement site. Driveways are made of the asphalt, sidewalks are made with concrete slabs coating and lawns.

The asphalt concrete coating is arranged in the following sequence:

1. Site is applied and fixed in accordance with the project
2. Soil cutting with a bulldozer is developed
3. Developed soil is loaded by excavator into dump trucks
4. Soil is transported outside of the construction site
5. Dumping and compaction of the sand layer are performed
6. Dumping and compaction of the crushed stone layer are performed
7. The quality is controlled and work acceptance is performed
8. Asphalt coarse-grained, porous coverage with the 60 mm thickness is organized
9. Asphalt fine-grained, porous coverage with the 40 mm thickness is organized

Asphalt coverage may be placed only in dry weather. The base under the asphalt coverage should be cleaned of dirt and dried.

Sidewalks are performed in the following sequence:

1. Site is applied and fixed in accordance with the project
2. Soil is cut
3. Sand base is laid
4. Crushed limestone sand is arranged with subsequent road rollers compaction
5. Sand layer stabilized with cement is poured (ratio 1/10)
6. piece-paving slabs coating is performed

Landscaping work must be carried out only after topsoil laying, driveways, sidewalks, playgrounds and fences are established and construction waste is removed after the construction.

Prepare spots for planting trees and shrubs must be made in advance so that spots as long as possible were exposed to weathering and solar radiation. Spots preparation is allowed directly in front of the landings. Lawns should be made on fully prepared and planned vegetable ground. [20]

2.6 The commissioning of the building

A state Commission is formed which includes representatives of the investor, customer, Executive authorities, contractors, designers, sanitary inspection, fire inspection, service of state construction supervision and examination, a specially authorized agency in the field of environmental protection and other state agencies controlled object, each of which makes a conclusion in its competence.

The state Commission oversees:

1. construction and installation works
2. compliance with the approved project documentation
3. compliance with existing building regulations, norms, standards, specifications
4. conformity of decoration work samples and investment contracts conditions

A document package is prepared for obtaining the building commissioning permit. Service of state construction supervision and examination gives permission to the object for building commissioning. The building obtains constant electricity, water and heat systems.

At this stage there is:

1. The signing of the commissioning act
2. Garbage disposal

3. Observations elimination identified by the state Commission (for 2-3 months)
4. Systems checking (heating, sewage, water supply, ventilation, elevators, etc.)
5. The water, light and heat connection [21]

2.7 Check-in to the apartment

Check-in occurs after full purchase price payment, utility bills payment and signing of reception-transmission act.

At this stage there is:

1. The signing of the transfer and acceptance act
2. The house is completely ready to move in (all utilities are connected)
3. Key pass, settling

3 Conclusion

Construction is a long and difficult process. The design and construction of residential structures requires the efforts of many specialists.

In conclusion, the acceptance of monolithic reinforced concrete structures must be carried out strictly in accordance with SNiP 3.03.01-87. There is a special field supervision which controls the construction. Supervision is carried out during the construction period from the initial stage of digging pits to enter buildings in operation. Representatives of field supervision have their own responsibilities. All members of the control and supervision are members of the selection committee at the time of building the facility. Any deviations from the project during construction works must be agreed with the designers.

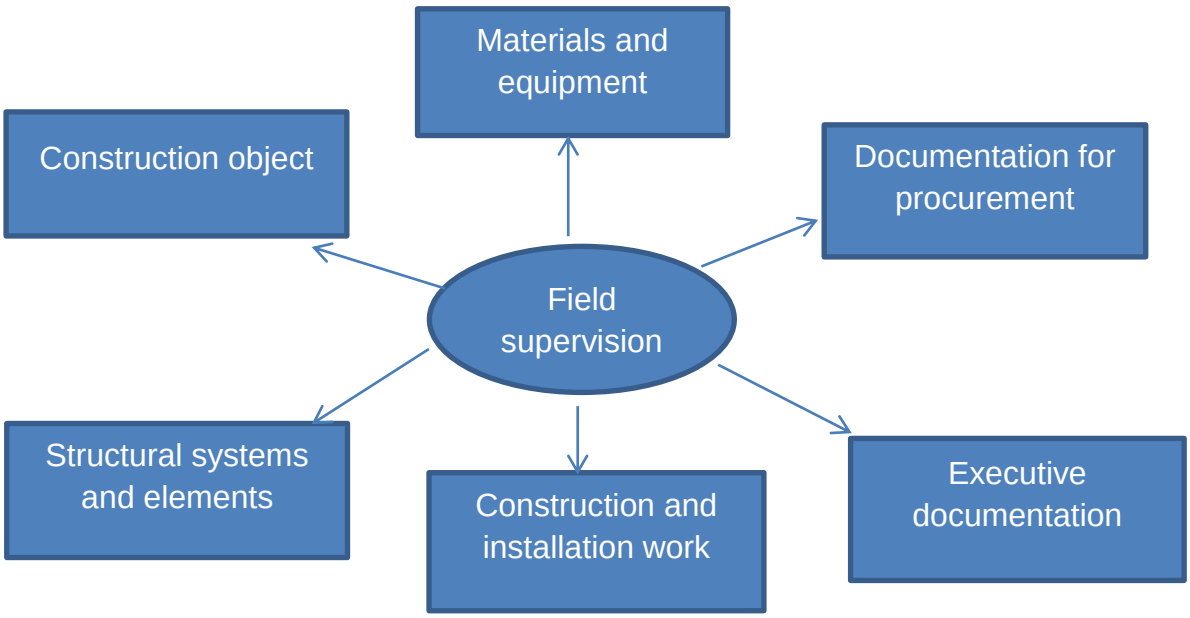

Figure 8. Supervision objects

Proper construction process organization, the implementation of the tasks and the timely resolution of any issues lead to commissioning at the specified date.

In the thesis the construction stages of the building were described and assimilated, each stage content was considered in detail, works occurred at the stage were explored and each stage results were identified.

The provided work is useful for Seven Suns Development. This work is relevant for the employees (workers) training in the construction industry. The work will provide an opportunity to advance construction methods abroad.

Tables

Figures

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Appendix A

Table 3. Statement of quantities of major construction works

№	Name of works	Units	The volume of construction and installation work			
			Total	by construction periods		
				2014 г.	2015 г.	2016 г.
Building 4						
1	Concrete preparation installation	m^3	132,9	-	132,9	-
2	The monolithic reinforced concrete Foundation slab installation	m^3	664,6	-	664,6	-
3	The monolithic reinforced concrete walls and columns installation	m^3	1116,5	-	1116,5	-
4	The monolithic reinforced concrete floors installation	m^3	1387,5	-	1387,5	-
5	Reinforcement installation	T	256,2	-	256,2	-
6	Precast concrete staircases installation	T	53,1	-	53,1	-
7	The walls of aggregate concrete blocks Polarit Classic 5	m^3	423,2	-	423,2	-
8	Wall insulation with mineral wool Paroc FAS 3 (120 mm)	m^3	334,8	-	334,8	-
9	Walls thermal insulation Penoplex	m^3	29,4	-	29,4	-
10	Partition and walls insulation of aggregate concrete blocks	m^3	296,5	-	296,5	-

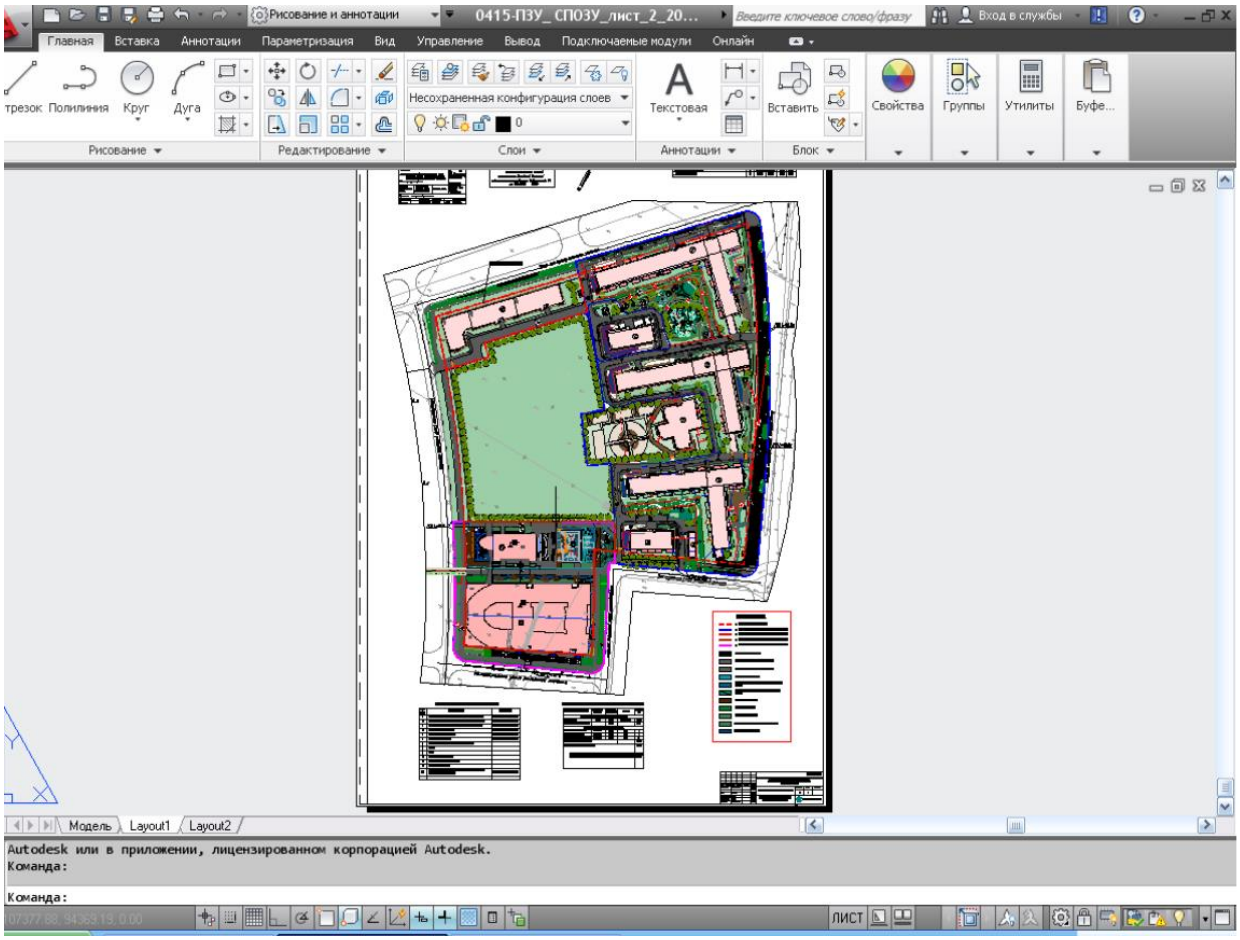
11	Cement-sand screed insulation (40 mm)	m^2	5015,7	-	5015,7	-
12	Floors coverings with a parquet	m^2	3862,9	-	3862,9	-
13	Floors coverings with a ceramic granite	m^2	440,4	-	440,4	-
14	Facing surfaces with ceramic tiles	m^2	109,2	-	109,2	-
15	Facades plastering	m^2	2789,7	-	2789,7	-
16	Interior surfaces plastering	m^2	17898,5	-	17898,5	-
17	Surfaces painting	m^2	6428,2	-	6428,2	-
18	Suspended ceilings insulation Armstrong	m^2	451,7	-	451,7	-
19	Roofing coating insulation Isoplast - 2 laeyrs	m^2	1278,4	-	1278,4	-
20	Thermal insulation of roof with mineral wool Paroc ROB 60 – 20mm	m^3	25,5	-	25,5	-
21	Thermal insulation of roof with mineral wool Paroc ROS 30 – 180mm	m^3	230,1	-	230,1	-
22	Roof vapor barrier Isospan B	m^2	1278,4	-	1278,4	-
23	Filling gravel for slope - 20…150 mm	m^3	108,6	-	108,6	-
24	Window blocks installation	m^2	697,4	-	697,4	-
25	Doors installation	piece	108,0	-	108,0	-

Table 4. Requirements of construction in main construction materials, designs, products and semi-finished products.

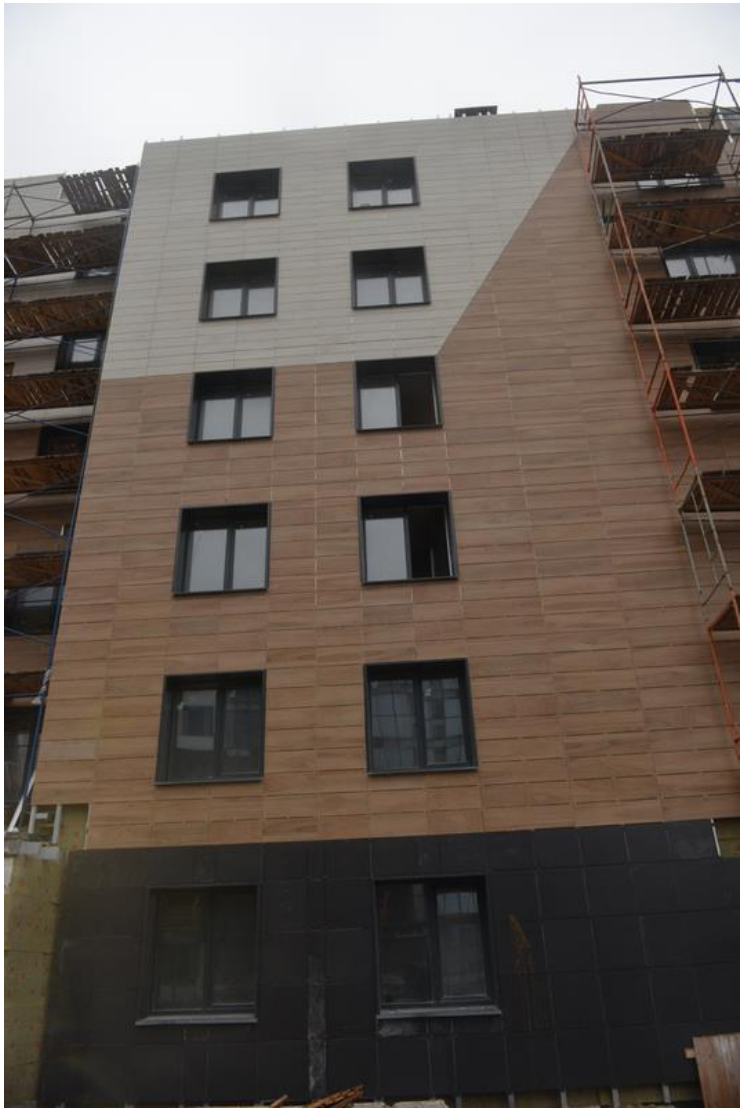
№	Name of works	Units	The volume of construction and installation work				
			Total	by construction periods			
				2014 г.	2015 г.	2016 г.	
Building 4							
1	Concrete for preparation installation	m^3	132,9	132,9	-	132,9	-
2	concrete for monolithic reinforced foundation slab	m^3	664,6	664,6	-	664,6	-
3	Concrete for walls and columns	m^3	1116,5	1116,5	-	1116,5	-
4	Concrete for floors	m^3	1387,5	1387,5	-	1387,5	-
5	Reinforcement	T	256,2	256,2	-	256,2	-
6	Precast concrete staircases	T	53,1	53,1	-	53,1	-
7	Ceramsite units Polarit Classic 5	m^3	423,2	423,2	-	423,2	-
8	Mineral wool slabs Paroc FAS 3	m^3	334,8	334,8	-	334,8	-
9	Penopleks	m^3	29,4	29,4	-	29,4	-
10	Gypsum units	m^3	296,5	296,5	-	296,5	-
11	Cement-sand mortar	m^3	200,6	200,6	-	200,6	-

12	Parquetry	m^2	3862,9	3862,9	-	3862,9	-
13	Granite slabs	m^2	440,4	440,4	-	440,4	-
14	Ceramic tile	m^2	109,2	109,2	-	109,2	-
15	Cement-lime mortar Caparol	m^3	55,8	55,8	-	55,8	-
16	Cement-lime mortar	m^3	358,0	358,0	-	358,0	-
17	Painting	Kg	642,82	642,82	-	642,82	-
18	Suspended ceilings Armstrong	m^2	451,7	451,7	-	451,7	-
19	Isoplast	m^2	2556,8	2556,8	-	2556,8	-
20	Mineral wool slabs Paroc ROB 60	m^3	25,5	25,5	-	25,5	-
21	Mineral wool slabs Paroc ROS 30	m^3	230,1	230,1	-	230,1	-
22	Clay gravel	m^3	108,6	108,6	-	108,6	-
23	Isospan B	m^2	1278,4	1278,4	-	1278,4	-
24	Window blocks	m^2	697,4	697,4	-	697,4	-
25	Doors	peace	108,0	108,0	-	108,0	-

Appendix B



Picture 1. Planning organization scheme of the land area.



Picture 2. The building 4